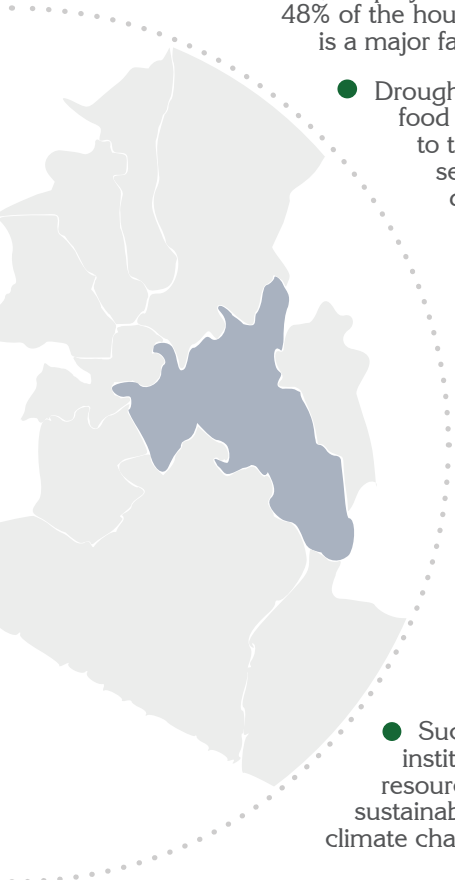
Climate Risk Profile
Nakuru County

Highlights



- Nakuru is a diversified County in terms of climate, people and livelihoods. Agriculture is the main sector providing food, income, employment creation and raw materials for industries pursuing processing. The sector provides about 48% of the household income and employs over 60% of the employed population. However, climate change is a major factor affecting the sector.

- Drought, intense rains, floods, and high temperatures already challenge productivity, incomes and food security in the County and are expected to pose even greater challenges in the future. Looking to the future in the years 2021-2065, prolonged moisture stress is projected to occur across both seasons of the year analysed and consecutive days of moisture stress are projected to more than double in the first wet season from approximately 35 days to over 70 days on average. While only small changes in intense precipitation are expected to occur, precipitation is projected to increase by 0.3% in the first wet season, and 6% in the second wet season. These all indicate the need of preparing agricultural systems to expected increased incidence of droughts and floods in the future..

- At the moment, crop farmers' strategies to cope with climate hazards include tree planting, soil and water conservation and changing crop type, and, to lesser extents, staggered cropping, diversification of enterprises, and post-harvest storage and processing. In livestock production, farmers resort to changing livestock type and feed conservation. However, the lack of productive resources, infrastructure, and technical skills often result in low uptake and adoption of these strategies.

- Off-farm services such as early warning systems (EWS), insurance schemes, agricultural extension and training, credit, storage facilities, and market information are offered to farmers to increase their climate-adaptive capacity and their ability to respond to climate threats in an effective manner. However, availability, accuracy, and access to these services remains low throughout the County, being constrained by limited funding and human resource and technical capacity among institutions in charge of delivering these services.

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

KAPP
Kenya Agricultural Productivity Programme
Republic of Kenya
WORLD BANK GROUP

List of acronyms

AEZ	Agro Ecological Zone
AFC	Agricultural Finance Corporation
AMS	Agricultural Mechanization Services
ASDSP	Agricultural Sector Development Support Programme
ATDC	Agricultural Technical Development Centre
CAADP	Comprehensive African Agricultural Development Programme
CDN	Catholic Diocese of Nakuru
CIG	Common Interest Group
CIP	International Potato Centre
EAAPP	Eastern Africa Agricultural Productivity Project
ESP	Economic Stimulus Programme
EWS	Early Warning Systems
GEF	Global Environmental Facility
ICS	Interim Coordinating Secretariat
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPAP	Kenya Agricultural Productivity and Agribusiness Programme
KAPP	Kenya Agricultural Productivity Programme
KDB	Kenya Dairy Board
KES	Kenya Shillings
KITI	Kenya Industrial Training Institute
KFS	Kenya Forestry Service
KMD	Kenya metrological Department
NAAIAP	National Agricultural Accelerated Input Access Programme
NCCRS	National Climate Change Response Strategy
NCPB	National Cereals and Produce Board
NEMA	National Environmental Management Authority
NGO	Non Governmental Organization
NMK	Njaa Marufuku Kenya
PELUM	Participatory Ecological Land Use Management
SCCF	Special Climate Change Fund
SHCP	Smallholder Commercialization Project
SHDP	Smallholder Horticulture Development Project
SUPKEM	Supreme Council of Kenya Muslims
SUPPA	Sustainable Practical Programme for Africa
THVC	Traditional High Value Crops Promotion
VCC	Value Chain Commodity
VS	Veterinary Services
WB	World Bank

Foreword

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

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

To strengthen local capacities to reduce the near-, medium- and long-term vulnerability to current and future climate variability, the Kenyan Government, through the Ministry of Agriculture, Livestock and Fisheries (MoALF) is implementing the Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) project. The project is funded with a grant from the Global Environmental Facility (GEF)/ Special Climate Change Fund (SCCF) through the World Bank (WB). The present study is part of the KACCAL project; it aims to inform the County government and stakeholders on the climate change risks and opportunities for agriculture so that they are able to integrate these perspectives into their development plans and processes.

Presented here is the County Climate Risk Profile for Nakuru County, where climate variability has been accompanied by a significant increase in attendant risks, as frequently reported in national and international news. Floods in 2011 nearly doubled Lake Nakuru's total area, increasing land degradation[1]. In 2015, floods brought about catastrophic effects on the urban and rural communities, when more than 200 homes were destroyed and hundreds of acres of crops uprooted due to flooding[2]. The cycle of floods is matched by serious droughts that affect more than 90% of the County, leading to water rationing and other coping mechanisms[3]. The disastrous nature of these hazards makes the identification of impending climate risks an urgent matter: likewise, considering practices that help citizens become more resilient in the face of imminent threats to their health, safety, and livelihoods becomes an exercise with the potential to affect hundreds of thousands of lives and safeguard key natural systems.

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

1 As reported by Reuters news (Reuters, 2015)

2 As reported by The Star online newspaper (The Star, 2015).

3 As reported by Standard Digital online newspaper (Standard Digital, 2015)

Agricultural context

Economic relevance of farming

Nakuru County lies within the Great Rift Valley, bordering eight other counties: Kericho and Bomet to the west, Baringo and Laikipia to the north, Nyandarua to the east, Narok to the south-west and Kajiado and Kiambu to the south. The County covers an area of 7,495.1 square kilomters (Km2) (GoK, 2013).

Agriculture is the mainstay of Nakuru County. It plays a critical role in provision of food and employment creation. Other major economic activities are tourism and geothermal power generation. The agricultural sector comprises the following sub-sectors: livestock keeping, fish farming and food and cash crops farming including horticulture and floriculture. Both subsistence and large-scale commercial farming is practiced.

Although the sector provides for about 48% of the average household income, income sources are not diversified within the sector where over 70% of the households depend on a single income source. About 37% of male-headed households and 17% of female-headed households depend on income from crop-related on-farm activities, while 29% and 19% of these households respectively depend on income from livestock activities. The primary occupation of the households was crop and livestock production (71%), where 42% of the adult male youth, 13% adult females and 16% men relied on this for their livelihoods (GoK, 2014).

In 2012, the main food crops produced in the County included maize (250,065 tonnes), Irish potato (270,986 tonnes), wheat (58,000 tonnes), and beans (22,614 tonnes) valued at 6.5 billion Kenyan shillings (KES), KES 4.7 billion, KES 1.7 billion and KES 1.2 billion respectively. In the same year, the main livestock products were milk (182 million litres), beef (120,600kg), mutton (86,400 kg) and eggs (33,242 trays[4]). The value of these products was KES 4.1 billion, KES 33.7 million, KES 25.9, and KES 8 million respectively (GoK, 2015).

The contribution of agriculture sector to employment is immense. More than half of the population is employed in the sector[5]. The adult female (42%) provides the largest share of family labour, while hired labour for livestock production is dominated by youth.

In the marketing of crops, 39% of the households in the County had contractual agreements with buyers of their produce. The main crops sold by households on contract were maize (34.4%), Irish potato (27%), pulses (11.7%), and green peas (11.7%). Livestock products sold on contract were milk (56%), live animals (15%) and eggs (21%) through informal (61%) and formal (39%) agreements (GoK, 2014).

People and livelihoods

According to the most recent census, the Nakuru County population stands at 1.6 million (GoK, 2013). With a population growth rate of 3.05% per annum, the population is projected to increase to 2,046,395 by 2017 assuming constant mortality and fertility[6] The population is largely youthful with over 70% being below 30 years7. The County is cosmopolitan comprising populace of diverse ethnicity and nationality. The settlement patterns are influenced by availability of natural resources, soil fertility and rainfall, pasture, infrastructure, economic opportunities, proximity to urban set-ups and security. Although a large population is in the rural areas, the urban centres have the highest population density due to rural-urban migration as a result of well-developed infrastructures, employment opportunities and security as in the case of Molo Town. The rural population is estimated at 62% (GoK, 2013).

