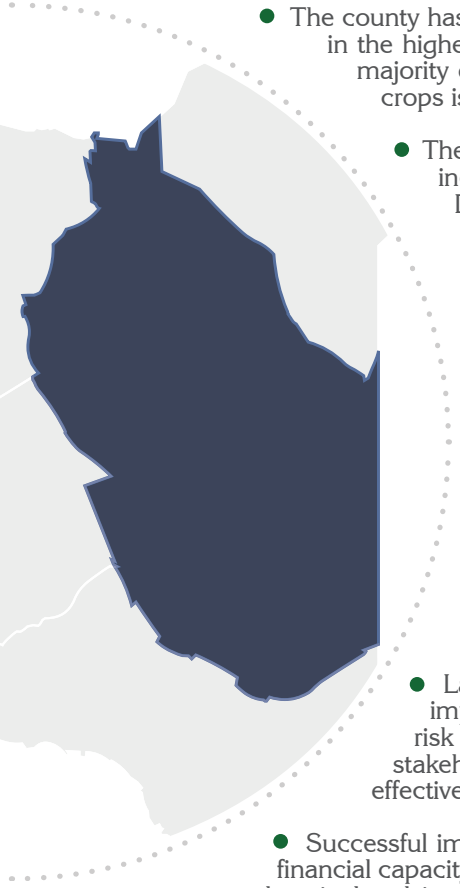
Climate Risk Profile
Wajir County

Highlights



- The agricultural sector (mainly livestock keeping) accounts for 85% of Wajir County household income. Nomadic pastoralism is more prominent in the county and defines the lifestyle of most of the county's inhabitants.
- The county has a total 1,024.06 km2 of arable land out of which, 3,823 ha are under food crop production in the higher altitude regions; Available data shows that the county has a food poverty rate of 72% and majority of its inhabitants depend primarily on relief food because the acreage under food and cash crops is negligible.
- The historic climate scenario in the last decades showed an increase in drought and a moderate increase in temperature in the First wet season (January – June); the Second wet season (July-December) was characterised by an increase in precipitation and a low increase in mean temperature. Models of future climate projections show that Wajir County will remain highly susceptible to drought and high temperatures. Over the next decades, we expect high increases in the length of drought spells, moderate increases in mean temperatures and moderate decreases in intense rain in both seasons.
- Current and potential adaptation strategies to climate hazards for crops and livestock farming systems include water harvesting through construction of water pans, shallow wells, boreholes and dams, conservation agriculture, planting drought-tolerant crops, and early-maturing crops, agro-forestry, livestock migration, fodder production, disease control and surveillance, destocking, and rearing livestock breeds adapted to drought..
- Off-farm services such as early warning systems, agricultural extension and training, and market information exist to increase farmers' adaptive capacity. Despite all these efforts, farmers' adaptive capacity is still very low especially because of very high poverty and illiteracy levels with women and youth being among the most vulnerable groups in the county, with the lowest adoption rates of adaptation strategies.
- Lack of and/or weak county-specific policies, inadequate mechanisms, capacity to coordinate, implement and monitor interventions present important institutional barriers to effective climate risk management in the county. However, there is a need to strengthen collaboration among stakeholders for optimal use of resources, reduction of duplication and ultimately more efficient and effective response to the hazards in the County.
- Successful implementation of climate adaptation strategies requires strengthening of the institutional and financial capacity of the respective stakeholders in the County. This will enable them to deliver basic resources and agricultural incentives to the target beneficiaries and thus keep them engaged in sustainable agricultural activities

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

List of acronyms

ALDEF	Arid Land Development Focus
ADS	Anglican development Service
ADESO	African Development Solutions
ASDSP	Agricultural Sector Development Support Programme
CIS	Climate Information Service
CRS	Catholic Relief Service
ILRI	International Livestock Research Institute
FAO	Food and Agriculture Organisation
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Programme
KDLDP	Kenya Dryland Development Programme
KFS	Kenya Forestry Service
KLIP	Kenya Livestock Insurance Programme
KMD	Kenya Meteorological Department
KRC	Kenya Red Cross
KWS	Kenya Wildlife Service
MoLAI	Ministry of Lands, Agriculture and Irrigation
MoALF	Ministry of Agriculture, Livestock and Fisheries
MoWI	Ministry of Water and Irrigation
NDMA	National Drought Management Authority
NEMA	National Environmental Management Authority
NCCAP	National Climate Change Action Plan
REGAL-IR	Resilience and Economic Growth in Arid Lands for improving Resilience in Kenya
UNDP	United Nations Development Programme
VCCs	Value Chain Commodities
VSF	Veterinary Sans Frontiers
WASDA	Wajir South Development Agency
WFP	World Food Programme
WCCISP	Wajir County Climate Information Services Plan

Foreword

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

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

This document presents the Climate Risk Profile for Wajir County, which is very vulnerable to climate hazards. The hazards, mostly drought and occasional floods, are the major contributors to the high poverty and food insecurity incidences, as well as communal conflicts witnessed in the county. For example, approximately 111,900; 131,700; and 170,900 people were acutely food insecure in 2013, 2014, and 2015 following rainfall failure in those years[1]. More than 6,367 households were affected by the 2014 natural resource-related inter-communal feud in the county[2]. Looking to the future, the situation is likely to worsen based on the current trends, which show that there is a tendency that out of five rains, at least two rains fail in Wajir County. Some of the severe droughts recorded in the county include those of 1984/1985, 1991/1992, 1999/2000, 2005/2006, 2009 and 2011. In the event of these droughts, pastoralists lose up to more than half of their livestock. An example is the 2011 drought, where the pastoralists lost up to 40 – 70% of their livestock[3]. Conversely, floods are equally disastrous in Wajir. For instance, the floods following the torrential rains in the county and in Ethiopia in 2017 affected 500 households and put their livelihoods at risk. These extreme weather events have attracted interventions from various stakeholders, both government and non-government. Interventions undertaken include provision of food relief and social protection measures such as cash transfers. These measures may help in abating the consequences of the hazards. The county is yet to benefit from measures that address the existing institutional and political gaps in building resilience and sustainably, thus increasing agricultural productivity.

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

1 Wajir County Government; WFP (2015).

2 http://www.fao.org/fileadmin/user_upload/drought/docs/SC%20Drought%20Assessment%20Report%20-%20Northern%20Eastern%20Kenya-%2011-24%20April%202011.pdf

3 http://www.fao.org/fileadmin/user_upload/drought/docs/SC%20Drought%20Assessment%20Report%20-%20Northern%20Eastern%20Kenya-%2011-24%20April%202011.pdf

Agricultural context

Economic relevance of farming

Wajir County is located in the northeastern region of Kenya and lies between latitudes 3° N 60'N and 0° 20' N and Longitudes 39° E and 41° E. It is a featureless plain covering an area of 56,685.9 km^2 and borders Republics of Somalia to the east and Ethiopia to the north, Mandera County to the north east, Marsabit County to the west, and Garissa County to the south. The county has its headquarters in Wajir Town (GoK, 2014).

The ASDSP county survey indicates that the agricultural sector accounts for 85% of household income with 284,265 people engaged in the sector. The livestock sector accounts for over 80% of incomes earned under the pastoral livelihood zone and employs over 65% of the county's labor force (Forty-five percent of all men and 17.1 % of all youth in the county). Income from livestock activities is the most important source of on-farm income earned by 69% of youth-headed households[4]. Adult females provided about 5% of the combined labor input. Youths provided most of the labor at 68% of the total input. This was considerably higher than that contributed by adult males (27%). Disaggregated by activity, youths contributed the most (82%) to hired labor dedicated to livestock production. About 71% of hired labor was dedicated to crop production. Youths (81%) and adult females (18%) mainly provided combined hired labor while adult males contributed the balance (GoK, 2014).

According to CIDP 2013-2017 (GoK 2013), the total household income per annum for the county was KES 148,815 while the annual gross household wealth was KES 670,959. The annual per capita income and per capita gross wealth were KES 19,711 and 88,869 respectively. The mean daily per capita income was KES 66 for youth-headed households, way above KES 16 and 50 for female-headed and male-headed households respectively. The households earn an average of KES 60,038 with crop sources contributing an average of KES 19,667. Livestock earn households an average KES 62, 350 with youth-, male-, and female-headed households earning KES 46,179, 70,912, and 34,050, respectively. In 2012-2014, earnings from major value chain products[5] were estimated at over KES 3 billion.

The main livestock bred[6] include cattle (Boran), camel (Dromedary Somali type), goats (Galla), sheep (Black head Persian), donkey, and poultry (indigenous birds and hybrid layers) which is mostly practiced in Wajir Town. Beef, milk[7], eggs, and mutton are the main livestock products with milk and meat annual production estimated at 3,875,940 liters and 191,100 kg (GoK, 2013). Meat production is mostly from local goats and sheep where 60% and 29% of farmers slaughtered the respective species during the year. Local goats are the most frequently sold livestock species, involving about 70% of the community. The products sold to buyers included milk (80%), eggs (13%) and live animals. Milk had the highest value at KES233 million followed by mutton at KES177 million, beef at KES48 million, eggs at KES 1.5 million, and poultry meat at KES 0.8 million.

Up to 37 % of all households are engaged in value addition of livestock products. Crop products value addition activities are almost missing since the crop portfolio in Wajir County is small. Although a few activities on fruit ripening, de-hulling, grading, and making flour exist. Of all livestock products that underwent value addition, 47% were on milk, 20% on chevon, and 11% on beef. The most important value adding activity applied to milk was boiling (66 %); the rest was fermented. For chevon, drying (48%), nyirinyiri, i.e. dried animal meat preserved in animal fat (26%), and salting (26 %) were the value addition activities undertaken on meat. Most (87%) of the beef and mutton (55 %) was salted while eggs were boiled and hides and skins dried (GoK, 2014).

People and livelihoods

According to the projected Kenya Population and Housing Census (KPHC) of 2012, Wajir County human population[8] was 727,965 persons of whom 327,916 (45%) were male, 400,049 (55%) female, and the youth population (aged 15 to 30 years) was about 185,959 (26%). The projected total population growth in 2017 is 852,963 persons. The county has a population growth rate of 3.22%, which is higher than the national rate of 2.9% attributable to high levels of illiteracy, and strong religious and cultural beliefs that support polygamy and oppose family planning. The life expectancy is 61.3 and 62.3 years for men and women

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

5 Mainly beans, cowpeas, green grams, vegetables, cattle, sheep, goats. chickens, camels

6 According to the 2009 population and housing census, there were 794, 552 cattle, 1,406,883 sheep, 1,866,226 goats, 115,503 donkeys, and 533,651 camels.

7 Milk production is an important economic activity in the county, with average production being 1.86 liters per cow per day, 1.85 liters per cow per day, and 2.13 liters per camel per day.

8 The county population consists mainly of Somali people who identify themselves by clans (major clans are Hawiya and Dawod).

respectively. The population density is relatively low, at 12 persons per km2 compared to other counties in high rainfall areas.

The county's rural population was 700,100 (96.2%) and urban population was 27,865 (3.8%). Currently, only 13.8% of total population lives within the main urban or peri-urban centers of Wajir and Habaswein. The rest of the population lives in other minor urban settlements and rural areas (GoK, 2013). The households in the county depend on five main sources of livelihoods. They are classified into five livelihood zones namely Agro-pastoral, Pastoral all species, Pastoral Cattle, Pastoral Camel, and Informal Employment Business. The county is characterised by a very high level of absolute poverty which stands at 84% (Wajir county and WFP, 2015.) especially since majority of the people are still heavily dependent on relief food from the government and other organisations.

According to a report by ASDSP, there is a higher population with primary school education (24.5%) than that with secondary school education (3 %). Only 23.6 % can read and write; 70.2% had not attended any schooling; 24.5% had acquired primary school education; 3% had attained secondary school level. The low level of literacy in the county makes it difficult for the pastoralists to access crucial agricultural information and other technologies regarding land use. (GoK, 2014).

