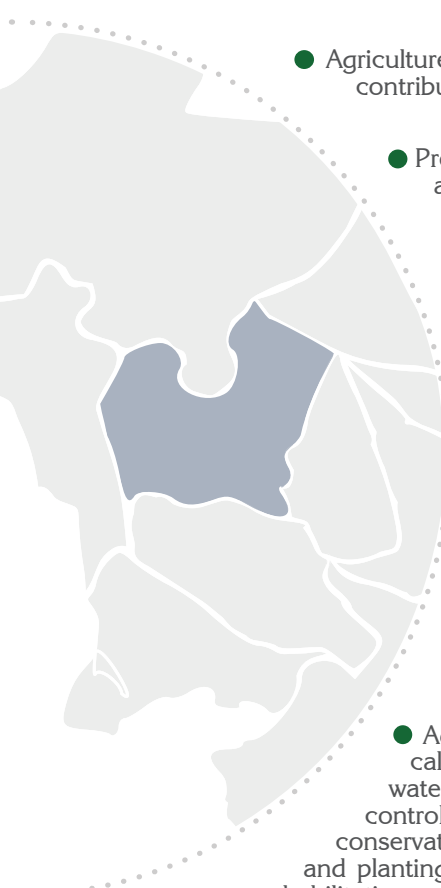


# Climate Risk Profile Nyeri County

## Highlights

- 
- A map of Nyeri County is shown on the left side of the page, with its sub-counties outlined. One sub-county, Kieni West, is highlighted in a darker shade of blue, indicating its vulnerability to drought and landslides.
- Agriculture is an important sector in Nyeri County. It employs approximately 66% of the labour force and contributes about 57% to household incomes (GoK, 2013).
  - Productivity in the sector is low, as it faces several challenges such as poor agricultural credit access, land degradation, poor access to agricultural inputs, crop livestock diseases and most importantly climate hazards. Problematic climatic challenges in the county are drought, extreme temperatures, frost and floods.
  - Kieni East and West are the most prone to floods; Kieni West, East Mukurweini, Mathira West and Tetu Sub-county to drought and Mukurweini, Tetu, Nyeri South, Mathira East and West sub counties more prone to landslides. These hazards affect agricultural production negatively. For instance in 2013 resulted in a 15% decrease in crop areas in Kiamathaga and Munyu locations, and an equal reduction in maize yields (Orre et al., 2013). Drought incidences are foreseen to increase following a decrease in rainfall amounts after every 3-4 years (Karienyne et al., 2012).
  - Despite the high adoption rates of adaptation strategies (72%), 74%, 68%, and 60% for the male-, female- and youth-headed households, hitherto, the youth and female are the most vulnerable due to factors such as limited resource (for example land) control. These adaptations are heavily embedded in the farmers' local knowledge which is based on experience of their local environment and resources.
  - Adaptation strategies for crop farmers include improved seed varieties, changing the cropping calendar, use of indigenous information in controlling diseases, irrigation, water harvesting, soil and water conservation, drought tolerant crops and use of greenhouse, use of indigenous information in controlling diseases, irrigation, and use of greenhouses. Strategies for livestock farmers include fodder conservation, rearing improved breeds, feed supplementation, livestock intensification (zero grazing), and planting drought- tolerant fodder crops. There is need to promote strategies such as tree planting, rehabilitation and conservation of water sheds and value addition for both livestock keepers and crop producers.