The poverty level in the County is relatively high (41%), especially in the urban areas (55%). High unemployment and low agricultural productivity are some of the likely reasons leading to high poverty. Despite the high literacy (those who can read and write) levels in the County (80% among youth), skill mismatch and lack of innovation, coupled with increased rural to urban migration, hinder economic

4 A tray holds 30 eggs.

5 The population working in agriculture in 2012 was estimated as 942,168 (GoK, 2013)

6 Based on National Population and Housing Census 2009. In 2009, the population was 1,603,325 (804,582 male and 798,743 female)

7 The implication for a large youthful population is that it will exert pressure on resources available including social amenities and physical infrastructure needed to match the needs of the high population.

development of urban areas. Unemployment stood at 24% in 2012. Only 34% of the population has access to electricity for lighting, while over 80% use firewood for cooking (GoK, 2013).

The food poverty[8] rate in the County stands at 36% (GoK, 2013). Female-headed households are the most affected, most likely due to lack of agricultural production inputs. In many cases this is associated with cultural practices that marginalize women in terms of asset ownership.

The main livelihood activities in the County are livestock keeping, crop farming, small businesses (retailing) with minimal mining, tourism and industry. The main livestock types in the County are dairy cattle, local poultry and wool sheep.

Agricultural activities

The County has several Agro-Ecological Zones (AEZ), which cover different regions of the County: AEZ TA (covering Molo, Olenguruone and Njoro), AEZ UH1 (Molo, Mau Narok, Bahati Forest, Olenguruone), AEZ UH2 (Molo South, Mau Summit, Keringet, Olenguruone), AEZ UH3 (Mau Narok, Olenguruone), AEZ LH2 (Kabazi, Ndundori, Mau Narok), AEZ LH3 (Njoro, Ngata, Menengai, Naivasha, Subukia), AEZ LH4 (Rongai, Naivasha, Upper Gilgil), AEZ LH5 (Gilgil, Naivasha, Karati), AEZ UM3 (Mbogoini, Bahati), AEZ UM4 (Weseges, Lower Solai, Kampi Ya Moto), AEZ UM5 and UM6 (Lake Naivasha, Mbaruk, Longonot), AEZ LM5 and LM6 (Mbogoini)[9].

Altitudes in these AEZs range between 2980-3050 m.a.s.l (in TA) and 1480-1550 m.a.s.l. (in LM5 and LM6). Annual rainfall varies between 1200-1900 mm/year in TA and UH1 and 100-1200 mm/year in LH5, and 550-700 mm/year in UM5 and UM6. The short rains fall between October and December, while the long rains fall between March and May.

Temperatures in the County range from a high of 29.30 C between the months of December, January, February, and part of early March to low temperatures of up to 120 C during the month of June and July. Molo and Kuresoi sub-counties are relatively cold while Naivasha, Gilgil and parts of Rongai sub-county experience extreme hot weather.

The soil pattern presents a complex distribution with three main classifications that have been influenced by climatic conditions, volcanic activities and underlying rock type. These are: *Latosolic soils, planosolic, and alluvial and lacustrine deposits*[10]. These soils range from poorly-drained to well-drained with low to moderate fertility. Despite the arid and semi-arid conditions of the land, there is an increased potential for agricultural production, provided that irrigation facilities are built (GoK, 2013).

Nakuru County has a total of 503,941 ha of arable land. This represents 67% of the total land area in the County and about 1.8% of the national arable land. The land area under food and cash crops is about 243,711 ha and 71,416 ha respectively. Most of the crop farming is practiced in Bahati, Njoro, Molo, Rongai, Olenguruone, Mau Narok and Njoro Divisions, mainly in AEZs TA, UH1, UH2, and UH3. The main crops produced include maize, bean, Irish potato, and wheat. Fruits and vegetables are grown mostly in small-scale farms (average 0.77 ha) under mixed farming (crops and livestock) particularly in Nakuru North, Subukia and Molo sub-County, and include tomato, pea, carrot, onions, French bean, citrus fruit, peach, apple, cabbage, kale, strawberry, asparagus, and leek. The majority of the large commercial farms (averaging 263 ha) in the County are found around Naivasha, Molo and Rongai (LH4 and LH5 AEZs).

Livestock production is a major economic and social activity in the County. The main livestock reared include cattle, poultry, sheep and goats[11]. The most common livestock reared in the ranches[12] are dairy and beef

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8 Kenya's food poverty line is defined as the cost of 2,250 kilocalories from a food basket consistent with rural and urban consumption recorded in the Kenya Integrated Household Budget Survey 2005/2006 (KNBS, 2007).

9 The County can be also characterized by its three broad climatic zones (II, III and IV) exhibiting a bimodal rainfall pattern with a high of 1800 mm and a low of 500 mm. Zone II covers areas with an altitude between 1980 and 2700 m above sea level and receives minimum rainfall of 1000 mm per annum. This zone covers Upper Subukia, Rongai and Mau Escarpment. Zone III receives rainfall of between 950 and 1500 mm per annum and covers areas with an altitude of between 900 and 1800 m above sea level. This zone covers most parts of the County and is the most significant for agricultural cultivation. Zone IV occupies more or less the same elevation as Zone III although it has lower rainfall of between 500 and 1000 mm per annum. This zone dominates Solai and Naivasha.

10 *Latosolic* soils are well-drained, red, volcanic soils and cover Njoro, Nakuru, Lake Elementaita and Maai Mahiu in Naivasha areas. Planosolic soils are poorly drained, dark brown, clay soils and cover Olenguruoni, Molo, Rongai, and parts of Njoro. Alluvial and Lacustrine Deposits are shallow soils with low to moderate fertility and cover Lake Nakuru, Lake Naivasha, Lake Elementaita, Solai, and the Menengai Crater.

11 The main dairy cattle breeds are Ayrshire, Friesian, Guernsey and Jersey, local and several crosses, while beef cattle breeds include Boran, Sahiwal and their crosses. Sheep breeds: Merinos, Blackhead Dorper, Corriedale, Romney Mash and Hampshire down. Goats breeds: East African goat, Saanen, Toggenburg, German Alpine, Galla, Boer and Angola breeds. For poultry, there are both commercial (White leghorn, Rhode Island, Light Sussex, Black Australorp and hybrids) and indigenous breeds (Normal, crested, naked neck, dwarf, fizzle and improved breeds (improved kienyeji).

12 Ranches occupy approximately 17,000 ha and include Soysambu, Marura ranches, Major Boinet, Kedong, Sanctuary Farm, Morendat, Marula, Malewa Bay Loldia, Olsuswa, Korongo, Wileli (Kipkulei), Lapieve Ltd (Kongoni), Soysambu, Mboi-Kamiti, Malewa, and Munyaka Farm.

Livelihoods and agriculture in Nakuru

Demographics

4.1% Of Kenya´s population

1,900,000 inhabitants

62% Live in rural areas

50% 50%

Access to basic needs

41% of the population lives in **absolute poverty**

Potable water	63%
Electricity for cooking	1%
Electricity for lighting	34%
Education (youth literacy rate)	80%

Food security

36% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

31% Children **stunted**

7% 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)

Nakuru

Farming

County´s farming area 503,941ha 67%

59% of the population employed in agriculture production

72% of farmers have title deeds

ND% are women

Farming activities

Food crops 48%

Cash crops 14%

Of county´s agricultural land

Livestock

12 Group ranches

5 Company ranches

Farming inputs

Water uses

ND ND ND

Fertiliser types (% of households)

NPK

18% Organic manure

54% Basal fertiliser

16% Top dress fertiliser

Pesticide types (% of households)

12% Field pesticides

7% Storage Pesticides

25% Herbicide

cattle, goat and sheep. The ranches are mostly found in Naivasha (AEZ LH4). Dairy farming under the zero grazing system is emerging as an important economic activity due to diminishing land size, favourable weather environment, and milk market.

Fisheries activities range from fishing in Lake Naivasha, community-owned dams, and fish farming in fish ponds[13] and water reservoirs owned by individuals and registered groups.

Roughly 42% male-headed households are involved in crop/livestock production activities, while female- and youth-headed households account for 13% and 15% respectively. Women tend to have more decision-making power around production of subsistence crop, poultry (especially chicken), and household labour, while men take most decisions in relation to the production of commercial crops and large animals (cattle, goats and sheep).

The land tenure system in the County comprises land with title deeds or allotment letters, leased/ rented, communal land and squatters (Annex 2). Disaggregated by gender, the majority of male-headed households (64%) and female-headed households (69%) have title deeds or allotment letters to the land they own, whereas youth-headed households (26%) own land but with no title deeds. Less than 20% of the households in the County are considered to be landless (GoK, 2013).

Various agricultural inputs are used in the County at varied proportions depending on the season and the crop. Annex 3 presents input use in annual crop production in Season 1 (March to May) and Season 2 (October to December). The inputs include seeds, fertilisers, irrigation water, herbicides, and pesticides. At least 80% of maize, vegetables, and onions producers use improved seed, while at least 90% of those growing beans, garden peas and Irish potatoes use local or recycled seed. The usage of fertilisers, pesticides and herbicides is low except for basal fertilisers which have a high usage. Usage of organic manure, pre-harvest pesticides, and post-harvest is higher among male-headed households, compared to female-headed households. Maize and Irish potato use a lot more fertiliser as basal and top dressing.