Over 94.9% of the households rely on firewood and charcoal as their main source of energy. Out of the 88,574 households in the county, only 0.2% use electricity for cooking, 0.2% use petroleum products, while 0.1% uses solar energy. For the purposes of lighting, majority use kerosene 48.4% while 3.4% use electricity, 11% use gas lamp, and 0.2% use solar energy. The rest of the population use other means (GoK, 2013). Provision of clean sources of alternative energy is critical in slowing down felling of trees, extensive degradation and health complications associated with pollutants from fossil fuel. The county records more than nine hours of sunshine per day and hence has a huge potential for harvesting and utilisation of solar energy. Access to water is also a big challenge; only 5.1% of the residents have access to potable water and 1.4 % have access to piped water. The average distance to a water source is 30 km[9]. Most communities depend on water pans, water trucking and shallow wells for both domestic and livestock water supply. Each year, in water-stressed areas of Wajir County, vulnerable households have to survive on as little as eight liters of water per person, per day. Unfortunately, due to prolonged droughts and higher evaporation rates lack of water may continue in the future. (NDMA, 2017).

In terms of access to certain financial services such as agricultural credit, agricultural insurance, and the warehouse receipting system. Just a paltry 0.7 % (all from youth-headed households) accessed formal saving services. Majority of the households did not have enough food for their family needs throughout the year due to climate variability. Overall, the proportion of households that did not have enough food to meet their household needs was 82.1%. Among the male-headed households, about 84.8 % did not have enough food to meet the household needs, while 15.2% indicated that they had enough food throughout the year. Not all female-headed households had enough food due to low access to productive inputs and land while 88.1% of youth-headed households did not have enough food. Food poverty significantly affects health and nutrition of children with the prevalence of wasted children being 21.1% while that of stunting children stands at 26.4%. (GoK, 2014). Children under five are at a higher risk of malnutrition as the food situation worsens in the county.

Agricultural activities

Wajir County has two ecological zones namely semi-arid near the high ground, quickly becoming arid in the lower plains. The county falls in Ecological Zone V-VI. Zone V receives 300-600 mm of average annual rainfall and has a low cover of trees, grass, and shrubs. Zone VI receives 200-400 mm of mean annual rainfall. The higher area of Bute and Gurar receives 500-700 mm. The county experiences annual average relative humidity of 61.8%, which ranges from 56% in February to 68% in June. It has an average temperature of 27.9°C. The warmest months are February and March with an average of 36°C while the coolest are June, July, August and September, with an average low of 21 °C. There are two rainy seasons, i.e., short (October to December) and long rains (March to May). The rains are erratic and unreliable hence cannot support crop farming; this partly explains the high food insecurity and food poverty levels recorded in the county.

Nomadic pastoralism is more prominent in the county and defines the lifestyle of most of the households. However, crop production exists especially in the higher altitude areas and agro pastoralism around water sources (shallow wells, Lorian swamp, Ewaso Ngiro Belt in Habaswein and along drainage lines in Bute sub-county). The main crops grown include fruits (pawpaw, watermelon, and lemon); cereals (maize, sorghum, and millet); pulses (beans, green grams and

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

cowpeas); and vegetables (kales and spinach). There are efforts to increase crop acreage through irrigation. The National Irrigation Board in collaboration with County Government plans to drill boreholes to provide irrigation water in parts of Wajir South. Across the county, we have about 14,360 shallow wells, 206 water pans, and 98 boreholes to boost agricultural production and provide water for Livestock consumption which uses over half (53%) of this water.

Support from several organizations' such as National Irrigation Board, the Kenya Red Cross Society, World Vision, and CTF through introduction of greenhouses, shade nets and drip irrigation technologies has promoted crop production in areas such as Eldas and Wajir East. The main food crops grown include drought-resilient maize, sorghum, and watermelon, occupying approximately 700, 800, and 200 ha respectively. In 2012, 191 MT of maize was valued at KES 6.4million while other crops such as sorghum, cowpea, green grams, and millet were valued at 3.6m, 0.5m, 0.3m, and 0.03m respectively. However, most of the farm products consumed within the county on a substantial scale are imports from neighboring counties such as Meru, Isiolo, Nairobi and Moyale. These crops include potatoes, tomatoes, carrots, cabbages, avocado, and pawpaw (GoK, 2014).

The average farm size is 2.4 ha since most of the area is under communal grazing. There are few cases of landlessness mainly in the urban centers, where poor immigrants do not own land or plots. In terms of land use, crops have low acreages with average size of cropland owned by a household being 0.51 ha, (excluding communally grazed pastureland) with a minimum holding of 0.01 ha and a maximum of 4.91 ha. However, when disaggregated by gender, male-headed households owned 0.60 ha with a minimum holding of 0.02 ha and a maximum of 4.91 ha whereas female-headed households owned 0.07 ha with a minimum of 0.02 ha and a maximum of 0.24 ha. Only 5.1% of this land had title deeds out of which 65% of formal owners were male-headed households. Lack of these title deeds discourages willing and potential investors from investing in the county. The communal land tenure system also hinders long-term investments in conservation and lends itself to inter-communal conflicts, particularly during dry spells as different communities claim rights to the land (GoK, 2013).

According to ASDSP (2014), the key constraints to input use in crop farming and livestock production were high prices, long distances (over 60km) to input market, unavailability of inputs, and lack of access to climate information and agricultural services. Among the households that accessed the different services, 70% accessed them from the public sector while the rest accessed them from private sector institutions. Households accessed climate information from public sources, as did 93% of the households in the case of agricultural services. Adult males had more access to most of the services than adult females while youths had more access to climate information services. About 30% of the respondents were not satisfied with veterinary services despite the importance of livestock in the county; 73% were satisfied with extension services and 33% with research. Compared to women and youth, men tend to use fewer inputs, given their engagement in pastoral livestock activities and continuous search for water and pastures.

Sources of climate information in order of importance were traditional indigenous knowledge (used by 99.3% of the sample), radio (44.3%), NGOs (25.7%), partners (9.3%) and KMD (0.7%) On climate change adaptation, only 12.8% of the households employed water-harvesting strategies with all female-headed households and 35.7% of youth-headed households adopting the strategy. Other adaptation strategies used included soil and water conservation, changing livestock types, tree planting, irrigation, and building of food storage structures. None of the households had a member trained in any of these strategies (GoK, 2014).

Agricultural value chain commodities

A broad diversity of agricultural commodities is grown in the county. Of these commodities, various value chains have been prioritised as being strategic for the county as indicated in the County Integrated Development Plan (CIDP) and the e ASDSP as well as by government institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis based on: prioritisation in county frameworks and programmes; economic value (KES/bag or KES/livestock or KES/unit livestock product)[10]; resilience to current weather variability and future climate change[11]; and number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth, and the poor[12]). The VCCs selected are camel milk, sorghum, poultry, and watermelon.

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

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

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

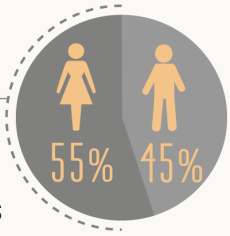
Livelihoods and agriculture in Wajir

Demographics

2% Of Kenya´s population

727,965 inhabitants

96% Live in rural areas



Access to basic needs

84% of the population lives in **absolute poverty**

Potable water	5.1%
Electricity for cooking	0.2%
Electricity for lighting	3.4%
Education (youth literacy rate)	24%

Food security

72% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

26% Children **stunted**

21% Children **wasted**

ND: No data

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

Farming

County´s farming area

1,024 km² ND

39% of the population employed in agriculture production

0% of farmers have title deeds

0% are women

Farming activities

Food crops

Cash crops

Livestock

Of county´s agricultural land

0 Group ranches

0 Company ranches

Farming inputs

Water uses

53% 30% 10% Others 7%

Fertilizer types (% of households)

10% Organic manure

11% Planting fertiliser

10% Top dress fertiliser

Pesticide types (% of households)

11% Field pesticides

11% Storage Pesticides

11% Herbicide

Camel (milk)

Camels are multipurpose animals increasingly kept for milk and meat. Camel milk is one of the most strategic value chains in Wajir according to the Agricultural Sector Development Programme (ASDSP) (GoK, 2014). Camel milk is a major contributor household food security and income and serves a significant cultural function to the pastoral communities in the county. Households are increasingly producing milk for the market as well as for subsistence, contributing to the growth of the camel milk subsector in the face of increasing climate variability and change. Camel milk has become very popular not only among the traditional Somali people but also among the general public especially because of its claimed therapeutic properties, attributed to various plant species that they browse on .

The greater Wajir area has about 522,661 camels with a daily milk production of about 1,988,798 liters in good seasons. The camel population is mainly in the central and northern parts of the county with the highest camel population in Giriftu and Khorof Harar, lower population in Tarbaj and El Ben, and the lowest population in the northern areas of Eldas and Gurar. The milk sold from Wajir County is from the rural markets in Giriftu, Lehele, Wagberi, Orhey, and Soko Mjinga among other areas. On average, a trader handles 10 liters of camel milk daily. Productivity was estimated at overall 2.13 liters per day of camel milk (MHH=2.23, FHH=0.63, and YHH=2.05). Adult males' make most of the production decisions on all types of camels (GoK, 2014).

The preferred breeds with high milk production and tolerance to the harsh climate are the Somali breed (heavy feeder, brown-cream coat color, less hardy, with a live weight of 450-700 kg. Average milk yield is 5litres per day) and Rendille/Gabbra breed (moderate feeders, brown cream coat color, have moderate hardiness and a live weight of 300-450 kg. Milk yield averages 3litres per day) and Pakistan breed (heavy feeder with a predominantly grayish coat color, droopy lips, wider chest and least hardy. Has a live weight 400-600 kg and a milk yield of 10litres per day).

The value chain characterization in the County shows that between 61- 80% of the population is engaged in this value chain. In the provision of seeds and other inputs stage, the types of actors in the value chain are the service providers at medium scale, and suppliers at medium scale. The importance of women in the value chain is very low scale while all genders (Youth, Men and Women) importance is at medium scale. In the on farm production stage, the types of actors in the value chain are the service providers at medium scale, and farmers at small scale. Harvesting, storage and processing stage, the types of actors in the value chain are the service providers at small scale, and processors at medium scale. At the product marketing stage, the types of actors in the value chain are the service providers at medium scale, and wholesalers/ retailers at medium scale. The importance of women in the value chain is high.

The main actors in the value chain are the veterinary officers from both private and county government. Households are involved in activities such as feeding, milking, spraying, transportation, storage, and marketing. In conjunction with national organizations[13] the marketing groups have made efforts to improve the quality of camel milk traded in Wajir through training of producers and traders on hygienic milk handling, promoting the use of aluminum cans instead of plastic containers, and adding value to products such as pasteurized milk, sour milk, yoghurt, and Sussa. Areas of focus in capacity building include cooperative management and compliance issues; production and business aspects of camel milk production; milk hygiene; quality standards; simple technologies for value addition to enhance product diversification; markets; and marketing models

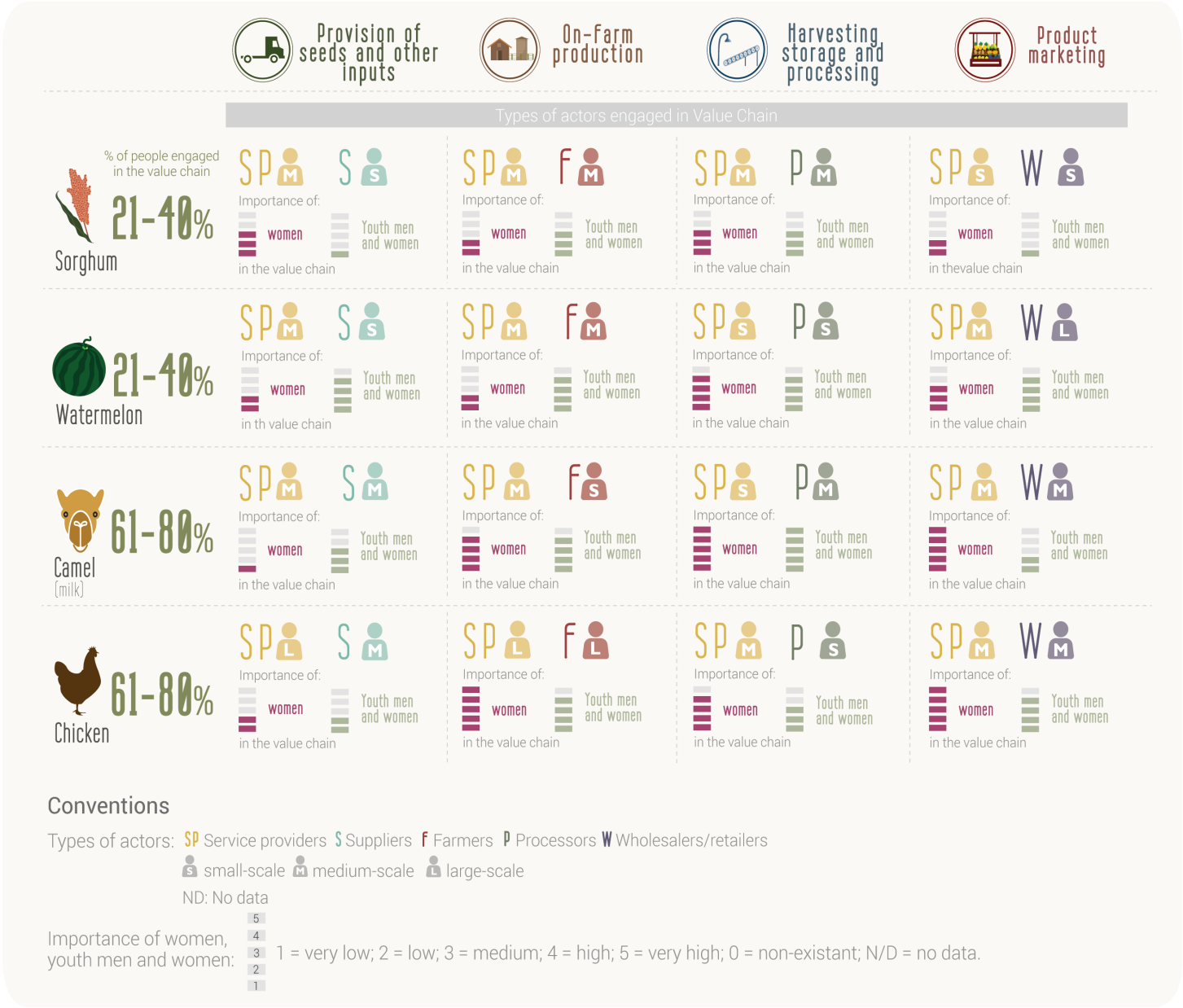
Despite the major contribution of camel milk to pastoral communities' livelihoods, there are high post-harvest quality deterioration and quantity losses because of unfavorable high ambient temperatures, and longer time taken for milk to cool. A solar milk pasteurizer[14] for value addition would be ideal or a county established milk-processing plant to pasteurize and add value to the milk, reduce post-production losses and remove market barriers related to quality and safety standards. Production of camel ghee and yoghurt as food security products, and basic packaging of camel milk for ease of quality transportation and distribution to consumers is essential. The most commonly used containers for milk storage and transportation from herds to markets are plastic jerricans. More efforts needed to improve hygiene by providing aluminum cans and milking buckets - during harvesting, post-harvest handling and transportation.

Camel herders sell the raw milk to urban consumers,

13 Kenya Camel Association (KCA), the Kenya Livestock Marketing Council (KLMC) and development agencies such as WASDA, REGAL-IR, Mercy Corps, SNV, and VSF-Suisse.

14 It consists of a flat plate water-heating solar collector and a 1.5-mm stainless steel cylindrical milk vat. The milk vat has a capacity of 80litres and a 50-mm-wide hot water jacket insulated with a 38-mm-thick fiberglass Water in the solar collector is directly heated by the sun; the hot water produced is used for pasteurizing milk. Valves are provided at appropriate points to operate the device.

Agricultural value chain commodities in Wajir



largely comprising of the Somali community in Garissa and Nairobi's burgeoning Eastleigh Estate. Here households and restaurants buy most of it; a smaller but increasing proportion goes to other estates and wholesalers in Nairobi. Camel milk traders retail it in Wajir and Garissa Towns. According to Akweya et al. (2012), the consumption percentage rate of raw camel milk is highest in Nairobi (30%), followed by Garissa Town (28%) and then Wajir (25%). The milk prices range from KES100 to 150 per liter.

Camel milk in Wajir Town is handled by individual traders and marketing groups. They have bulking centers with cold facilities or a cooling tank to consolidate all the milk. There are three camel milk-marketing groups in the town: Wajir Milk Traders, Wagalla Milk Traders, and Al Mustaqim Women Group. They all provide market information, training, and credit facilities; most importantly, they provide bargaining power over the sale price of camel milk to the terminal market in Nairobi. Prospects for growth in demand within this market segment are positive due to superior quality compared to cow milk (in terms of flavor as well as the acclaimed medicinal value and because of the frequent extended dry periods during which cow milk is largely unavailable.

Sorghum

Sorghum (*Sorghum bicolor* (L.) Moench) is widely grown as a food crop in marginal, semi-arid environments characterised by low and erratic rainfall. On the other hand, semi-arid environments are also characterised by low population densities, poor infrastructure, and limited access to markets. These factors raise transaction costs and reduce incentives for both growers and buyers. Despite the numerous benefits of sorghum, its adoption, production, and utilisation as a staple and commercial crop in Kenya remains low. This is largely due to low yields, lack of specific varieties for various products, inadequate promotion, unfavorable policy environment, poor agronomic practices, diseases and pests, underdeveloped seed supply systems, and poor marketing channels. To address these constraints, KALRO and other partners have been involved in the introduction of superior, disease-resistant varieties as well as TIMPs and post-harvest handling technologies.

Sorghum production is under rain-fed systems and the production zones have two cropping seasons. Planting for the long rain season starts in March and ends in May, with harvesting taking place in July-August while the short rain season starts in October and ends in December with harvesting in January and February. Sorghum is a short-duration crop and the bulk of production occurs during the short rains. Sorghum grows countywide, with higher concentrations being in Lorian Swamp and along the drainage lines in Buna. Here it occupies approximately 250 ha. Large-scale farms are in Kutulo, Griftu, and Khorof Harar., medium scale in areas around El Ben, Tarbaj, Dif, Eldas, and Buna and small-scale farms in Habaswen.

Exclusively smallholders who either consume it at household level or sell it produce sorghum. During the first season, 20% of the male-headed households grow sorghum on about 0.62 ha (GoK, 2014). Yields on smallholder farms, which rely on rainfall, are affected by drought, and average only 97 kg per ha. In drought years, growers prioritize household food security and are reluctant to sell, making it difficult for buyers to ensure a consistent supply. During the year 2012, 62.91 MT of sorghum was valued at KES 2.576 million (GoK, 2014).

The value chain characterization in the County shows that, between 21- 40% of the population is engaged in the sorghum value chain. In the provision of seeds and other inputs stage, the types of actors in the value chain are the service providers at medium scale, and suppliers at small scale. The importance of women in this value chain is at medium scale. On farm production stage, the types of actors in the value chain are the service providers' at medium scale, and farmers' at medium scale. Harvesting, storage and processing stage, the types of actors in the value chain are the service providers at medium scale, and processors at medium scale. The importance of women in the value chain is medium while all genders importance is medium scale. At the product marketing stage, the types of actors in the value chain are the service providers at small scale, and wholesalers/retailers at small scale.

Improved sorghum varieties such as high-yielding and drought-tolerant white sorghum: Gadam and KARI Mtama-1 are proposed. Since they yield up to 5 tons per ha with good agricultural practices[15]. Another variety is the brown sorghum: Hybrid Mtama-1. It has high extractable starch (77.4%) and has early to medium maturity early-maturing varieties flowering in 56-59 days while medium-maturing varieties flower in 100-110 days. Gadam and KARI/Mtama I varieties are suitable for cultivation in these regions. The two varieties grow well under irrigation and in areas with an elevation of 50-1800m that receive about 250mm of rainfall per season. The varieties recover fast from drought.

Sorghum is disease tolerant but control diseases when necessary. Insect pests include the shoot fly and stem borer. The major diseases include smut, charcoal rot, anthracnose, stem and leaf rust. Marshall or Dipterex should be used at 3 kg per ha to control the stem borer and shoot fly. Seed should be dressed with a combination of fungicide and insecticide to control most of the diseases. Bird damage is a major problem; since they prefer white-seeded sorghum and will eat it before eating brown-seeded varieties.

When the sorghum grain is hard and does not produce milk when crushed between the fingers it is harvested. Control for storage pests, is through dusting of the grains with super actellic at 50g per bag; or with any other effective storage chemical. To minimize aflatoxin contamination, the sorghum heads should not be heaped and dumped when wet. This provide suitable conditions for growth of mycotoxin-producing fungi, leading to post-harvest losses, a perennial problem amongst smallholder farmers. Hence, the heads should be harvested, threshed, and stored in a cool, dry place.

In the sorghum value chain, the farmers mainly engage in land preparation, weeding, harvesting, spraying, storing, transporting, processing, bulking,

15 Good land preparation and planting seed rates, thinning, fertilizer application, weeding, tillering and ratooning

and marketing. In both seasons, 60 % of the farmers planted local varieties. Males made 60 and 70 % of the decisions in season 1 and season 2 respectively. Only a few inputs (fertilizer) were used during the two seasons. In most cases, the sorghum produce is marketed directly with the buyers though, 7 % of the farmers marketed it through contractual arrangements. Market channels for the value chain are mainly brokers and sometimes schools. The farmers received three support services namely infrastructure, climate early warning and agricultural services. Most respondents (85 %) indicated that infrastructure, though critical, was the least accessed, followed by agricultural services. Climate early warning is accessed in less than 2% of the cases while financial and credit services were not accessed at all. Various NGOs such as Wajir South Development Agency (WASDA), REGAL-IR, ADESO, Arid Land Development Focus (ALDEF), MERCY CORP, World Vision and Kenya Red Cross (KRC) offer farmers' seeds and technical advice. In addition, the above-mentioned NGOs provide seeds; climate-related information; and extension services on input utilization, good agronomic practices, and storage in collaboration with the county government and the Ministry of Agriculture (GoK, 2014).

Chicken (local)

In Wajir County, many households keep indigenous poultry though some keep hybrid layers. Poultry keeping is more practiced county wide, but more pronounced in Wajir Town. The indigenous poultry sub-sector has remained largely rudimentary and the value chain needs to be enhanced. This can contribute positively to resilience building for settled pastoralist communities by diversifying livestock production activities. The poultry sector has continued to be constrained by various challenges that include feed quality and low productivity. Other challenges include fluctuations in production and demand levels, poor marketing infrastructure, diseases, and inadequate research and development. For Wajir County, the demand for local chicken is picking up with changes in livelihood patterns and pastoral lifestyles.

The value chain characterization in the County shows that, between 61- 80% of the population is engaged in the local chicken value chain. In the provision of seeds and other inputs stage, the types of actors in the value chain are the service providers' at large scale and suppliers at medium scale, while the importance of all genders in the value chain is at low scale. On farm production stage, the types of actors in the value chain are the service providers' at large scale and the farmers' at large scale. The importance of women in the value chain is very high while all genders importance is very high scale. Harvesting, storage and processing stage, the types of actors in the value chain are the service providers' at medium scale, and the processors' at small scale. The importance of women in the value chain is high while all genders importance is medium scale. At the product marketing stage, the types of actors in the value chain are the service providers is medium scale, and wholesalers/retailers at medium scale. The importance of women in the value chain is very high while all genders importance is high scale.

The majority of poultry farmers are women and youth, as men tend to be more engaged in other livestock types such as cattle, goats, and camels. In the local poultry value chain, the farmers mainly engage in feeding, cleaning, vaccination, slaughtering, processing, collection, transportation, and wholesaling. The role of women in poultry management is significant; through provision of basic care. Farmers sell the chicken to traders, who bulk and transport them to Wajir Town, or consume them at the household. Eggs are sold in crates at KES450-600 per crate. Chicken prices vary according to size, season, and sex. The average weight per bird sold is 1-2 kg. Currently, the contact market nodes are brokers as the producers are disadvantaged by lack of market information. The income from the sale of chicken and eggs is used to purchase food that the farmers do not produce on their farms, supporting food security

Large-scale production is practiced mainly in the areas near Wajir Town and Habaswein while small-scale production is practiced in Giriftu, Tarbaj, Khorof Harar, Eldas, Buna, and Bute Na Gurar. Average flock sizes for small-scale producers range from 10 to 50 while those for large-scale production range from 100 to 400. This is a low-input sub-sector as no supplementary feeding is practiced. Chicken are left to scavenge for food. Often, they source supplementation from kitchen left-overs. For commercial farmers, they get their feeds as far as Nairobi. In 2012, the number of trays of eggs produced was 2130 valued at KES1, 278, 000 (GoK, 2013). Efforts should be made to support the local communities in the region develop poultry sub-sectors in which commercialisation can be nurtured to address food insecurity and create wealth. Significant efforts are required in stimulating production through a number of approaches including sensitisation, support in breed selection, extensive extension support and training in disease management.