More than half of the households (67%) use farm machinery and equipment, including tractors (47% of households). The machinery is usually hired rather than owned. The main mechanized activities are ploughing (49%) and harrowing (24%).

The main modern storage facility in the County is the silo, owned by the National Cereals and Produce Board (NCPB) and Cargill East Africa. However, this storage is not sufficient and farmers are sometimes forced to sell their produce at low prices to avoid post-harvest losses due to spoilage.

Agricultural value chain commodities

Nakuru County has a broad diversity of agricultural production systems. Crops, livestock and fisheries comprise various agricultural value chain commodities (VCC) that have been identified and prioritized for development interventions by different government organizations and programs. These include the Ministry of Agriculture, Agricultural Sector Development Support Programme (ASDSP), the Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi survey, and the Kenya Agricultural Productivity Program (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities were selected for in-depth analysis based on their contribution to food security, productivity characteristics and importance to the economy. These VCCs have been selected from a list compiled from the available literature, interviews with various County experts and a validation workshop. The indicators used for prioritization include: harvested area (hectares), production (90 kg bags), variation in production (in the past five years), value of production (US$/bag), dietary energy consumption (Kcal/capita/day), protein content (gr of protein/100 gr of product), iron content (mg of iron/100 gr of product), zinc content (mg of zinc/100 gr of product), and Vitamin A content (IU Vitamin A/100 gr of product). The VCCs selected are dairy cow (milk), maize, Irish potato, and local poultry. Maize and Irish potato were selected mainly for food security reasons, whereas dairy cow and local poultry were selected for their economic importance. Annex 4 shows a summary of the indicators. Dairy cow, maize, and local poultry are produced throughout the entire County, while Irish potatoes are produced in Molo, Olenguruone, Njoro and Bahati divisions (AEZ TA, UH1, UH2 and UH3).

13 Many fish ponds were introduced through the Economic Stimulus Programme (ESP) by the Government of Kenya in 2009.

Dairy (cow)

Dairy is important for food security and economic reasons in the County. The major breeds are local, cross breeds, and exotic (Friesian, Jersey, Ayrshire and Guernsey). In 2014, the dairy cow population was approximately 286,050 animals and the milk produced was about 296 million kilograms. Production activities such as feeding and milking of the cows are mostly carried out by women and youth, who also supply the majority of hired labour in the livestock sector. Productivity is highest among female-headed households compared to male- and youth-headed households (11.3 litres/animal, 10.5, and 9.4 respectively)[14]. Ownership of cows and income generated from milk selling generally rest with men.

The major marketing channels include local markets and cooperatives, which sell to the processors and middlemen. The cooperatives include Wanyororo, Tegat, Kamwaura, Suka, Njoro, Rongai, Kuresoi and Sakaitim. Processors include Brookside Dairies, Happy Cow and New Kenya Cooperative Creameries Ltd.

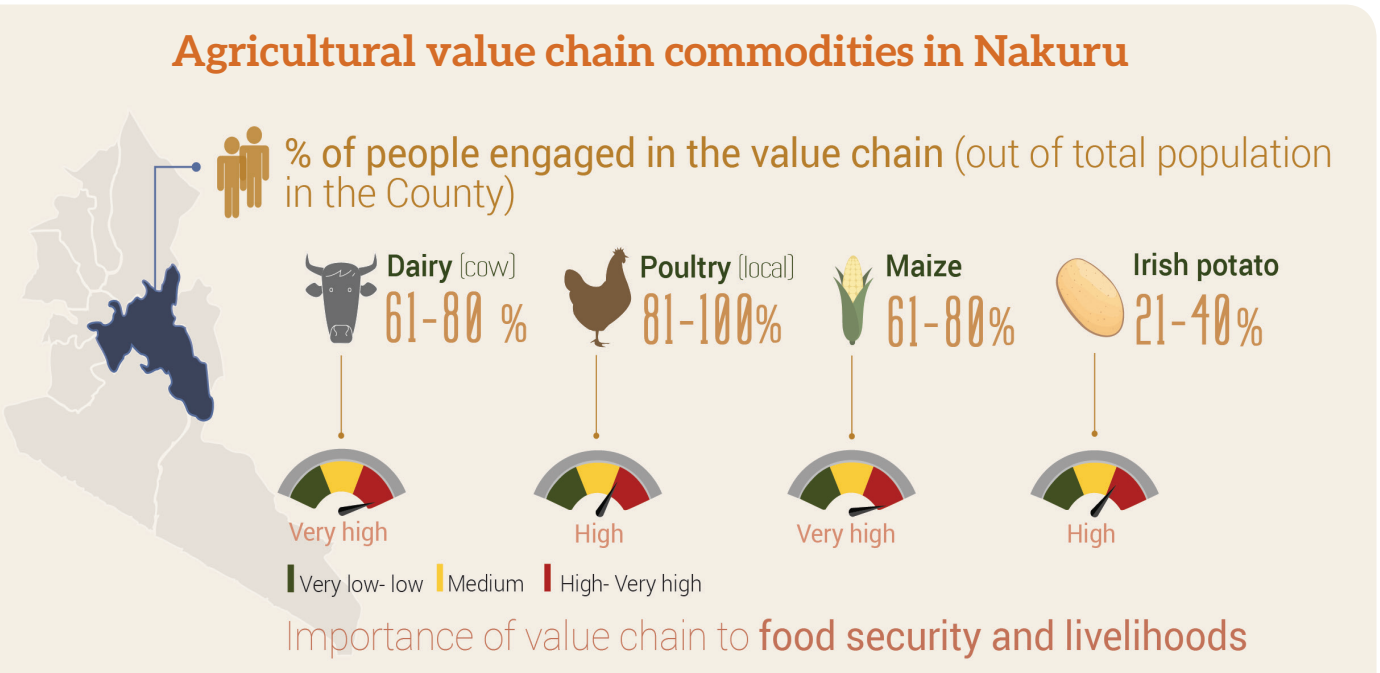
Value addition activities include fermenting, yoghurt making, ghee, cooling, boiling/pasteurization, bulking, and transporting. However, about 80% of farmers sell raw milk. This is largely due to the farmers' limited know how and capital to invest in value addition.

Key challenges to the dairy sector include poor feeding and breeding, unreliable input supply, lack of organized marketing structures for dairy products, diseases (such as tick borne and mastitis(, unreliable milk market outlets, among others. A poor road network also worsens the marketing situation in the County, mostly during the wet season.

Maize

Maize is a key staple food for Nakuru County and a major contributor to the livelihoods. It is grown in the entire County under a rain-fed system. Production is mostly small-scale. Slightly more female-headed households engage in maize production compared to male- and youth-headed households (91%, 87% and 83% respectively). However, productivity is highest in youth-headed households compared to female- and male-headed households (1614 kg/acre, 1467 kg/acre and 1375 Kg/acre respectively). Youth are generally more likely to adopt new technologies such as high yielding varieties and fertiliser. Basal fertiliser use was found highest in youth-headed households compared with male- and female-headed household (371 kg/acre, 182 kg/acre and 118kg/acre respectively).

Between 61-80% of the County´s population is engaged in the maize value chain. Farmers are involved in the production activities such as land preparation,



14 Women contribute more in terms of agricultural labour, hence improved animal care for exotic animals. For local breeds, male-headed households' production is more while youth-headed households are highest in cross breeds.

weeding, harvesting, storing, and in some cases sorting and transporting. The main value addition activities done by farmers are sorting and sometimes transporting the maize to the local markets.

Challenges encountered by the actors in the maize value chain include changing onset seasons, poor road network, high input prices, low farm gate prices, pests and diseases (e.g. Maize Lethal Necrosis [MLN] that affected the maize crop in 2014).

Irish potato

Irish potato is a food security and income-generating crop for farmers in Nakuru County. Production largely takes place in Molo, Kuresoi North and South, Njoro and Bahati sub-counties. The crop is grown in both seasons. Small-scale farmers mainly depend on rain and family labour to enable the production of the crop. In general, productivity levels depend on the season and input utilization levels. In the first season, productivity is highest among female-headed households (3055 kg/acre), compared to male- and youth-headed households (1680 Kg/acre and 1583 Kg/acre respectively), while in the second season it is youth-headed households that register higher productivity values (2832 kg/acre), compared to male- and female-headed households (2587 kg/acre and 2297 kg/acre respectively) (GoK, 2015).

Between 20–40% of the population in the County is engaged in the Irish potato value chain. The average acreage for potato production is 1.5 acres. Planting is normally done by all family members, harvesting by women, while spraying and transporting is mostly done by men. Farmers usually recycle planting material in both seasons, given the unavailability and high cost of improved planting material. The common varieties in the County include Shangi[15], Nyayo, Rudolf, Jerry and Carruso.