In 2014, the county had an average of 163,783 chicken with an annual poultry meat production estimated at 38,449 kg and valued at about KES35 million. Eggs were produced by local indigenous chicken, improved indigenous chicken, and exotic chicken. However, 32%

of the eggs were from indigenous birds (GoK, 2014).

Mortalities are relatively high with limited survival rates across the varied ages. Mortalities are associated with predation, pests and diseases, hunger, and poor housing. Less than 5% of the households have built dedicated pens for their flocks. The number of birds is high in the market during the dry period. Such times also coincide with disease outbreaks and severe food scarcity. Poultry keepers market their birds for two reasons – to address household financial needs, and, where necessary, offload the flock so as to reduce losses due to mortality. Various NGOs such as WASDA, REGAL-IR, ADESO ALDEF, Mercy Corps, and KRC offer farmers vaccines and technical advice.

The proposed chickens are the KARLO improved indigenous breeds. These are available from KARLO Naivasha and are recommended for these areas. The KALRO improved chickens are dual purpose (egg and meat). Hens start laying at 4.5 months of age and produce 180-280 eggs. Males attain 2 kg live weight in about 5 months. The high productivity will reduce greenhouse gas emissions per unit of product. Feeding indigenous chicken is important as it increases production of meat and eggs. To attain a balanced diet, it is recommended that in addition to scavenging, chicken should be offered feed supplements containing energy, protein, vitamins, minerals, and water. The need for feed will change depending on the age, breed, and status (e.g. broody or laying) of the bird. The cheapest way to supplement poultry diet is to use local resources e.g. maize, millet, sorghum, blood meal, termites, worms, insects and rumen content. This can form over 75% of poultry feed. In Wajir blood meal and rumen content can be sourced from the slaughter houses while maggots and worms from cow dung. KALRO has formulations of high quality poultry feed based on Soya SB 19 and SB9. The KALRO high-yielding soya bean varieties SB 19 and SB 8 have high crude protein (38% CP) and are therefore suitable for use in non-ruminant feeds. Improved nutrition can raise the average number of eggs laid per clutch by 100%. Provide clean and fresh water all the time at a specific place.

Breeding should be managed to reduce inbreeding by introducing one cock for every 10 hens every 2 years. Care should be taken when storing eggs. For example, eggs should be stored with the broad end facing upward. Eggs that are more than 14 days old should not be used for hatching. Improved management increases survival rates from 2 to 6. Other breeding management strategies include serial hatching, synchronised hatching, artificial incubation, and management of chicks.

Pests and disease management is important in local chicken farming. Important diseases include: New Castle Disease, pullorum disease, coccidiosis and fowl typhoid. Pests and diseases can be controlled through vaccination e.g. the Thermostable New Castle Disease vaccine – Avivax I and strategic worm control. Pests and diseases can also be managed through improved sanitation, eggs and nest fumigation using formaldehyde pellets in the nest. Broad-spectrum antibiotics such as Sulphur drugs controls infections also. Up scaling McMaster Egg floatation technique, computerized detection of Anthelmintic resistance, and Salmonella screening technique are other methods of detecting worms in chicken population.

Watermelon

Watermelon (*Citrulluslanatus*) or Qara (Somali), *Tikitimaji* (Swahili) belongs to the family Cucurbitaceae. Water melons are delicious red fleshed refreshing fruits commonly eaten as desserts. Nutritionally the fruit contains vitamin A, thiamine, riboflavin, nicotinamide, and ascorbic acid. Water melon performs well in warm, dry tropics, which have enough sunlight for growth. Watermelon is sensitive to frost and are monoecious (both male and female flowers are produced on the same plant). The flowers remain open for approximately a day and are insect pollinated. Watermelon production is suited to low and medium rainfall areas with additional irrigation. They grow best under hot temperatures (22 and 28°C). They can grow well at altitudes of up to 1500 m.

The crop prefers good and well drained soils, preferably sandy loam soil texture with a pH of 5.8 to 7.2. Clay soils do not raise a good crop. Cultivation in heavy-textured soils results in a slower crop development and cracked fruits. If your soil is difficult, create raised beds by adding organic matter to improve drainage and aeration. It is usually recommended to lime soil to pH values below 5.5. Good agronomic practices such as spacing to allow good air circulation, fertiliser application, micronutrients, watering, plant development, and care that include weeding, pruning, and irrigation is recommended.

Early use of insecticides is important. Constant scouting is crucial in controlling pests and diseases. Fungicides can be effective if used early. Major insect pests include aphids, melon fly, and mites. Major diseases include powdery and downy mildews, anthracnose, alternaria leaf spot, gummy stem blight, and Fusarium wilt. Maturation period is 4 months; planting should be timed such that harvesting takes place during the dry period for rain-fed water melon crops. For best quality, one needs to scout the crop daily; looking out for the

maturity indicators is important so that melons can be picked when they are at their best. Watermelons are not adapted to long storage. At low temperatures they are subject to various symptoms of chilling injury and loss of quality, and at high temperatures they are subject to decay. Between 10 and 15°C is a good compromise. They should be consumed within 2 to 3 weeks after harvest, primarily because of the gradual loss of crispness. Quality hybrids are able to keep longer. Watermelons should not be dropped, thrown, or walked on, as internal bruising and flesh breakdown will occur.

The value chain characterization in the County shows that, between 21- 40% of the population is engaged in the watermelon value chain. In the provision of seeds and other inputs stage, the types of actors in the value chain are the service providers at medium scale, and suppliers at small scale. The importance of women in the value chain is at low scale while all genders (Youth, Men and Women) importance is high. On farm production stage, the types of actors in the value chain are the service providers at medium scale and the farmers at medium scale. The importance of all genders in the value chain is high. At the harvesting, storage and processing stage, the types of actors in the value chain are mainly the processors at small scale. The importance of women in the value chain is low while all genders importance is also low. At the product marketing stage, the types of actors in the value chain are the service providers at medium scale, and wholesalers/retailers at large scale. The importance of women in the value chain is medium while all genders importance is high scale.

The watermelon subsector is relatively fragmented, particularly at the production and marketing levels. Most of the watermelon production is still destined for the local market; it passes through wholesale markets and then to direct consumers, petty traders, and retail stores. But this market is becoming saturated across the county during rainy seasons. Though production is countywide, large or commercial scale is seen near Wajir Town, where it occupies approximately 162 ha Small scale production is practiced in Habaswein, Buna, Korof, and Harar. In Bute and Buna, it occupies approximately 45 ha. The value chain encompasses the full range of activities and services that are necessary to bring a product from its conception to final consumption. It is made up of a series of actors—from input suppliers to producers and processors to exporters and buyers at small scale. Value chain services, in turn, are the supporting activities that are sector specific, such as agricultural extension, and cross-cutting, such as finance and transport. Input suppliers provide some services to producers, including extension services. In the water melon value chain, the farmers mainly engage in land preparation, purchase of seeds, planting, weeding, spraying, collection, harvesting, storing, transporting, value addition (processing and bulking), and marketing. Water melon fruits are normally distributed by a source of retailers to various consumers in a variety of places like food stores, vegetable shops, grocery stores, and on the roadside. The main market for water melon is Wajir Town, Garissa, Isiolo, Meru, and Nairobi.

In 2016, the production of water melons was 300 tons during the short rains and 288 tons during the long rains. The market price is KES27-30 per kg at farm gate and in major towns the price is KES35-40 per kg. During the year 2016, 588 MT of watermelon valued at KES 7,919,730 million were produced in both seasons. Adult males made decisions on water melon (100%) in both seasons. Only a few inputs were used during the two seasons, reflecting little cropping activity in the county. The level of input use in an annual water melon crop at farm level by gender was very low, at 1kg of fertilizer by household head (GoK, 2014). In conjunction with the Ministry of Agriculture, the marketing groups have made efforts to improve the market of water melon traded in Wajir. The County was given funds by USAID through Resilience and Economic Growth in Arid Lands for Improving Resilience in Kenya (REGAL-IR). The project, implemented by ADESO, is aimed at supporting women's groups in the communities.

Agricultural sector challenges

Livestock is the backbone of Wajir's economy; with 80% of the population depending on it for their day-to-day livelihood, both directly and indirectly. However, the sector faces several challenges. Drought caused by low and poorly distributed rainfall is the major cause of low agricultural production in the region. Other challenges include inadequate rainfall and flooding in some areas, a poor road network, rampant insecurity within the county especially due to clan-based and externally instigated conflicts, high illiteracy levels among farmers, poor access to market and timely market information, and a high dependency syndrome. Poverty affects the capacity of people to produce and make decisions on land use. The challenge of illiteracy limits an individual's ability to access information and technologies regarding land use.

These constraints impact negatively on the economy of the county, leading to reduced livestock and crop productivity, high livestock mortality, loss of income, famine, and malnutrition. Herd sizes among pastoral households are decreasing due to deaths of livestock during severe droughts. Severe droughts have contributed to a shortage of livestock forage and

water, leading to low milk production and the deaths of livestock. This has in turn contributed to food insecurity in the community, as reflected in their reliance on relief foods. The frequency with which droughts occur and the wider failure to support the productivity of the livestock industry in general make the populations increasingly vulnerable.

Farmers are not able to afford the optimum use of inputs, technology, agricultural information, financial services, and insurance. Increasing distances from water sources to grazing areas and endemic livestock diseases have continued to reduce livestock productivity. As a result, this has not only led to increased pressure on the natural resources, but also to increased poverty levels. The key constraints to input use were high prices, insufficient income to buy inputs, distance to input market and lack of access to inputs at the right time. These constraints negatively affect production. Poor infrastructure leads to inflated prices for food and other basic commodities and also undermine an effective supply chain for highly perishable livestock products such as milk and meat. The poor state of the roads, lack of modern abattoirs and livestock holding grounds is an indication of the little attention given to the sector Pressure has also been exerted on the region by the influx of pastoralists from the neighboring counties. The traders interviewed complained of insecurity in the county, especially when trekking or trucking livestock. Bandits take advantage of the poor state of the roads to attack trucks or people trekking animals to markets, escalating the insecurity problem.

The county has put in place regulations that restricts access to and movement of livestock. The aim is to decrease the likelihood of disease outbreaks such as Rift Valley Fever and Anthrax normally contracted from animals. In order to be granted permits for moving their livestock, households need to vaccinate them. Vaccination services are offered by the county government through the veterinary department under the Ministry of Agriculture, Livestock and Fisheries at subsidized rates. However, pastoralists move with their livestock, sometimes at night, making vaccination and regulation of livestock migrations difficult. Inadequacy of finances to enable the veterinary department to purchase the vaccines also reduces accessibility to the veterinary services.

Despite economic contributions, the livestock sector in Wajir faces many challenges. It is clear that the pastoral meat trade contributes formally and informally to the local economies, yet little effort is made to strengthen or support the sector. The county lacks agro-based industries, especially the milk processing plant and abattoirs, which add value to farm and livestock products and enable farmers and pastoralists to fetch good prices. There are no value addition plants such as milk processing plants for agricultural produce such as camel milk. In Kenya, this segment of the market is currently supplied by the only camel milk processing plant in the country - the Vital Camel Milk Limited (VCML) based in Nanyuki. Focused interventions in construction of a processing plant in the camel milk value chain and abattoirs could assist in unlocking the immense potential of the sub-sector.
Lack of capacity to undertake value addition, and the lack of storage facilities, has forced households to sell their raw products to middlemen at very low prices. Agricultural production has, however, varied over the years due to the erratic and unreliable rainfall. The increasing temperatures and low rainfall coupled with poor soil fertility impact negatively on productivity of the various crops. The crops become more vulnerable to pest and disease attacks, causing micro-organisms that lead to reduced crop yield, poor quality produce and sometimes contributing to total crop failure. Moreover, several interventions geared towards improving agricultural productivity such as construction of water pans, dams, and proper land use management have been affected by insufficient funding.

Agricultural production in the county is also challenged by competing demands for and conflict over natural resources. Cases of livestock invading croplands, especially during dry spells, are very common. As a result, crops are destroyed and sometimes human and livestock life is lost. In addition, the current land tenure regime does not stimulate long-term investments and conservation measures such as agro forestry. This is due to non-excludability (impossible to restrict utilization to a certain group of people only) and free riding, which occurs when some members abscond from participating in conservation but still benefit from the efforts of other people. The cultural social norms and beliefs also hinder agricultural development. This is exacerbated by the low literacy levels in the county. Culturally, farmers with many livestock are considered wealthy and command respect in the community. The common practice of keeping large herds and the reluctance to sell livestock decreases the herd's overall productivity and exposes pastoralists to the risk of losing the livestock during dry spells. The negative perceptions about financial institutions such as banks also limit access to credit and reduce acceptance of initiatives such as livestock insurance and other new technologies. Negative perceptions arise from the belief that these institutions are there to exploit farmers rather than help them. Some of the key specific interventions that appear to be of high priority is farmer awareness and education through information dissemination and market-based awareness campaigns.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Wajir County is located in a semi-arid area with relatively hot dry climate throughout most of the year. Mean annual temperatures are above 25°C across the majority of the county with only a small pocket in the northern corner having mean annual temperature below 25°C. Annual average rainfall in the county is predominantly between250mm and 500mm per year, with a small strip in the south-east having rainfall average between 500mm and 700mm, and a large pocket in the west having annual average rainfall below 250mm. Rainfall in the county is erratic making Wajir generally unfavorable for rain-fed agriculture. Being one of the driest counties in Kenya, dry spells, prolonged drought, heat stress, shift in seasons, moisture stress and occasional floods are hazards that strongly contribute to agricultural risk in the county.

Analysis of temperature trends in the county over 25 years (1981 to 2005), indicate a moderate increase in temperature of 0.5°C in the first season and 0.2°C in the second season. Analysis of rainfall over a 35-year period (1981-2015) showed that average first season rainfall had reduced by approximately 50mm, although average second season rainfall had increased slightly. These changes have resulted in a moderate increase in the number of heat stress days in the first season and a low increase in the number of heat stress days in the second season. Throughout the years, droughts have become more common with studies indicating a higher frequency and intensity of droughts in recent years (Wanjuhi, 2016). Looking at the trends in the different seasons, the first season has had a marked increase in extreme weather events (both droughts and floods) although the second season has experienced no change in the occurrence of extremes. The longest drought period is considered to have occurred between 1999 and 2001 and 2004 and 2008 for the MAM season and 1971-1976, 1983-1988, 1998-2001, 2004-2007 for the OND season. The highest damage to rain-fed agriculture and pastures was borne in these years (Wanjuhi, 2016).

Climate projections for the period 2021-2065 based on two representative concentration pathways (RCPs[16]) indicate that under both scenarios there is expected to be a moderate increase in mean annual temperatures. As a result, the number of heat stress days[17] rises from approximately 63 days in the first half of the year to over 80 days in both scenarios while in the second half of the year they rise from approximately 18 days per year to approximately 38 days in the low emissions scenario and over 40 days in the high emissions scenario. Under both scenarios the start of the first growing season is expected not to change significantly, with the start of the second season expected to shift backwards moderately.

The most significant impact of these changes being a high reduction in the length of the first season under the high emissions scenario. The number of moisture stress days[18] in the first half of the year is projected to increase by approximately 50% under both scenarios; however the number of moisture stress days in the second half of the year is expected to reduce slightly although variability about the mean is projected to increase. Despite the future climate change projections under the two GHG emissions scenarios showing some differences, both indicate the likelihood of significant changes in the weather and climate particularly increased heat stress and prolonged moisture stress.

Climate Perceptions by the farmers

Farmers' climate change perceptions are likely based on an observed decline in water availability due to temperature increases as well as other environmental and social drivers such as an increase in population density and environmental degradation. Perceptions may also be influenced by more recent climate trends such as the prolonged and severe drought spells and rising temperatures in recent years. From the farmers' perspective there has been a remarkable variation in the climatic conditions in Wajir County over the years. The most common changes cited include warmer temperatures, erratic rainfall, water scarcity, and prolonged drought periods that occur after every two years. In terms of perceptions of long-term change in climate, an overwhelming majority of farmers perceived an increase in average temperatures and a decrease in average precipitation over the last 5 years. There is already evidence of problems in the decrease in water table, erosion, decrease in crop yields, proliferation of vectors which cause disease and reduction in forest coverage as a result of deforestation and overgrazing. They reported that the weather has become more

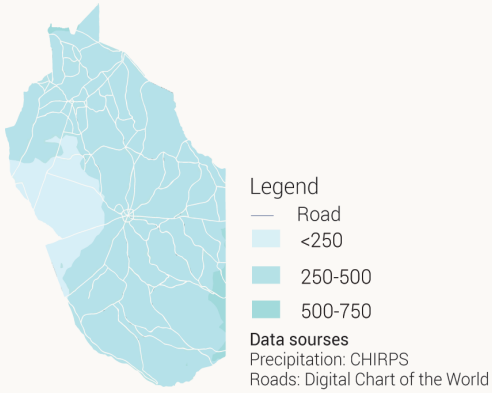
16 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible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

17 Total number of days with maximum temperature ≥ 35°C

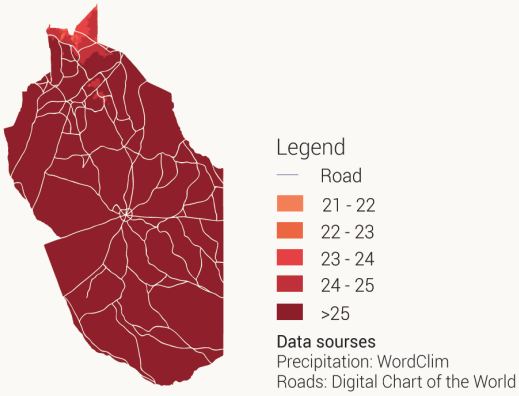
18 Number of days with ratio of actual to potential evapotranspiration ratio below 0.5

Past and future impacts of climate hazards in Wajir

Historical annual mean precipitation (mm/year)

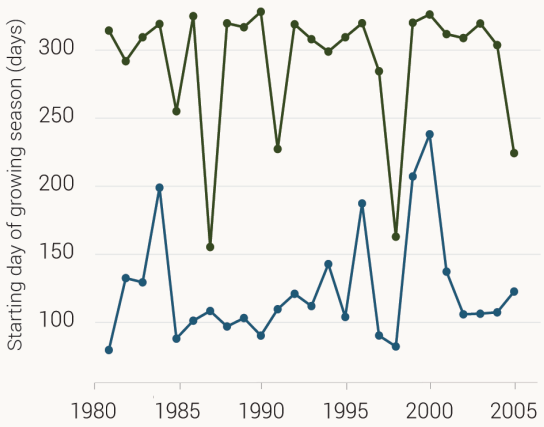


Historical annual mean temperature (°C)

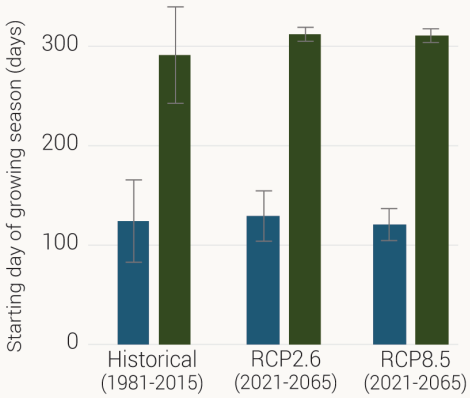


Uncertainity in the start of growing season hazards

Historical uncertainity in the start of growing season stress events

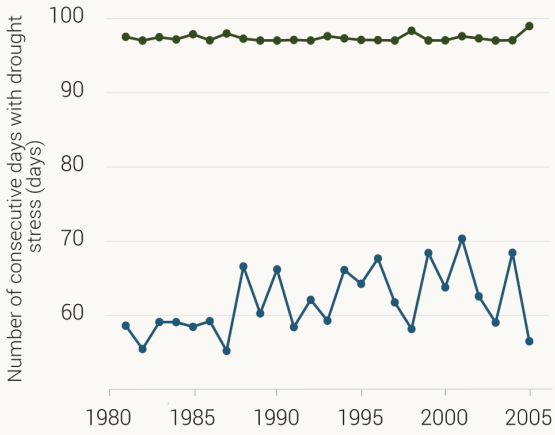


Historical and expected uncertainity in the start of growing season stress events

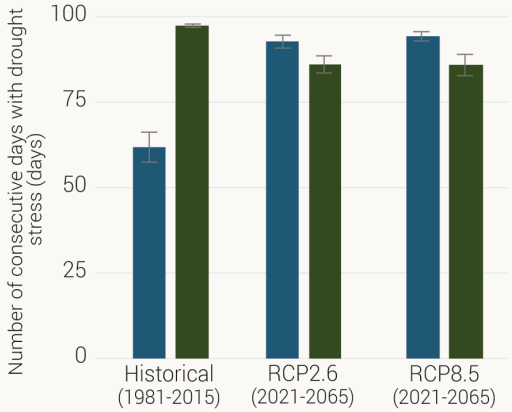


Moisture stress hazards

Historical extreme moisture stress events



Historical and expected extreme moisture stress events



January - June July - December

unpredictable than in the past, mostly as a consequence of human activities and land degradation.

Moreover, farmers reported a long-term decrease in rainfall variability, across all AEZs apart from the higher areas of Bute and Gurar that receive higher rainfall of between 500mm and 700mm. Major climate change and variability hazards noted by farmers include prolonged drought periods where the water sources (e.g. shallow wells, boreholes, water pans) become totally depleted and high temperatures generate heat stress that destroys crops and pastures. The heat stress suffered by animals also reduces the rate of animal feed intake and results in poor growth performance and low production of milk and meat. Frequent crop failures as a result of droughts or high temperatures increase people's susceptibility to food insecurity and poverty. Due to high evaporation rates as a result of high temperatures, there is need for supplemental irrigation for food crops, which is low in the county.

Farmers reported that the rains have not only decreased but have also changed patterns. For instance, they said that the Long Rains, normally expected in October to December have been replaced in recent years by dry spells. Migration of livestock towards the neighboring counties and country of Ethiopia is common, and often results in increased risk of resource use conflicts and loss of assets. High temperatures are reported to have brought about increased incidences of pests and diseases in livestock. An increase in insect-related diseases as well as the appearance of new insects and occurrence of new diseases was commonly blamed on these climatic changes. In addition, women travel long distances in search of water due to water depletion in reservoirs, whereas men spend more time migrating with livestock in search of pasture and water.

Due to low, unsustainable incomes from agriculture, women engage in other income-generating activities such as charcoal burning, whereas men and youth migrate to urban centers in search of employment. These changes have resulted in family disintegration and higher school dropout rates among the youth and children. Increased and uncontrolled charcoal burning has led to deforestation and environmental degradation, worsening the impacts of climate variability. The effect of climate change has seen an increasing number of families lose their entire herds to droughts, forcing them to settle for relief food. These are expected to impact negatively on the economy of the county, leading to reduced livestock and crop productivity, high livestock mortality, loss of income for community members, famine, and malnutrition.

Climate vulnerabilities across agriculture value chain commodities

Expected future climate change and variation pose serious threats to the value chain commodities prioritised for analysis in this study. Hazards include drought, increased temperatures, moisture stress, and uncertainty in seasons (onset and duration). Drought and high temperatures were identified as the most problematic hazards, both currently and in the future. These hazards affect the prioritised value chain commodities differently.

Camel (milk)

The major climate hazards affecting camel milk include more days with moisture stress and uncertainty in seasons as a result of climatic weather condition. Due to prolonged droughts, there are more days with moisture stress and late start of seasons experienced county-wide. Moisture stress and late start of seasons caused by low and poorly distributed rainfall is the major cause of low camel milk production in the county. More days with moisture stress and late start of seasons lead to reduced pasture for the animals, hence milk production is reduced as the body condition of the animals deteriorate sand increase in livestock diseases such as Rift Valley Fever, and pests, including ticks leading to animal deaths. Milk is more sensitive to high temperatures both at production and value addition (transportation) levels. As a result, milk output is affected, and most milk is often spoilt before reaching the market as refrigeration facilities are not available to households and value addition are limited. Consumers also receive less milk when production decreases as a result of prolonged drought spells. Low milk production affects the food security of households, and especially pastoralists. Transporters are also affected by the decreased demand for transportation.