Value addition activities include French fries (mostly for hotels and other small food outlets), packaging, bulking (so as to reduce transport costs) and transportation (by private contractors). Njoro Canning Factory does frozen chips while the Kenya Defence Forces (KDF) has put a factory in Gilgil.

The major challenge faced by Irish potato farmers in the County is marketing. Most of the Irish potato is sold to middlemen who not only offer very low prices but also use extended bags (more than the recommended 50 kg) in purchasing the potatoes. Lack of storage facilities, poor transport network, and reduced farm sizes due to land fragmentation, are further factors that impeded / diminish marketing opportunities for farmers.

Local Poultry

Local poultry are kept all over the entire County for both meat and eggs. Production is small scale with every household having at least a chicken mainly for consumption purposes. In 2014, there were about 1,183,108 indigenous chickens in the County. The meat and egg production in the same year was approximately 140,000 kg and 5,144,499 trays[16] respectively.

More than 80% of the population is engaged in the local poultry value chain. The main actors in the value chain are farmers, who keep between 2-10 chickens, and input suppliers, who are also small scale (private agro vets, millers and chicken suppliers who are supplying improved local poultry[17] like KALRO in Naivasha).

Local poultry production is mainly ensured by women. Men are responsible mainly for the construction and maintenance of housing structures and value addition activities (mainly defeathering, grading, packaging, boiling), but also selling of poultry products. Local market comprises of institutions (schools, hospitals), traders (brokers, hawkers), and individual buyers.

Challenges to the poultry value chain include low production levels due to lack of quality breeding stock for the local birds, high feeds costs inadequate skills in poultry rearing, lack of processing, lack of organized marketing structures for meat and eggs and unreliable market outlets.

Agricultural sector challenges

Due to the high poverty levels[18], farmers have limited resources to acquire agricultural inputs (certified seeds, fertiliser and irrigation system), technology, information and financial support (loans and insurance). Consequently, low productivity creates a cycle of low productivity in the following season as the farmers have limited alternative income sources.

15 Shangi is preferred by buyers for its quality in French fries/crisps processing.

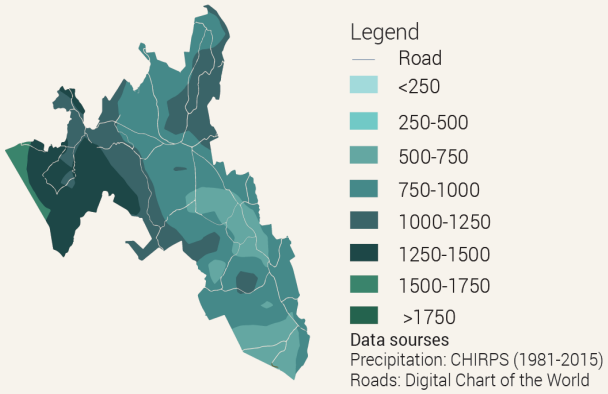
16 A tray has 30 eggs.

17 Improved local poultry has been developed by Kenya Agricultural Research Institute (KARI) now Kenya Agricultural and Livestock Research Organization (KALRO). The improved local poultry is considered local poultry in this work.

18 Many farmers relate poverty levels to environmental degradation, as there is massive destruction of forests to get firewood, charcoal and clear land for agricultural production.

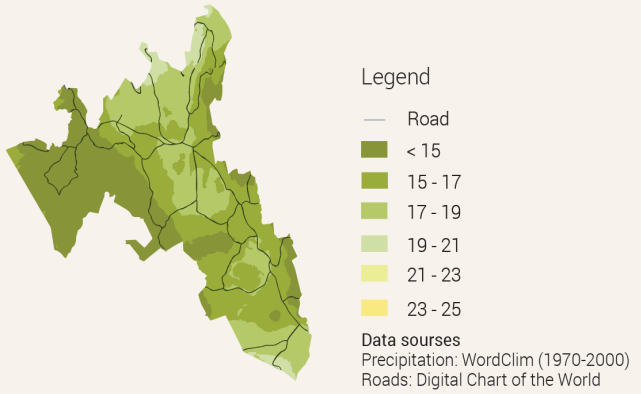
Past and future impacts of climate hazards in Nakuru

Historical annual mean precipitation (mm/year)



Data sourses
Precipitation: CHIRPS (1981-2015)
Roads: Digital Chart of the World

Historical annual mean temperature (°C)

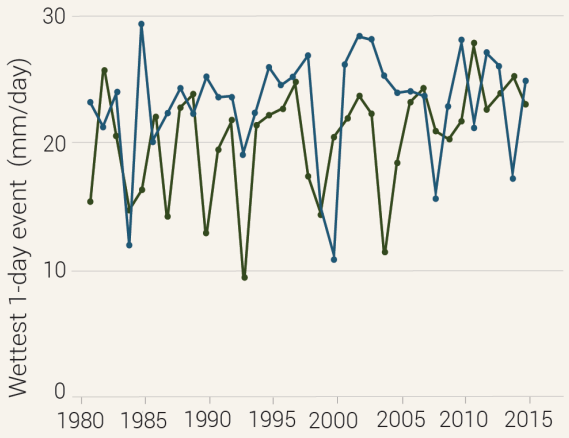


Data sourses
Precipitation: WordClim (1970-2000)
Roads: Digital Chart of the World

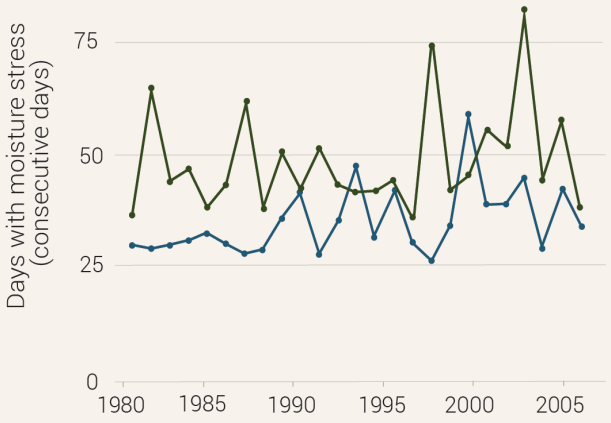
Flood hazards

Drought hazards

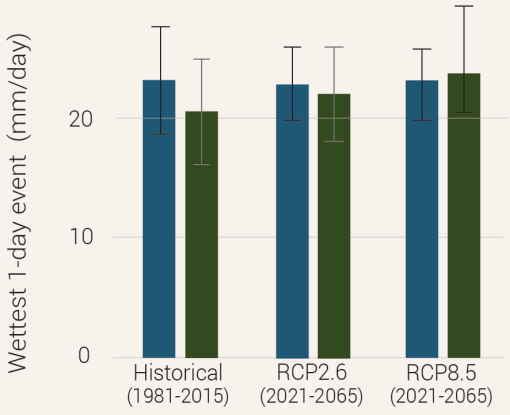
Historical extreme flood events



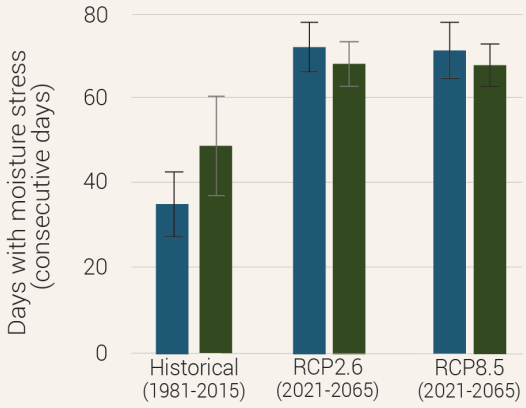
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



January - June July - December

Reliance on rain-fed agriculture remains a challenge especially when rains tend to be erratic and unpredictable. This affects both the quantity and quality of produce.

There is also low adoption of technologies and services that can enable higher, sustainable productivity, such as high-yielding crop varieties, adequate application of fertiliser and manure, efficient tillage and cultivation methods, fair cost of inputs, and access to productive resources such as credit and irrigation infrastructure. Despite the relatively well-developed financial sector, access to credit remains low in Nakuru County.

Rephrase first sentence 'Although there is inadequate storage facilities at the farm level, farmers do sell their produce early as they need the money. This situation may also cause food shortages especially after a prolonged dry season. The available storage[19] is mostly designed for maize and wheat hence other produce remain largely uncatered for.

Lack of capacity to undertake value addition, together with limited storage facilities, lead to farmers selling their produce at low prices hence low returns in the sector.

Poor infrastructure in some parts of the County is a serious challenge to input access and final product marketing. During the rainy season, some of the roads in the rural areas become impassable leading to delayed land preparation, post-harvest losses and market inaccessibility.

Agricultural production is also affected by insecurity that often results from tribal conflicts in parts of the County. The areas affected by these conflicts include Molo, Njoro and Kuresoi divisions which experienced armed ethnic conflict between 1991 and 2008. This has led to migration to urban areas causing pressure on the available resources including increased deforestation for firewood, charcoal and building timber. The migration has reduced production as labour and capital are moved out of the farms.