Chicken (local)

A number of challenges are associated with both hazards; during high increases in the length of drought spells and high temperatures, local chicken production is affected. The mostly affected areas in the county by both hazards are the southern, the central, and part of the north but increases in drought spells are mainly felt in the northern part of the county. The state of value addition as the value chain operates is quite minimal due to input supply arrangements, production, brokerage, trading, and the entire market structure developments.

The notable consequences of the drought and high temperatures are increase in poultry feed prices and drugs as a result of feed scarcity and farmers cannot afford to buy them, reduced extension service (farmers migrate to different places in search of pasture and water hence extension officers cannot locate them, reduced egg collection due to high temperature, reduced shelf life due to reduced quality of eggs, less products for linkage (less birds and egg production), low volumes in the market- (low turnout of buyers and traders), high prices (low of supply and demand), high perishability to eggs, lack of water for cleaning, and increased incidences of pests and disease causing organisms. Women and youth remain highly vulnerable to climate impacts on poultry production, since they have limited resources to buy the feeds and lack of access to vaccines.

Sorghum

Both moisture stress and late start of seasons impose a number of challenges on the sorghum value chain. Sorghum is mostly affected by moisture stress county-wide, while uncertainty of seasons is most felt in the central and northern parts of the county.

The consequences are low production and poor quality of the product that result in food insecurity at household level. Other challenges associated with moisture stress and late start of seasons include; unavailability of and increased expenditure on production inputs (seeds, fertilisers), poor germination, crop failure, high commodity prices due to low supplies and high demand, and in-flow from other counties, reduced access to extension services, high transportation cost and reduced mobility due to heat stress, increased crop infestation from the incidence of pests, lack of good storage facilities, capacity to add value, reduced market linkage, and hampered marketing. Moreover, heat stress affects land preparation activities since few households will get involved in the farming activities, thus reducing land acreage for planting. Women and youth are generally the group most affected by these consequences on green gram, since they are the main growers.

Watermelon

Both moisture stress and late start of seasons affect the areas where sorghum is grown, which is mainly the central and the northern parts of the county. Challenges that are associated with moisture stress and late start of seasons include: delayed land preparation, poor germination, crop failure, unavailability of and increased expenditure on production inputs (seeds, fertilisers, pesticides), reduced access to extension services, inadequate supply to external markets, high transportation cost and reduced mobility due to heat stress, increased crop infestation from the incidence of pests, reduced produce for storage, loss of job, losses due to inadequate value addition for watermelons and high market prices. Moreover, heat stress affects land preparation activities since few farmers will get involved in the farming activities hence reducing land acreage for planting. Poor market linkages in the county and lack of information are some of the factors impairing access to these markets. Men and youth are generally the group most affected by these consequences on water melon, since they are the main growers.

Adaptation to climate change and variability

Some of the adaptation strategies Wajir households are using to cope with these constraints to agricultural production and food security are specific to certain value chains whereas others cut across value chains. For crop farmers, these include use of improved drought-resilient crop varieties, and inputs such as fertilisers and pesticides, the introduction of water harvesting through roof catchment and collection of run offs, irrigation using shallow wells, soil and water conservation. Afforestation and increase in forest cover also enhances proper environmental management. For livestock farmers these include fodder conservation, rearing improved breeds, vaccination of livestock before migration, and livestock change. To manage and lessen the impacts of climate change and its extreme weather events, there is need to implement mitigation measures and adaptation strategies that are resilient to extreme climatic events. Training on crop species and livestock breed suitability can be emphasized in technology adoption in the county.

Results from ASDSP survey of 2013 showed that only 20% of the households had made use of any adaptation strategies—either learned or indigenous. Only 12.8%of the households employed water harvesting with all female-headed households adopting that strategy and 35.7% of youth-headed households doing so but none of the male-headed households adopted the strategy. Other adaptation strategies used included soil and water conservation, changing livestock types, tree planting, irrigation and building food storage structures. None of the households had a member who had been trained in any of these strategies. Male-headed households are more likely to apply climate change adaption strategies on their farms. This is due not only to their higher decision making power on household resource utilisation. Women are more likely to adopt strategies aimed at diversifying production,

and post-harvest value-added activities such as food storage facilities and tree planting.

On-farm adaptation practices

On-farm adaptation options that can survive drought and high temperatures are particularly important given the local context in Wajir County, which falls into two agro-climatic zones, semi-arid-zones (Zone V and VI). The population is dependent on four main sources of livelihood, which are classified into five livelihood zones comprising: Agro-pastoral (23.4%), Pastoral all species (18.7), Pastoral Cattle (24%), Pastoral Camel (16.8%) and Informal Employment Business (17.1%) respectively (GoK, 2013).

According to ASDSP survey of 2013, less than 20% of all households adapted to the perceived climate change, regardless of gender, age, or agricultural designation (pastoral, and agro-pastoral). The main on-farm adaptation strategies used in Wajir were irrigation (1.8%), integrated soil water conservation (4.6%), water harvesting (12.8%), and food storage (0.9%). In livestock production, changing livestock type (3.7%) and feed conservation (0.9%) were considered important. None of the households had a member who had been trained in any of these strategies. Women-headed households adopted highest strategies for adaptation to climate change in water harvesting (100%), livestock change (25%) and tree planting (25%) (GoK, 2014).

For both livestock and crop producers, water harvesting is the most widely used means of facing climate change and shock. The strategy involves construction of water pans, shallow wells, de-silting of the existing dams, and water tanks. Water harvesting typically requires investments on input materials and labor, which can be prohibitively costly. Capacity building of water user's associations and the water management committees is also undertaken. Farmers use improved irrigation technologies such as pumps, canals, and water tanks to protect themselves against drought and heat stress. Some challenges to adoption of water harvesting techniques include water scarcity and high poverty levels among the population, who do not have the means to invest in such a capital-intensive practice. Crop farmers also opt for change in the crop types and varieties they cultivate as a response to increased extreme events. A good example is the farmers who, due to water scarcity, have adopted early-maturing and drought-resistant crops such as sorghum and green gram. The youth-headed households are more likely to adopt the strategy compared to male- and female-headed households, given their increased interest in new technologies. A major impediment to using this strategy is poor access to improved seeds, given high prices, but also low productivity of the new crop types and varieties.

Adaptation strategies within the livestock sub-sector vary depending on climatic hazard. For drought and high temperatures, the farmers consider water conservation through water pans, drilling boreholes and shallow wells, or rearing more resilient animals such as camels and local poultry that can survive longer without water. Pastoralists sometimes move animals towards riverine areas or other counties so that they have better access to water and pastures. The major challenge with this strategy is that most pastoralists sell the livestock when they are already in poor body condition due to lack of feed and water. This means that the livestock fetch lower prices and are more likely to die if they don't find a buyer. Farmers also receive alerts from relevant departments like NDMA and sell animals ahead of the critical time of the drought hazard to avoid massive losses occasioned by the hazards. Projects currently being undertaken are funded by Ministry of Water and Irrigation, Ministry of Northern Kenya and other arid lands, Ministry of Regional Development through Ewaso Nyiro North Development Authority and NGO's in the county (GoK, 2014).

Mass vaccination of livestock is another important adaptation strategy for the livestock sector. It is common in the entire county in view of the many livestock disease outbreaks particularly during the dry season; the situation is worsened by migration of livestock from neighboring counties. This measure helps reduce the likelihood of livestock contracting diseases as they migrate. In spite of the adaptive measures, there is need to strengthen disease surveillance in the county as well as establish disease-free zones. This needs to be accompanied with regulation of livestock movement from the neighboring counties. Rehabilitation of grasslands through reseeding, production of pastures under irrigation and fodder conservation are the on-going adaptation strategies to the problem of feed shortage common during the dry season. Fodder conservation was found to be common in male-headed households according to the ASDSP survey of 2013.

Soil and water conservation is an important adaptation strategy in the county. This involves preserving soil conditions, maintaining water content with mulching, tree planting and agro forestry, and using manure. High adoption of soil and water conservation measures among the female headed households may be attributed to the fact that women are the ones who are responsible for water harvesting, and more involved in crop farming compared to men who are more likely to move to other areas with livestock in search of water.

Currently, very little conservation agriculture is being practiced in the county. Value addition was also found to be a common adaptation strategy carried out by crop farmers and pastoralists in all AEZs. It helps increase the shelf life of agricultural products while enabling an increase in farmers´ bargaining power especially through activities such as bulking. Value addition also makes farmers get better prices compared to selling raw products. Value addition for crop production (and mostly in the sorghum value chains) refers to sorting, grading, transporting, bulking and processing. These are mostly farmer group initiatives. The biggest challenge to value addition in the livestock and crop sector is lack of capacity in terms of knowhow, equipment, and resources. The challenge of poor access to markets has not been addressed satisfactorily by the on-going adaptation strategies such as selling individually, value addition (given that it is minimal) and premature harvesting. These strategies can be complemented with options such as collective selling, training farmers and providing the required resources for value addition, and engaging farmers in contract farming. Encouraging farmers to organize themselves into groups can also help in reducing the cost incurred in transportation.

Off-farm adaptation practices

Off-farm services such as early warning systems, extension and training, credit, storage facilities, and market information are offered to farmers in Wajir County to increase their climate adaptive capacity. Extension involves field visits, focus group discussions, and workshops on aspects related to the entire value chain. These include: crop planting and growing times, input utilization and value addition, and amount of product to sell on the market. Extension training includes fodder conservation, post-harvest handling, proper storage, beekeeping and marketing. In the livestock sector, farmers have been trained on the importance of destocking and feed storage, which helps increase production. Nevertheless, it was reported that the number of farm visits by agricultural officers has been significantly reduced in the past years due to low budgetary allocation and poor road network in the county.

Early warning information enable farmers to know when and where to plant, and when to move with the livestock, based on information on occurrence of drought and floods. Access to this information reaches farmers by means of radios, workshops, and trainings organized by the above-mentioned organizations. A challenge to the early warning information is that most of the time farmers neglect the information and limits the number of farmers who may be reached owing to the high illiteracy levels.

Despite existence of financial institutions such as banks in the county, access to financial credit (loans and insurance) is very low according to the ASDSP survey of 2013. The situation persists since most of the financial institutions shy away from the ASALs given the high production risks. Lack of awareness about credit services (from the side of the farmers and pastoralists alike) is also a contributing factor. As an alternative option, farmers have been seeking off-farm employment opportunities such as sand harvesting, Gums and Resins harvesting, business or move to urban centers in search of jobs to mitigate the climate variability risks.

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

Camel (milk)

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Changes in rainy seasons (onset and duration)	Browse and pasture scarcity. Reduced quantity and quality of pasture. Difficulty in accessing extension and veterinary services due to the need to move long distances for pasture, feed and fodder. Higher electricity costs for cold storage of vaccinations	Reduced milk production. More time spent on tracking animals which have moved in search of fodder. Difficulty in managing livestock health	Reduced milk quantity and quality. Difficulty in collecting milk for bulking. High cost and time for transportation of milk. Greater chances of milk spoilage	Reduced availability of market and supply information. Lower income for farmers. Reduced volumes for value addition. Reduced market access
Magnitude of impact	Major	Major	Severe	Major
Farmers' current strategies to cope with the risks	Border point disease monitoring by farmers. Farmer-to-farmer sharing of information on browse and pasture availability	General livestock health management – deworming and hoof trimming)	Awareness raising on milk hygiene	Group sales and marketing. Using motorbikes to transport milk
Other potential options to increase farmers' adaptive capacity	Recruitment of more extension staff. Training of community paravets. Out scaling of formal disease surveillance mechanisms. Finalising and local level application of national Livestock Policy	Training on improved herd health management	Farmer training on milk hygiene & processing (attachment of trainers to producers' groups). Introduction of improved milk handling and storage equipment. Introduce solar cold storage equipment. Establish decentralised processing plants	Establish designated milk selling stalls at agricultural marketing centres. Introduce large vehicles with cold storage systems for milk transportation
Drought/ Moisture stress	Feed and browse scarcity. More resources required for stock control, veterinary health and feed. Increased cost of veterinary inputs (vaccines and drugs) – although greater income for inputs suppliers	Reduced production. More time spent tracking animals which have moved in search of fodder and browse. Difficulty in managing livestock health	Difficulty in collecting milk for bulking. Low volumes for bulking. High cost of transportation – motorbikes have to travel further into interior to look for milk. Cold storage costs increase	Irregular supply to markets. Less volumes for sale. Higher transport costs. Lower profits for producers and traders
Magnitude of impact	Major	Major	Major	Severe
Farmers' current strategies to cope with the risks	Movement of animals from place to place in search of browse, pasture and water. Sharing of early warning information from farmer to farmer	Vaccination of animals by government	Consumption of milk at household level. Farmer groups for milk collection and sales	Individual sales at local market or to middlemen. Use of passenger vehicles for transport to market
Other potential options to increase farmers' adaptive capacity	Improvement of drought and pasture/ browse monitoring and information sharing systems. Establishment of subsidy for inputs during droughts	Regular disease surveillance. Regular animal condition assessments. Training on managing heat stress in camels. Improve linkages between extension agents and farmers even in hard to reach camel migration areas. Training farmers on diagnosis and treatment of camel disease	Capacity building on milk handling and distribution of modern milk handling equipment. Construction of milk collection facilities and incubation centres along strategic livestock routes (including far to reach camel migration areas). Capacity building on camel milk value addition	Introduce refrigerated milk transport vehicles. Improve market information systems. Improve information system related to camel movement and livestock routes. Establish designated milk sales stalls at agricultural markets (including in far to reach areas)