The budgetary allocation for the agricultural sector in the County is very low (5.8% in 2014/2015) compared to the minimum of 10% suggested by the Comprehensive African Agricultural Development Program (CAADP). This contributes partly to inadequate service provision to farmers, such as extension services.

Land use practices and environmental policies in the County have also encouraged land fragmentation, extension of urban development into agricultural land, retention of idle land, cultivation of river banks, deforestation and encroachment into catchment areas and wetlands. Inadequate enforcement of land use regulations lead to catchment degradation and soil erosion. The case of Mau Forest's complex encroachment is illustrative of this situation, leading to public outcry in 2008[20]. The forest is one of the major water towers in Kenya and the single most important water catchment in Rift Valley and western Kenya. It is argued that the forest's complex biodiversity and habitats provide vital ecological services to the country in terms of water storage, river flow regulation, flood mitigation, recharge of groundwater, reduced soil erosion and siltation, water purification, conservation of biodiversity, and micro-climate regulation. The negative impact of the degradation of the Mau Forest has been felt mostly by farmers along the valleys through which rivers originating from the forest drain, as well as the tea and tourism industries in the neighbourhood[21].

Climate change-related risks and vulnerabilities

Climate vulnerabilities across agriculture value chain commodities

Nakuru County is fairly moderate in temperature throughout, and ranges from more moist in the north and western portions to drier in the south. The northwest and northeast receive over 1250 mm precipitation and are under 15°C on average, whereas the entire central part of the County running from the north to the south receives less than 750 mm of precipitation and is around 17-21 °C on average annually. The first wet season of the year (January-June) tends to be about 1°C warmer and about 30% wetter than the second wet season on average; however, seasonal precipitation varies substantially from year to year. Due to this strong gradient in climate throughout the County, dry spells, intense precipitation and heat stress are all hazards that contribute to agricultural risk in the County.

19 Silos, farm stores and warehouses cumulatively have a storage capacity of 5,808,592 bags of maize (GoK, 2013).

20 Consequently, the Interim Coordinating Secretariat (ICS) for the Restoration of the Mau Forest was set up in 2008. By 2015, the Secretariat has not only managed to halt the encroachment and about 70 % of forest destruction, but has also put in place sustainable measures to restore the forest's complex biodiversity in collaboration with Kenyan Forest Service (KFS) and other development partners.

21 Production of tea requires a cool climate possible in the vicinity of tropical forests such as the Mau. The Mara and Waso-Ngiro Rivers which feed the Maasai Mara Game reserve and Lake Natron respectively, originate from the Mau.

Historic analysis of weather in Nakuru County shows that both dry spells and extreme precipitation are hazards in the County. Dry spells are on average longer during the second wet season averaging close to 50 consecutive days of moisture stress, but ranging from 35 to 80 days in any given year. The first wet season experiences about 35 consecutive days of moisture stress, ranging from about 25 to 60 days in any given year. Extreme precipitation and flood risks[22] are moderate in both seasons with most years receiving between 20 and 30 mm of precipitation on the wettest day[23].

Climate has already been observed to change in the County. Since 1981, the first wet season has experienced a moderate (1°C) increase in mean temperature and associated reduction in crop cycle, a significant increase in heat stress days, and no detectable change in precipitation. The second wet season experienced a mild (~0.5°C) increase in temperature, and no change in precipitation.

Looking to the future in the years 2021-2065, prolonged moisture stress is projected to occur across both seasons of the year analysed, whereas intense precipitation looks to change little. Within 30 years (by the early 2040's), temperature is projected to increase by 0.3°C, with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to increase by 0.3% in the first wet season, and 6% in the second wet season. Consecutive days of moisture stress are projected to more than double in the first wet season from approximately 35 days to over 70 days on average. Similarly, moisture stress in the second wet season is projected to increase from approximately 50 to 70 days. These projections of future climate change under the two climate scenarios—RCP 2.6 and RCP 8.5[24]—show some small differences, but generally show the same future projections, suggesting climate change impacts will be fairly similar during this time frame no matter the greenhouse gas emissions that occur.

Climate from the farmers' perspective

From the farmers' perspective, there is observable variation in climatic conditions in Nakuru County over the years. Weather patterns have become more unpredictable compared to the past. The farmers relate this phenomenon to human destructive activities on the environment such as deforestation, poor land use and industries.

The onset of seasons has changed. Moreover, the rains have become more unpredictable and unreliable. Normally, October to March used to be dry, coinciding with the harvesting period for crops such as maize. However, this has changed and October to December and sometimes January records high rainfall destroying the crops. The rains also fall in portions; even within a small area there can be rain in one portion while totally dry in the other portion. There is also the phenomenon of intense rains in the highlands causing flooding in the lower areas.

Farmers indicated that they have experienced significant temperature. It is now warmer, leading to crops like maize to have a shorter crop cycle as the temperatures have increased. The farming of beans is now favoured by the increased temperatures where areas that used to be very cold are warmer hence the crop is performing well. However, the increased temperatures are also associated with higher incidences of pests and diseases.

Climate fluctuations have important economic and social consequences. Rains during harvesting often lead to post harvest losses as the crop is destroyed and even the infrastructure is affected implying that marketing is affected due to inaccessibility. Hence farmers earn less making them unable to meet their needs including children's education, health and national development. When the temperatures rise beyond normal, the agricultural output is affected. Livestock such as dairy cows yield less milk under heat stress. Equally crops suffer heat stress that may lead to crop failure exposing the farmers to food insecurity. Farmers are also required to use more pesticides and herbicides. High evaporation rates require irrigation, which is very scarce in the lower parts of the County. These contribute to high production costs that make agriculture less viable to many locals.

During drought, the time spent by women especially in search of water is more. Again due to low and unsustainable incomes from agriculture, there is migration to urban areas to seek alternative livelihoods.

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

23 Note that this is 20 mm on average over the entire County, so specific parts of the County will have experienced greater than this (possibly much greater), whereas other parts will have experienced less.

24 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 modeling 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.

Since migration is mostly by men, the result is family disintegration that is associated with several social challenges such as higher child school dropouts.

Climate vulnerabilities across agriculture value chain commodities

Across the County, climate change and variability pose serious threats to the value chains identified in this work. The following section highlights the major climate risks faced by key value chains.

Maize

Maize is sensitive to climatic fluctuations. The entire value chain is affected by intense rainfall, drought, high temperature and low temperatures. Intense rains during the growth stage affect the crop causing soil erosion, leaching of minerals and lodging. Dry spells and high temperatures lead to low productivity or crop failures. Due to low productivity from subsequent seasons, farmers lack the ability to purchase inputs such as fertilisers and improved seeds. As such, the cycle of low productivity and food insecurity continues especially for subsistence crop farmers. Cases of aflatoxins were reported to be more common during the rainy season severely affecting the quality of produce and subsequent marketing.

Infrastructure, especially roads, are destroyed by heavy rains leading to inaccessibility of some areas due to the poor road network. This results in post-harvest losses and low prices for the produce. Moreover, access to inputs, processors, millers, and service providers such as extension staff are also hindered in accessing the farmers.

These impacts are exacerbated by high poverty rates and lack of extension services, which reduce their capacity to be prepared or diminish the risks by, for instance, building water dams or using climate information in day-to-day farm decision-making. This is also common to Irish potatoes production, since maize farmers also grow Irish potatoes.

Irish potato

Participants to the study identified intense rains and high temperatures as the most relevant hazards for the Irish potato value chain. These become a problem as the weather is becoming more unpredictable. High temperatures cause reduced working hours in the farm, poor germination and scorching of the early germinated seeds, loss of moisture and nutrients through evapotranspiration hence poor crop establishment resulting to low yields. During dry spells, farmers rarely plant; not only due to water scarcity but also due to lack of planting material. The early maturing varieties are too expensive for farmers. The quality of the Irish potato tremendously deteriorates during the dry spells since farmers harvest prematurely so as to take advantage of the high prices on the markets. In addition, there is limited utilization of pesticides in case of diseases, since the chemicals scorch the crop during this period.

Intense rains also become more unpredictable and have severe impacts over Irish potato production and marketing. Production costs are highest during the wet season. Labour requirements on activities such as land preparation, weeding and harvesting increase significantly. Farmers are also required to use more inputs during this season (intense rain) since the fertilisers and pesticides get washed away by the rains before benefitting the crop. The soils are more likely to degrade due to erosion ad to become more acidic due to continued leaching, reducing productivity. In addition, prevalence of diseases such as early and late blight, and pests such as the potato cyst nematode (PCN) and leaf miner increase during the wet season increase demand for and prices of pesticides.

Lack of capacity to undertake value addition mainly due to resource scarcities, high power costs and scarcity of appropriate storage facilities for Irish potato such as cold rooms make the farmers very vulnerable to climate risks. Due to poor road and market infrastructure, farmers are not able to transport and sell their products in times of heavy rains. They feel obliged to bring their products to collection centres, where they receive lower prices from middlemen.

Dairy cow

During dry spells water and feed scarcity are preeminent, affecting milk production and farm incomes. Drought causes failure of most fodder crops (especially Napier grass). Shortage of pastures and fodder require farmers to opt for more expensive commercial feeds. As such the dairy cow becomes more susceptible to malnutrition conditions such as infertility. Upsurge of other diseases such as Foot and Mouth, Lump Skin disease and Rift Valley Fever become common during this period due to immune-suppression.