Chicken (local)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Increasing temperatures	Poor health of chicks and increased mortality. Reduced movement of extension service providers due to heat. Higher vaccine storage costs (increased electricity for cold storage of vaccines)	Low hatching rates, high mortality rates and slow growth – overall lower production due to heat stress. Increased pests and diseases. Reduced feed consumption resulting in slower growth	High costs associated with cold storage requirements. Increase in perishability of meat and eggs. Low quality and smaller chickens and eggs harvested	Low prices due to quality (size and weight) of eggs and chickens. Difficult for transporters to transport meat and milk in hot conditions
Magnitude of impact	Major	Major	Moderate	Minor
Farmers' current strategies to cope with the risks	Farmer-to-farmer sharing of information on changes in weather and climate. Farmer-to-farmer information sharing on health management	Participatory scenario Planning (PSP) for various climate and weather scenarios. Training of disease community reporters (DCR). Improved (ventilated chicken housing). Feed supplementation (household waste)	Home consumption of small eggs. Local slaughter slab establishment	Sales to middle men. Sharing of market information from farmer-to-farmer
Other potential options to increase farmers' adaptive capacity	Funding of radio programmes to share information on weather variability and climate change. Purchase of refrigerated vaccine storage equipment. Expansion of access to electricity for vaccine storage. Development of small-scale feed production facilities	Construction of improved (temperature regulating) enclosures	Establishment of modern chicken and egg collection, storage, processing and grading facilities. Provision of packaging and labelling material and equipment for poultry and eggs	Development of cooperatives for collective marketing. Development of chicken and egg business plans for cooperatives and individuals. Improved road networks for easier market access
Droughts	High chick disease prevalence. High mortality rate of chicks. Diversion of extension services to emergency drought mitigation measures. Feed shortages and increase in prices of inputs	Increased incidence and susceptibility to pests and diseases. Low hatching rates, high mortality rates and slow growth – overall lower productivity due to drought stress	Reduced quantity of chicken and eggs harvested. Reduced processing due to limited availability of funds during droughts. Quality of slaughtered birds and eggs is lower	Reduced household income from chicken and egg sales. Reduced sales and shortages on local markets. Reduced prices of chickens
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Use of local ingredients to supplement feed. Sharing of drought early warning information from farmer-to-farmer	Participatory scenario Planning (PSP) for various climate and weather scenarios. Training of disease community reporters (DCR). On-farm water harvesting	Prompt slaughter sales of chickens using local / household slaughter slabs	Local household consumption
Other potential options to increase farmers' adaptive capacity	Training of farmers and extension services on chicken and egg production during drought. Local refrigerated storage of adequate medication and vaccinations for chickens. Improved feed production, storage and conservation methods and facilities	Use of recommended disease management (vaccination, deworming) schedule. Enhancing on-farm water harvesting and storage facilities	Capacity building of farmers on poultry value addition. Establishment of local poultry and egg processing plants. Construction of modern abattoirs and cold storage facilities	Capacity building on marketing and sales. Improve road networks for better market access. Government supported chicken sales during drought

Sorghum

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Changes in seasons (onset and duration)	Unpredictable supply and availability of seed, fertiliser and other inputs due to uncertainty in season start. Delayed extension advice. Farmers delay to buy inputs – affects the incomes of agro-dealers	High costs of land preparation – sometimes have to plough twice. Emergence of weeds results in additional weeding costs. Reduced harvests. Uncertainty in planning farm operations	Unpredictability in timing of harvest period. Reduced and inconsistent business and income for transporters and processors	Higher on-farm consumption and reduced sales in markets. Higher prices due to inconsistent supply
Magnitude of impact	Moderate	Major	Major	Major
Farmers' current strategies to cope with the risks	Variety selection	Intercropping, staggered planting. Early weeding. Use of indigenous knowledge to inform seasonal activities	Use of on farm storage facilities. Local processing (store grinding)	Sales to middle men. Individual sales. Local consumption
Other potential options to increase farmers' adaptive capacity	Capacity building on seed conservation and bulking. Capacity building on appropriate seed selection (short season and early maturing varieties)	Scaling up conservation agriculture. Training on mulching for weed suppression. Water harvesting and small scale irrigation. Capacity building on integrated pest and disease management. Improve access to advice on planting dates	Improved extension capacity on pre- and post-harvest management. Capacity building on value addition, processing and packaging. Improve access to extension advice (harvesting times)	Collective marketing through cooperatives. Enforce harmonized producer pricing mechanism
Drought/ Moisture stress	Lack of availability of seeds. Reduced purchase of pesticides and other farm inputs. Lower income for agro dealers	Extra labor (and costs) in land preparation and weeding. Low germination rate and poor stand establishment. Wilting of crops	Low yields. Poor quality produce. Little processing	Most produce consumed on-farm hence low sales to markets. Shortages on local markets. Higher prices due to high demand. Market opportunities underexploited
Magnitude of impact	Moderate	Major	Major	Major
Farmers' current strategies to cope with the risks	Variety selection	Use of indigenous knowledge to inform planting. In-field contours and ridges for moisture conservation	Early harvesting. Household consumption with minimal value addition. Use of traditional on-farm storage structures	Use as animal feed. Household consumption with minimal sales at local markets. Sharing market information from farmer-to-farmer
Other potential options to increase farmers' adaptive capacity	Capacity building on appropriate seed selection (short season and early maturing varieties). Improved agrometeorological information and drought early warning	Scaling up of conservation agriculture techniques – mulching, cover crops, intercropping. Capacity building on integrated pest and disease management. Construction of water harvesting structures. Improved advice on herbicide application	Construction of high quality storage facilities by government. Use of modern pre- and post-harvest equipment and facilities to reduce losses. Train farmers on modern storage structures. Train farmers on value addition (processing and packaging)	Support access to external markets. Improve market information access

Water melon

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Changes in seasons (onset and duration)	Limited seed availability. Farmers delay buying seeds and may divert funds previously reserved for water melon seed to other uses	Delayed land preparation. Untimely planting leading to reduced yield. Uncertainty in pesticide application – sometimes resulting in increased chemical residues in harvested crop	Reduced quantity and quality of crop. Reduced storage and processing	Irregular/ inadequate supply to markets. Low prices for low volumes and lower quality produce. Difficulty in securing constant market
Magnitude of impact	Major	Major	Major	Moderate
Farmers' current strategies to cope with the risks	Sharing weather and input information from farmer to farmer. Variety selection (drought tolerant – crimson sweet, sugar bay)	Use of shallow wells and generators for irrigation. Use of organic pest control methods. Late planting with onset of rains	Storage under trees for shade. Use of metal storage sheds to protect from heat	Individual sales at local market, roadsides or to vendors and processors. Sales based on size
Other potential options to increase farmers' adaptive capacity	Training of farmers on use of drought tolerant, early maturing hybrid varieties (Sukari F1, Asali F1)	Promotion of solar powered irrigation. Scaling up farmers' field schools for shared learning. Capacity building on IPM (neem and garlic seeds). Capacity building on early planting	Construction of storage facilities (cool warehouses) or shade facilities. Capacity building on value addition	Organise group marketing though cooperatives. Capacity building on sales by weight
Drought/ Moisture stress	Limited seed availability. Greater cost of seeds	Pesticide scorching by the sun during dry periods – results in higher chemical residue on the crop. Low germination rates. Increased presence of pests and diseases	Severely reduced harvest. Reduced income for transporters and processors	Reduced sales to markets. Higher prices at the market due to limited supply
Magnitude of impact	Major	Severe	Major	Major
Farmers' current strategies to cope with the risks	Sharing weather and input information from farmer to farmer. Variety selection (drought tolerant – crimson sweet, sugar bay)	Uninformed/ blanket use of pesticides and other chemicals. Manual land tilling (jembe, hoe). Infield water conservation (ridges and furrows)	Storage under trees for shade. Use of metal storage sheds to protect from heat	Individual sales at local market, roadsides or to vendors and processors. Sales based on size
Other potential options to increase farmers' adaptive capacity	Training of farmers on use of drought tolerant, early maturing hybrid varieties (Sukari F1, Asali F1). Seed buying through cooperatives (pooled resources)	Construction of water harvesting structures. Development of efficient irrigation infrastructure. Use of conservation agriculture (mulching, minimum tillage). Promotion of agroforestry for shade. Capacity building on appropriate spacing to reduce competition for water	Construction of storage facilities (cool warehouses) or shade facilities. Capacity building on value addition	Organise group marketing though cooperatives. Capacity building on sales by weight. Expand market information access (external and local market information). Use of technology for marketing (cell phones, internet)

Policies and Programmes

Policy documents are yet to be mainstreamed at the county level. Currently Wajir County is using National policies that include: Agricultural Sector Development strategy 2010-2020, National Food & Nutrition Security Policy, Crops Act 2013, Land Act 2012, Agriculture, Fisheries and Food Authority Act 2013, and National livestock policy 2008[19]. However, not all of these policies and strategies have been aligned with the 2010 Constitution of Kenya, which provides for devolved structures of governance.

- The National Agricultural policy focuses on; Increasing agricultural productivity and incomes, especially for small-holder farmers;
- Emphasis on irrigation to reduce over-reliance on rain-fed agriculture in the face of limited high potential agricultural land;
- Encouraging diversification into non-traditional agricultural commodities and value addition to reduce vulnerability;
- Enhancing food security and a reduction in the number of those suffering from hunger and hence the achievement of Millennium Development Goals (MDGs);
- Encouraging private-sector-led development of the sector; and
- Ensuring environmental sustainability.

The County Government of Wajir has put in place various initiatives in support of Climate Change Adaptation. One key initiative is the enactment of the County Climate Change Fund Act 2016, which will support climate resilience and adaptation projects in the communities. These initiatives stand to benefit greatly from Climate Information Services (CIS). Climate information is an important factor in decision making and needs to be communicated efficiently and effectively. A communication strategy for sharing Climate information and knowledge in the County has been developed. The County CIS will play a crucial role in the county development planning, for managing development opportunities and risks and for mitigation and adaptation. CIS can also support society to build resilience to future climate change and take advantage of opportunities provided by favorable climate conditions.

Effective CIS require established technical capacities and active communication and exchange between information producers, translators, and user communities. This initiative outlines a proposed framework for Wajir County Climate Information Services Plan (WCCISP) which aims to develop and deliver weather and climate information which can support local, sub-county and county-level decision making at time frames of hours, days, weeks, months, seasons and years in line with the County, national and international development frameworks including the County Integrated Development Plan (CIDP), Constitution of Kenya 2010, Kenya Vision 2030 and the National Climate Change Response Strategy (NCCRS) as well as the Global Framework for Climate Services (GFCS). This initiative once implemented will go a long way towards realizing the Kenya Vision 2030 in Wajir County and supporting the development of a community which is resilient to the adverse impacts of climate change, as envisioned in the National Climate Change Action Plan (NCCAP), (GoK, 2017).

The ASDP considers the implementation of NCCRS as important in addressing climate change. NCCRS has been operationalized through the development of the NCCAP which provides a framework for dealing with climate change and climate variability. NCCRS highlights various measures for adaptation and mitigation to the impacts of climate change on agriculture (GoK 2010b).These include use of a range of innovative technologies such as irrigation; early maturing and high yielding crop varieties as well as drought and pest resistant crop varieties and disease-resistant livestock. The NCCRS also advocates diversification of livelihoods; adaptation of agricultural technologies from analogue environments; and enhancing early warning systems with drought monitoring and seasonal forecasts with respect to food security.

The Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) seeks to promote development of capacity in managing climate-related risks through long term adaptation strategies. For the major value chain commodities, the programme supports production, farmer organization, value addition, and enhanced marketing. Farmers organize themselves into groups for production and marketing benefits. The ASDSP was initiated in 2012 and implemented by the government across Kenya, with the view to transform the agriculture sector through commercialization. For the major value chain commodities, the programme supports farmer organization into groups for production and marketing benefits, improved agricultural production, value addition, and access to markets, through capacity building programmes[20] (GoK, 2014).

The programme has been targeting increasing agricultural production and productivity in rural households through capacity building. The programme has also promoted Participatory Scenario Planning, where beneficiaries of a

19 http://www.wajir.go.ke/data/departments/departments_details/36.htm?dept_id=36&Ppage=Agriculture,%20Livestock %20&%20Fisheries

20 Through ASDSP, farmers are also able to access trainings on crop selection, the use of improved seeds and early-maturing varieties, among others.

certain intervention are given the chance to identify the most pertinent interventions as well as the most effective implementation strategies. Access to extension services which include knowledge sharing and transfer on crop selection, use of improved seeds and early maturing varieties has been promoted through development of linkages between farmers and relevant stakeholders in the agricultural sector such as research organizations and input dealers. In addition to the policies, a number of agencies such as the NDMA and Programmes such as the ASDSP operate/run in the county to operationalize the policies. Regulatory and institutional reforms are focused on climate change, sustainable land practices and natural resource management.

Appropriate policies will lead to more sustainable and equitable management of natural resources and systems to enforce their use. There are major bottlenecks regarding the enforcement of the above-mentioned policies, programmes. Some of the challenges are due to lack of awareness about the policies, programmes and norms, and to the vastness of the county, which requires a bigger task force to implement and enforce the policies. Despite the county government dispensation, most counties, Wajir County included, still run on policies that were designed at national level. Cultural inclinations such as the strong attachment to livestock for the pastoralists, non-sedentary lives, and low literacy levels pose major hindrances to effective enforcement of some of the policies. In addition, frequent monitoring and evaluation of the programmes and interventions become a challenge given the vastness of the region, a factor that is likely to reduce success rates of interventions.

A review of existing legislation is essential for the creation of an enabling environment for climate resilience, which reflects current challenges and opportunities identified at local level. Dissemination of policy issues to the community gives community members an opportunity to understand what is required of them. The potential benefits from enhancing the quality and use of meteorological, climate information and products in decision-making are enormous, but realizing these benefits will require improvement in infrastructure, human resources development, and engagement between the providers and users to improve the process for decision-making and realization of social and economic benefits.

Governance, institutional resources, and capacity

There are various governmental, non-governmental (NGOs), community-based, faith-based and private organizations in the county that directly or indirectly deal with climate risks. County-level government institutions include local offices of the Livestock and Fisheries Ministry, the Ministry of Lands, Agriculture and Irrigation, the KMD, the Kenya Forestry Service (KFS), the Ministry of Water and Irrigation (MoWI), the National Environment Management Authority (NEMA), the Kenya Wildlife Service (KWS) and the National Drought Management Authority (NDMA). These departments and agencies provide agricultural extension, inputs and policy support. Specific interventions include construction of water facilities such as boreholes and water pans by the water department, vaccinations by the veterinary department, and promotion of pastures by the agriculture department, and destocking by the livestock department under the (MoALF). Tree planting and controlled bush clearing are being promoted by KFS, regulation of livestock movement by KWS, regulation and coordination of various environmental projects by NEMA and policy support by ASDSP. The NDMA is the only organization that directly deals with climate change risks, providing early warning information to farmers in collaboration with KMD.

There are several NGOs working in the County which include WASDA, ALDEF, Oxfam, World Food Programme (WFP), Save the Children-UK, Kenya Red Cross Society, Islamic Relief, Veterinary Sans Frontiers (VSF), World Vision, Mercy Corps, Mentor and District Pastoral Association. These NGOs mainly operate in the livestock, health and education sectors offering subsidized treatment and supporting the government in vaccination. WFP, World vision and WASDA offer relief food services. Save the children and Islamic relief are involved in nutrition and livelihood programmes. The NGOs, also work in the county in areas related to provision of water tanks, agricultural inputs like fertilizers and pesticides, greenhouses, drip irrigations, trainings and extension on good agricultural practices. Faith-based organizations such as the Islamic Relief (IR), focus also on emergency response, engaging in activities such as conflict resolution, rescue services, administration of food aid, and disasters.

The above mentioned organizations also have a development component, providing extension, inputs such as fertilizers, high-yielding seeds and irrigation equipment to farmers. They also link farmers to markets by encouraging them to organize themselves into groups so as to strengthen their bargaining power. Community-based organizations are normally incorporated in implementation phase of adaptation since they are able to influence the farmers within their mandate. Coordination among these organizations exists at some stages of intervention design and implementation. Collaboration was reported to exist within the government departments. However, other than for a few cases, NGO to NGO collaboration and NGO to government department collaboration

were minimal if any existed. This may be due to the fact that most of these NGOs are autonomous in operation. Local people/beneficiaries are consulted on topics related to land tenure regimes and the general acceptability of the intervention in the planning phase, yet their engagement in subsequent steps is limited.

Early warning and emergency preparedness is necessary for diminishing the impacts of droughts, floods, diseases, and other climate hazards affecting crop and livestock systems. In the absence of an integrated data bank on crops, livestock and livestock products, feed and water availability, efforts of the government and other service providers to identify and support vulnerable groups are limited, leading to an inability to design appropriate intervention programmes and mobilize adequate resources.

There is no legislation on climate change for Wajir County that describes who, and how to enforce policies for climate change in addition to lack of a climate change policy. These factors reduce the degree of coordination and collaboration. The capacity of various institutions however, needs to be strengthened by adopting improved performance enhancing systems to deliver services more efficiently and effectively to the people of Wajir.

Effective preparedness and management of climate change impacts will largely depend on the establishment of an all-inclusive coordination mechanism that will bring together various key actors. Strong research and extension institutions are key in enhancing competitiveness in the agricultural industry and increasing agriculture/livestock productivity.
The main constraints in research and extension service delivery within the agriculture/livestock sub-sector include low investment in agricultural research by public and private sectors, inadequate attention to post-production research, particularly value-addition and marketing. Insufficient funds contribute to inadequate human capacity in terms of knowhow and number of staff in almost all the government departments and other organizations. Employing modern technology in crop production and livestock production will ensure food security in the region thereby enhancing self-efficiency. Improved value chain system will also ensure value addition to agricultural products thereby improving income generation to the local community.

The budgetary allocation for the livestock sector in the county is very low. This does not reflect the proportion of households engaged in livestock activities. This low allocation may explain the inadequate service provision to farmers, such as veterinary services and inputs. Farmers reported that most of their queries on agricultural services go unanswered due to long distances to the agricultural offices that hinder frequent follow-ups. A policy push is needed to ensure that this industry gets the support it deserves. Weather and climate have a significant impact on many aspects of people's lives, particularly amongst populations whose livelihoods are directly dependent on the agriculture sector. Consequently, although collection of early warning data and dissemination mechanisms are an essential component of disaster risk reduction, they must link with wider systems to trigger response. Secondly, investment must be made in quality, credible early warning and food security monitoring systems. The systems should provide real time information upon which clear actions can be taken and funded. Implementation of Wajir County Climate Information Services Plan (WCCISP) is paramount.

Synthesis and Outlook

The climate of Wajir is unfavorable for rain fed agriculture, thus making the county food insecure and a net food importer. Dry spells, heat stress, late start of seasons, more days with moisture stress, erratic rainfall, unpredictable floods and prolonged drought are hazards that strongly contribute to agricultural risk in the county. There is a great danger of desertification contributed by overgrazing and sporadic settlement. This greatly affects the key value chain and livelihood of the community and the sustainability of pastoralism and nomadism.

In terms of perceptions of long-term change in climate, an overwhelming majority of experts and households perceived an increase in average temperatures and a decrease in average precipitation over the last decades. The significant changes and variations in climatic conditions over the past years have been affecting agricultural production and livelihoods in the county. As drought and high temperatures are foreseen to occur with greater frequency in Wajir County in the future, enhanced capacity of households to cope with these new conditions are needed. This involves critical short-term and long-term adaptation measures that target production systems and value chains key for the population's food security and livelihoods, including livestock and crop systems. Significant initiatives to increase resilience in the agricultural sector have been evident in Wajir County. These include on-farm practices that target water and soil conservation and management, such as water pans, shallow wells, de-silting of existing dams and water tanks, crop rotation, agroforestry systems, drought resilient crop and drought- livestock breeds.

To complement the on-farm services, there are off-farm activities such as the early warning information and extension services to prepare and advice farmers on how to manage the risks, seeking off-farm employment opportunities such as sand harvesting, Gums and Resins harvesting, small business or move to urban centers in search of jobs to mitigate the climate variability risks. In addition, off-farm services and programmes have been provided to act as enablers for uptake of adaptation options. Such services and programmes include provision of early warning systems, extension services, and technical support.

Adaptive capacity to make informed and flexible decisions for action is becoming even more important to ensure resilience to climate change impacts. While it is important to continue implementing such initiatives and supporting them through actionable policies and strategies, integrated agricultural development requires adaptation measures that target the entire value chain activities. On-farm production is important; however, without ensuring enabling conditions for provision of and access to inputs such as seeds, fertilizers, pesticides, product storage and market access, farmers' livelihoods and incomes remain at risk. This is because climate hazards are expected to affect all important value chain activities. Distribution of the inputs, mainly seeds and fertilizers, should be timely and synchronized with rain cycles. This will address claims by farmers that the inputs are never available during on-set of rains. This can be achieved through construction of more input outlets and collaboration with the meteorological department (KMD). Also of particular importance are investments in road infrastructure that can enable farmers' access to market, but also to important services such as extension and veterinary support from the (MoALF). Moreover, value addition through, for instance, smoked and/or dried meat, and processed milk can open up new niche markets for farmers.

Identification of an appropriate institution to implement the National Climate Change Programme, which should cascade to the vulnerable smallholder farmers, is recommended. Apart from these measures, a long-term vision for the agricultural sector requires addressing underlying factors that continue to increase farmers' vulnerability and diminish their capacity to carry out climate adaptation activities more effectively. Investments in basic public services such as availability of and access to potable water, electricity, and education could help curb persistent, high poverty and illiteracy levels among farmers. These would enable them to invest in activities that secure their livelihoods and to access and adequately use vital agricultural inputs (fertilizers, vaccines, irrigation equipment) that could maintain and eventually increase productivity and ultimately incomes.

Climate information is important to communities and government institutions for livelihood and development planning, which can result in reduction of losses attributable to climate variability and change. Accurate climate prediction, proper interpretation, packaging, timely dissemination and use translates into increased agricultural yields and improved food security hence sustainable livelihoods. Communicating climate information, in ways that users can understand and apply is therefore a critical resource to support effective adaptation to climate change. Such information empowers vulnerable communities to make their own calculated and climate informed decisions on livelihood and risk management choices, innovation and use of services and resources. Technical and extension service information further amplifies these benefits as farmers apply better farm management practices based on climate and weather information. Strengthening farmer groups, improving the outreach of weather communication services and increasing linkages with the relevant ministries for service provision will help to further enhance the scale and sustainability of these positive results.

While the number of institutions supporting agricultural research has expanded over time, public expenditure and investments in agricultural innovation have not been sufficient to conduct research in climate resilience agriculture. An enabling institutional, policy and governance environment is also critical for addressing climate vulnerabilities of farmers. The formulation and implementation of county-level climate change action plans that are grounded in assessment of local needs and resources could represent an important step towards the operationalization of the country's climate strategy. Furthermore, increased alignment of public and private funds aimed for agricultural development to the sector's needs and relevance for local and national economy and food security, would enable a better functioning of the institutions, which currently lack resources to effectively deliver services (climate information, extension, veterinary support and subsidies). Promotion of collective action through interventions that target groups can further strengthen the existing local norms such as communal land ownership (for activities like community seed nurseries) and venturing into mass media (radio for instance) in offering extension services.

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