Intense rain affects all the stages of the dairy cow value chain. In Nakuru town, located on the lower part of Ndundori and Mau Forests. Floods often destroy fodder due to poor drainage and continued leaching leading to water contamination. Cases of animal diseases such as Salmonellosis and infertility have been reported to be on the rise due to water contamination. Destruction of roads due to heavy rains increases feed prices and milk collection cost.

Local poultry

Drought causes high feed shortage in the local poultry value chain. The costs for purchasing commercial feeds and of accessing veterinary services are higher high during dry spells, as a result of increased demand and few service providers (located mostly in the urban areas and trading centres). As such, disease incidences increase, decreasing egg and poultry meat production.

Intense rain doesn't affect the poultry value chain severely, since feed availability is improved as most of the poultry scavenge, while the growth of worms and vegetation is enhanced. However, challenges arise in post-production stages, where transportation to markets is impeded by impassable roads.

~~Extre~~mely low temperatures lead to chicken deaths, as most small farmers do not have warming facilities. Low temperatures also cause low egg production.

Adaptation to climate change and variability

Farmers in Nakuru County have adopted various strategies to cope with variations and changes in climate to ensure agricultural production and food security. Results from previous research has shown that nearly half of all farmers, regardless of gender or age have adopted water harvesting and conservation strategies. Male-headed households are more likely to apply strategies that require more inputs and target productivity, while women are more likely to choose strategies related to diversification, post-harvest and value-addition. Some adaptations are specific to certain value chains whereas others cut across the value chains.

On-farm adaptation practices

For crop farming, strategies currently adopted by farmers include tree planting, water harvesting, increased soil and water conservation, change of crop type[25], Integrated Pest Management (IPM), certified seeds, ploughing with on-set of rains (when the ground softens) or using heavy machinery (four wheel tractors) when the soil is dry, staggered cropping, and diversification of enterprises. According to the GoK (2014), at least 42% of all households in Nakuru County have adapted to perceived changes and variabilities in climate.

Tree planting and tree nurseries are common soil conservation strategies in the County, as a result of the activities of various organizations (Participatory Ecological Land Use Management [PELUM], Tree is Life) and government bodies (Kenya Forest Service [KFS]) that supply farmers with tree seedlings, encouraging tree plantation. The strategy also helps reduce crop damage by frost and wind.

Due to weather irregularities, staggered cropping has become a common practice in the County for crops such as Irish potato, as it helps reduce climate risks impacts. Male-headed households are more likely to use the strategy compared to youth- and female-headed households (30%, 29% and 24% respectively). This can be due to the bigger land size owned by male-headed households compared with female- and youth-headed households (average 5.6, 4.1 and 3.3 acres respectively).

Water harvesting, construction of trash-lines, strip cropping, crop rotations, construction of drainage channels, and conservation agriculture are also widely practiced in Nakuru, helping to maintain soil quality by reducing leaching and formation of hardpans. Approximately 34% of the households (especially youth) use at least one of the practices. Water harvesting is mainly promoted by Tree is Life, while financial institutions such as the Agricultural Finance Corporation (AFC) offer loans to construct structures such as water pans. Government departments such as the Agricultural Technical Development Centre (ATDC) promote conservation agriculture by encouraging chisel over the conventional disc ploughing, to reduce disturbing the soil and exposing it to moisture loss.

Adoption of agricultural technologies such as herbicides, pesticides, fertiliser, and irrigation is most common among male-headed households (65% of male-headed households), compared to female- and youth-headed households (21% and 13% respectively) (GoK, 2014).

25 Tree planting, water harvesting, increased soil and water conservation, and change of crop type are the major strategies adopted by 42%, 42%, 34% and 30% households respectively (GoK, 2014).

More than half of farmers in Nakuru County (62%) add value to cereals like maize by mainly grading and packaging, making flour and de-hulling (35%, 32% and 26% respectively). For root and tuber crops such as Irish potato the main value addition activities involve grading and packaging.

For livestock farmers, current adaptation strategies include changing of livestock type, feed conservation (hay and silage), water harvesting and conservation, fodder production, land preparation for fodder using manual equipment, artificial insemination (AI), chicken brooding, and diversification of enterprises.

Out of these strategies, the main adaptations are changing livestock type (15%) and feed conservation (13%). Male-headed households are more likely to engage in changing livestock type, due to higher resource ownership and cultural norms (that allow men to sell own and sell livestock). Adoption of fodder conservation strategies remains low, despite some interventions from government departments such as Livestock production, Veterinary Services (VS), and ATDC, due to high costs required for purchasing fodder chopping equipment.

For livestock, value addition in milk is mostly done by boiling and fermenting (44% and 38% of households respectively), while in local poultry it is defeathering and differentiating parts (42% and 33% respectively). Value addition helps overcome perishability of products (usually occurring during storage and transportation) and facilitate access to new markets, with potential to increase farmers' incomes. However, lack of capital and knowhow are the major impediments to value addition.

Off-farm adaptation practices

Off-farm services facilitate uptake of on-farm adaptation practices and improve farmers´ preparedness and resilience to climate risks. The services accessible in the County include early warning information, conservation agriculture, and extension through trainings, field days and workshops, and input provision, among others. The services are offered by government, non-government, private, faith- and community-based agencies. The vastness of the County, insufficient human and financial resources, and poor infrastructure are main barriers to services access.

Agricultural services (including extension, research and AI services) and climate-related services are mainly accessed from the private sector (62% and 72% respectively). Extension services target trainings on the implementation of good agricultural practices for soil and water conservation, of high yielding, early-maturing crop varieties and animal breeds, and value addition activities. Male-headed households are more likely to access such services (62% of male-headed households) compared to female- and youth-headed households (23% and 8% respectively), given their higher per capita income[26] as at 2014. Women access more of the research services (42%) than adult men (37%) and youth (11%) (GoK, 2014).

Early warning systems (EWS), including weather forecasts, inform farming plans and improves preparedness to climate hazards. EWS are mainly provided by the Kenyan Meteorological Department (KMD) in collaboration with MoALF, but also by the VS (in the case of disease outbreak warnings). Farmers perceive an improvement in the accuracy of information over the years. However, the number of weather stations is not proportional to the County vast areas (there are three weather stations: the Kenya Industrial Training Institute (KITI), near Nakuru town, Njoro and the other in Kabarak), and the unexpected costs for climate risks preparation incurred to vulnerable farmers, are important barriers to farmers´ capacity to use the information in a timely and effective manner.

Financial institutions like insurance companies, microfinance institutions, banks, and AFC offer credit services such as loans and insurance schemes to farmers. Loans enable farmers to undertake adaptive measures such as water harvesting, value addition, and fodder conservation. The upcoming crop and livestock insurance schemes in the County are aimed at cushioning farmers from unforeseeable risks, even though uptake of the financial services is low especially for youth- and female-headed households (8% and 23% respectively) compared to male-headed households (62%).

The adult male-headed households have more access than adult female and youth headed households to most of the services available in the County. However,

26 In 2014, men, women and youth per capita income stood at KES 50,294, KES 44,830 and KES 28,556 respectively in 2014.

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

Dairy (cow)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Breeding challenges; abortions; repeated inseminations; feed shortage; compromised feed quality	Disease and pest outbreaks; poor pasture germination/establishment; hygiene production challenges; low animal growth rate; parasitic infestations	Shortage of storage structures (damaged/flooded); farm - stores access challenges (poor transport/navigation)	Poor quality of processed products (milk/meat); difficulties linking producers to processors; high prices (scarcity) and low market activity (reduced marketing activities)
Magnitude of impact	Major-Moderate	Moderate	Moderate	Moderate-Minor
Farmers' current strategies to cope with the risks	Access to feed and mineral; conservation of crop (maize stover); residues for feed (hay/silage); pasture scavenging; change of animal breeds; input supplies (drugs) and veterinary advisory services	Construction of water drainage and catchment structures (dams); reliance on veterinary advisory services (disease outbreaks/management); silage and hay preparation from crop residues/pastures; use of indigenous drugs (herbs/concoctions)	Transport of dairy products (using animal means); value addition (fermented milk); storage in locally available cans/holding containers; immediate sale to prevent household storage	Transport to market centres (using donkeys); milk marketing at farm gate
Other potential options to increase farmers' adaptive capacity	Use of improved disease-control drugs; provision of feed relief; access to disease-resistant animal breeds	Construction of wide-scale drainage/ catchment structures (water pans/dams); animal disposal (selling)	Improved transport networks; access to refrigerated storage structures (milk and meat); establish community-based milk reserve structures; acquire modern milking equipment	Access to external market information; improved road infrastructure; formation of farmer cooperatives (ease marketing)
Droughts	Breeding challenges (poor fertility cycles); feed shortage and poor feed quality; limited access to agrovets	Increased prevalence of pest and disease outbreaks; higher labour costs; animal poor growth rate and malnutrition; low yields; low quantity and poor quality of animal manure	High perishability of milk/meat products; contamination of storage spaces (dust); reduced processing (economic losses)	High market prices (scarcity and high demand); reduction in market activities
Magnitude of impact	Moderate	Moderate-Minor	Major-Minor	Major-Moderate
Farmers' current strategies to cope with the risks	Animal feed supplementation (preserved fodder, mineral supplements); conservation of crop residues; resuming cattle breeding during drought period; pasture scavenging; preparation of conserved feed (hay/silage)	Early pasture establishments; use of veterinary drugs following veterinary advice; culling/selling of weak animals; use of indigenous parasite/disease control measures; enterprise diversification (crop growing and formal employment)	Milk export to areas with storage facilities; household milk consumption; value addition (powder milk, fermentation)	farmer bargains for establishing market pricing; association with organized marketing (cooperatives); sale to milk buying agents/vendors
Other potential options to increase farmers' adaptive capacity	Use of improved drugs; subsidize drugs and supplements; access to drought-tolerant animal varieties; access to animal cross breeds; government provision of pastures/feeds	Pasture establishment using mechanized means (tractors); introduction of drought-management policies (county level); county support for enterprise diversification for dairy farmers; community/ government support in water conservation/ provision	Access to small-scale cooling facilities; community milk reserves; mechanized milking	Government intervention in pricing of dairy products; strengthening of cooperatives (to source for external markets); dairy insurance products

Poultry (local)

	Provision of inputs	On-farm production	Harvesting storage and processing	Product marketing
High Temperatures	High construction costs of poultry sheds (scarcity of local building resources)	Poor flock conditions (drooping; loss of feathers); high mortality rates; high demand for veterinary services	Spoilage of meat carcass; high transport costs (demand for refrigerated vans)	Low egg and chicken meat prices; Limited access to markets (damaged road)
Magnitude of impact	Major-Minor	Moderate-Minor	Major-Moderate	Severe-Moderate
Farmers' current strategies to cope with the risks	Keeping poultry in household space; sourcing of chicks at local hatcheries; use of local resources to encourage chicken breeding ('kiterenge'); individual farmer breeding	Use of local herbs for pest and disease management; construction of chicken brooders (with electrical or charcoal heating sources); use of traditional drugs and extension services; culling and disposal for diseased flock	Manual labour for eggs collections and sorting; household slaughtering and packaging in polythene paper bags; household consumption of eggs/ meat	Use of cartons/ crates for local transport to markets (bikes); Farm gate and local sales; individual farmer marketing and use of brokers
Other potential options to increase farmers' adaptive capacity	Construction of modern poultry sheds; access to certified and drought-tolerant and chicken varieties; access to approved chicken feeds and drugs; chicken feed subsidies	Use of drugs for chicken pest and disease management; enforcement of quarantine measures during disease outbreaks; collection of poultry manure	Programed egg collection and sorting; use of improved packaging material; use of modern slaughter machines; use of cooler boxes and refrigerated van for storage; certification of poultry products (to assess quality/ enhance market sale)	Formation of cooperatives to facilitate poultry sales; introduction of chicken feather markets
Droughts	Feed shortage and poor feed quality; high feed prices; high prices of building material	High labor costs; increased pest and disease incidence; increased flock mortality; lack of water	Increased perishability (of meat/ eggs)	Low farm gate prices; high market prices to due scarcity (eggs/ meat); loss of marketing activities
Magnitude of impact	Severe-Moderate	Minor	Major-Minor	Severe-Moderate
Farmers' current strategies to cope with the risks	Poultry feed supplements with kitchen waste; farmer-to-farmer exchange of breeding stock; poultry drugs (use of indigenous and/or modern drugs)	Free ranging chicken; use of local herbs for pest and disease control	Household slaughtering and packaging in polythene paper bags; household consumption of eggs / meat	Use of cartons/ crates for local transport to markets (bikes); farm gate and local sales
Other potential options to increase farmers' adaptive capacity	Use of crop-based chicken supplements; construction of improved chicken houses using locally available resources	Use of extension services advisories and improved drugs for pest and disease management; enforcement of quarantine measures during disease outbreaks; collection of poultry manure	Programed egg collection and sorting; use of improved packaging material; use of modern slaughter machines; use of cooler boxes and refrigerated van for storage; certification of poultry products (to assess quality/ enhance market sale)	Formation of cooperatives to facilitate poultry sales; introduction of chicken feather markets

Maize

	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
Intense rains	Limited access to input (damaged rural access road); delayed input delivery; rearing poultry in household space	Delayed land preparation; loss of planted seed, of applied fertilizers and chemicals; challenges in weed management; high labor costs	Increased post-harvest spoilage (high humidity, rotting, moulding, aflatoxins); transport challenges (farm to stores)	Loss of marketing opportunities (limited market access); pricing challenges (due to poor quality of produce)
Magnitude of impact	Moderate	Severe-Major	Severe-Major	Major-Moderate
Farmers' current strategies to cope with the risks	Purchase of certified seed from local stockist; purchase of fertilizers from appointed agents; use of available agronomic equipment	Use of manual labour for land preparation and harvesting; replanting; reseeding; staggered planting; agroforestry; crop rotation; tree planting; conservation agriculture; establish drainage structures (dykes; canals); use of chemicals to control maize necrosis	Use of manual labour (thresh, shell, sieve, weigh and packaging in sacks); seed storage in house; construction of drying shed and raised stores	Marketing pricing using brokers/ middlemen; market information passed verbally between farmers, processors and middlemen; association with community groups for bulk selling
Other potential options to increase farmers' adaptive capacity	Continuous research and access to drought-resistant varieties; use of soil testing and analysis facilities; subsidies for access to agro-inputs	Use of crop-specific fertilizer niche reccomendations; access to farm machinery (planters, sprayers; harvesters); enterprise diversification (horticulture); formal employment; advisories from extension agents on disease/ pest control and best planting times	Access to machinery/ technology for drying, shelling , sorting, packaging); use of moisture-free transport means (lorries); reliance on crop-based insurance to cushion against production and post-harvest production losses; frequent advisories from early warning systems	Formation of cooperatives/ groups to facilitate profitable market sales; new markets to sell product
Droughts	Increased pest and disease incidences; reduced soil moisture; increased wildlife-farmer conflicts	Increased production costs for irrigation, labour and use of pesticides; reduced plant vigour and stunted growth Increased livestock/wildlife-crop farmer conflict over forage	Reduced yields; quality from spoilage	Low prices at farm gate
Magnitude of impact	Major	Severe-Moderate	Severe-Minor	Major
Farmers' current strategies to cope with the risks	Early maturing and drought-tolerant crops (e.g. cowpeas, watermelon); use certified seedlings	Timely planting Conservation agriculture; irrigation and manure application	Fruit and vegetable cleaning, sorting and grading at harvest	Food safety and handling standards
Other potential options to increase farmers' adaptive capacity	High yielding seed/crop (hybrid Kelelefi, gregrade); Establishment of Kitchen Gardens e.g. multi-storey gardens; develop gravity feed large irrigation schemes	Early warning information to guide decisions in planting irrigation and harvesting; provide extension services to support new technologies	Cold storage and processing facilities	Formal credit facilities to support investment in fruit production

Irish potato

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Intense rains	Inadequate nursery material (infected planting material); limited access to inputs (damaged road infrastructure); increased pesticide use and labor costs	Delayed land preparation; increased incidence of soil-borne diseases; increased application of pest and disease-control chemicals; increased demand for extension services and labour costs	Poor quality and low quantity of harvested produce; high post-harvest crop losses (pest/ disease damage); increased labor costs (harvest and storage handling); reduced shelf life	Shortage of the commodities in the market (low supply)
Magnitude of impact	Severe-Major	Severe-Minor	Major	Severe
Farmers' current strategies to cope with the risks	Input subsidies (government provided); selection of clean planting tuber material; utilization of pesticides provided by agrovets	Early planting; use of IPM, GAP strategies for disease and pest control; organic farming; crop rotations; strip cropping; tree planting in tuber fields; integrated land and water management (canals/ drains); advisory services (extension/ development agents); conservation agriculture	Use if IPM strategies to control pest and disease during tuber storage; makeshift shades; manual grading; use of locally available storage resources (gunny bags); use of human labour in harvesting; use of indigenous knowledge for tuber preservation; value addition (in grading and packaging)	Increasing the market prices due to low supply; grain banks at farm and community level
Other potential options to increase farmers' adaptive capacity	Input manufacturing plants (fertilizer plants); improved access to early-maturing tuber varieties and to credit to buy farm inputs	Land pooling by smallholders (increase acreage and economies of scale); improved access to crop insurance schemes and early warning systems	Improved harvest shed and storage structures; research/ provision of tuber varieties with longer shelf life (less moisture); use of open nets and bags (packing); improved packaging materials; equipment for mechanized harvesting	Controlled prices through establishing production policies
High Temperatures	Increased costs of extension service delivery; increased costs of seed production	Poor tuber formation; reduced germination and growth rates; scorching; increased pest/disease incidence; intense pesticide use; poor soil conditions (loss of soil cover)	Prolonged labour requirements; greening of tubers; pest infestation (moth); spread of viral diseases; reduced shelf life	Low volumes of supplied tubers; deteriorated tuber quality; high prices (due to scarcity and high demand); loss of marketing opportunities
Magnitude of impact	Severe-Major	Major-Minor	Major-Moderate	Severe-Minor
Farmers' current strategies to cope with the risks	Use of clean tuber planting material	Early/ staggered planting; use of IPM techniques (pest and disease control); safe pesticide use; conservation agriculture (mulching/ zero tillage); tree planting (wind breaks); crop rotation; intercropping (with maize); small scale irrigated organic farming; use of plastic mulches	Makeshift shade (farm/ field); manual labour for harvesting; household consumption of product, to avoid loss; enterprise diversification on storage structures (store grains/ pastures)	Farm gate sales; local marketing; local supply contracts (organizations/ institutions); disposal of damaged produce for livestock consumption
Other potential options to increase farmers' adaptive capacity	Research and improved access to drought-resistant crop varieties and to credit facilities	Drip irrigation, greenhouses; hydroponic farming; access to early warning system advisories and crop insurance schemes	Construction of on-farm improved storage facilities; use of mechanized harvesting technologies; use of cold rooms; capacity building in value addition	Marketing through cooperatives; niche-based marketing; access to external markets

Policies and Programmes

In Nakuru County, several national and local policies and programs are in place to broadly address problems related to climate vulnerabilities.

The ASDSP, developed in 2010, targets increasing agricultural production and productivity in rural households through capacity building. The program has promoted Participatory Scenario Planning, where beneficiaries (farmers) of a certain intervention are given the chance to identify the most pertinent interventions and most effective implementation strategies. Access to extension services, including 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.

The Interim Coordinating Secretariat (ICS) for the Restoration of the Mau Forest (ICS for the Mau Forest) was set up in 2008. By then, more than 100,000 hectares of forests (of a total of 416,000 hectares of forestland) had disappeared. The Committee was mandated to coordinate the relocation of people residing in the forests, to coordinate the restoration of all degraded forests and critical water catchment areas in the Mau Complex, as well as the mobilization of resources to implement these objectives and secure the sustainability of the entire ecosystem and the overseeing of alternative livelihood programs for the communities living in the proximity of forests. By 2014, the ICS in collaboration with KFS and other development partners, has managed to reduce further encroachment and forest destruction. Thus there is re-emergence of river tributaries after the conservation of Mau Forest. Nyayo Tea Zones, a parastatal, is also engaged in protecting the Mau Forest from encroachment. The parastatal intends to put up a buffer belt by planting 100 m-wide tea farms along the forest boundary in Nakuru, Kericho and Narok Counties that border the Mau Forest.

In the area of crop production, the NCPB has been the main institution to maintain product availability on the market (especially maize) and stable and affordable prices for Kenyan consumers. The Government has occasionally responded to low prices with higher tariffs, but market interventions have evidently focused on maintaining supplies especially in the major deficit market of Nairobi. The longer-term policies focus on increasing production through research, extension and other similar means. The import tariff was waived in response to the 2008 international food crisis and millers and grain dealers were allowed to import maize directly. Kenya has also been increasing its strategic grains stockpile to buffer against shortages. In 2010, the government reinstated the 50% import tariff for countries other than Uganda and Tanzania and the activity of the NCPB declined.

The Dairy Industry Act established the Kenya Dairy Board (KDB) after deregulation of milk prices. KDB's role in the dairy industry is to focus more on dairy regulation and development activities. The Board's main strategic objectives are to improve the quality of Kenyan dairy produce; provide timely and accurate dairy information; stabilize milk production; promote milk production in non-traditional dairying areas; and enhance consumption of milk and milk products.

Some programs aimed at supporting the agricultural sector in Nakuru County include:

- The Smallholder Horticulture Development Project (SHDP), which aims at facilitating farmers to generate income generating activities and market the resultant produce.
- The Kenya Agricultural Productivity and Agri-business Project (KAPAP), which facilitates farmers to form Common Interest Groups (CIGs) to increase productivity.
- The Eastern Africa Agricultural Productivity Project (EAAPP) supports the production of wheat.
- The Irish Potato Seed Multiplication (International Potato Centre [CIP]) programme supports the production of Irish potato through farmer training.
- The Njaa Marufuku Kenya (NMK) programme aims at supporting farmers to access funds for income-generating activities.
- The National Agricultural Accelerated Input Access Programme (NAAIAP) assists farmers with inputs and cereal banking.
- The ASDSP assists farmers increase productivity across identified value chains.
- The Traditional High Value Crops Promotion (THVC) promotes traditional high value crops through bulking and establishment of seed multiplication units.
- The E-extension Project trains staff on the use of information and equipment to reach farmers through e-extension messages.
- The Smallholder Commercialization Project (SHCP) support dairy farming uptake.
- SHEPPLUS which assists farmers to increase productivity of target small holder horticulture farmers
- Kenya Cereal Enhancement Programme which aims to graduate smallholder farmers to commercially-oriented, climate-resilient agricultural practices through improvements in productivity, post-production management practices and market linkages for targeted value chains

Governance, institutional resources, and capacity

There are various government, non-government (NGOs), community-based, faith-based and private organizations in Nakuru County that directly or indirectly deal with climate risks. The government institutions at the County level include the Livestock Production Department (LPD), the Agriculture Department (AD), Irrigation Department (ID), KMD, the National Environmental Management Authority (NEMA), and NCPB. The government departments and organizations are mainly for extension, input provision, and policy support. Specific interventions include extension and vaccination services by the VD, and the design, implementation, and mainstreaming of risk reduction strategies.

Other organizations working in Nakuru County in areas related to addressing food security issues, supporting agricultural development, and providing capacity building services include NGOs such as Hand-in-hand, Self-help Africa, Sustainable Practical Programme for Africa (SUPPA), and Mtakatifu Clara. Training and Research institutions such as KALRO, Egerton University and Baraka College also support climate change interventions. Faith-based organizations are also active and include the Catholic Diocese of Nakuru (CDN) and the Supreme Council of Kenya Muslims (SUPKEM) of Nakuru.

Several factors impair the success of climate risk interventions in the County. The major hindrance is lack of timely and sufficient funding, which hinder institutional capacity to provide effective interventions. Insufficient funds contribute to inadequate human (understaffing) and technical capacity (knowhow). Capacity building of governmental and non-governmental staff on change risk management in the agricultural sector is relatively rare, affecting the ability to transfer capacity and knowledge to farmers (through extension and other services).

Coordination among these institutions and their initiative takes place mostly when designing and implementing the interventions, yet the engagement of local people/ beneficiaries in stages that precede project planning is rather limited.

Lastly, multi-stakeholder fora on climate change are also scarce. No County-specific legislation on climate change describes who and how to enforce climate policies and actions plan in the agricultural sector.

Synthesis and Outlook

Agriculture is the main economic sector in Nakuru County, crucial for both food security, income generation and employment creation. However, climate change continues to affect the sector in various ways. Drought, intense rains and floods, and high temperatures are important indicators of climate change affecting the sector. Therefore, enhanced capacity of all players in the sector to cope with these new conditions is needed. This involves critical short-term and long-term adaptation measures that target production systems and value chains key to 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 Nakuru. These include on-farm practices that target water and soil conservation and management, such as crop rotation, agroforestry systems, and drought-resilient crops and animal types. In addition, off-farm services and programs have been provided to act as enablers for uptake of adaptation options such as provision of early warning systems, extension services, financing and technical support.

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. For instance, without ensuring enabling conditions for input provision and access (seeds, fertilisers, and pesticides), product storage and market access, farmers' livelihoods and incomes remain at risk since climate hazards are expected to affect all important value chain activities. Distribution of the inputs (seeds and fertilisers) should be timely and synchronised with rain cycles given the claims by farmers that the inputs are never available during onset of rains. This can be achieved through construction of more input outlets and collaborations with the KMD. Of particular importance are also investments in road infrastructure that can enable farmers' access markets and in extension and veterinary services. Moreover, value addition can enhance marketing of farm produce and open new markets for farmers.

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 (notably fertilisers, vaccines, irrigation equipment) that could maintain and eventually increase productivity and ultimately incomes.

An enabling institutional policy and governance environment is also critical for addressing climate vulnerabilities of farmers. The formulation and implementation of County-level climate change action plans that are grounded in

local needs and resources assessment could represent an important step towards the operationalization of the country's climate strategy. Furthermore, increased alignment of public and private funds intended 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. Currently the institutions lack sufficient resources to effectively deliver services such as climate information, extension, veterinary support, and subsidies. Promotion of collective action through interventions that target groups can further strengthen the capacity of the players in the sector such as cooperatives that can provide services including bulking, value addition and credit facilities.

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

Annex 1: Agroecological zones in Nakuru county
Annex 2: Proportion (%) of land tenure system, by gender
Annex 3: Agricultural input use in Nakuru
Annex 4: Value chain selection indicators
Annex 5: Climate analysis
Annex 6: Adaptation options in Nakuru as identified in ASDSP

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