## List of acronyms

<b>AEZ</b>	Agro-Ecological Zone
<b>ASDSP</b>	Agricultural Sector Development Support Programme
<b>CAIS</b>	Central Artificial Insemination Station
<b>CEEP</b>	Community Economic Empowerment Programme
<b>ECF</b>	East Cost Fever
<b>EMCA</b>	Environmental Management and Coordination Authority
<b>ERPARDP</b>	Economic Recovery Poverty Alleviation and Regional Development Programme
<b>ESP</b>	Economic Stimulus Programme
<b>FFEPP</b>	Fish Farming Enterprise Productivity Programme
<b>FMD</b>	Foot and Mouth Disease
<b>GEF</b>	Global Environmental Facility
<b>GoK</b>	Government of Kenya
<b>HDI</b>	Human Development Index
<b>IFAD</b>	International Fund for Agricultural Development
<b>KACCAL</b>	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
<b>KALRO</b>	Kenya Agricultural and Livestock Research Organization
<b>KAPP</b>	Kenya Agricultural Productivity Programme
<b>KENAFF</b>	Kenya National Agricultural Federation of Farmers
<b>KDB</b>	Kenya Dairy Board
<b>KLPA</b>	Kenya Livestock Producers Association
<b>KMD</b>	Kenya Meteorological Department
<b>KNBS</b>	Kenya National Bureau of Statistics
<b>KVA</b>	Kenya Veterinary Association
<b>LH</b>	Lower Highland
<b>MoALF</b>	Ministry of Agriculture Livestock and Fisheries
<b>NDMA</b>	National Drought Management Authority
<b>NCD</b>	Newcastle Disease
<b>NMK</b>	Njaa Marufuku Kenya
<b>PEGRESS</b>	Project on Enhancing Gender Responsive Services
<b>PSP</b>	Participatory Scenario Planning
<b>SCCF</b>	Special Climate Change Fund
<b>SHEP-UP</b>	Small holder Horticulture Empowerment Unit Project
<b>VCC</b>	Value Chain Commodity
<b>WB</b>	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 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 (MALF) 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. 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.

This document presents the Climate Risk Profile for Nyeri County. The county is prone to both drought and floods since some areas are semi-arid (those lying on the leeward side of Mt. Kenya) and others very wet. Rain patterns in Nyeri County have changed, with amounts decreasing after every 3-4 years (Karienyee et al., 2012). Drought is common in the semi-arid Kieni West, East Mukurweini, Mathira West and Tetu where the consequences include crop failures (if crops are

still in the field), or no planting at all (if the drought comes before farmers plant) and reduction in milk production following a decrease in quantity and quality of pastures. For instance the drought of 2014 that resulted to crop failure in the constituency exposed 180,000 people (33,000households) to food insecurity (Kenya News Agency, 2014). This saw food prices go high especially for beans where a kilogram was selling at 90 Kenya Shillings from 75 Shillings, a kilogram of tomato at 60 shillings from 50, and Capsicum selling at 100 a kilogram from 70 shillings (Business Daily, 2014), making it hard for farmers to procure supplies for planting and consumption; necessitating food aid interventions. The same was witnessed in 2016 when there was a remarkable decrease in water volumes in rivers, water pans and dams, increase in distance to water sources, decline in milk production, increase in food prices and increase in malnutrition cases (NDMA, 2016). In addition to the droughts, Nyeri County residents also suffer loss due to floods. For example, the floods of 2015, which destroyed crops, livestock and assets, displaced thousands in Kanyagia location in 2015 (Star, 2015). These extreme events compromising the livelihoods of thousands of people in Nyeri call for deliberate efforts in building resilience and adaptive capacity of the vulnerable.

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

# Agricultural context

## Economic relevance of farming

Nyeri is one of the 47 counties of Kenya located in the Central region of the County. It covers about 3,337 km<sup>2</sup><sup>1</sup> (KNBS, 2014) and borders Nyandarua County to the West, Kirinyaga County to the East, Muranga County to the South, Laikipia County to the North, and Meru County to the North East. The county is rich in natural resources with main features being the Mount Kenya, the Aberdare ranges and hills like Tumutumumu, Nyeri, and Karima. The main rivers in the county include river Chania, Sagana, Ragati and Gura whereas the wetlands include Thuti, Kandune, Njengu, and Kianjogu swamps. The terrain is rugged, making exploitation of the rivers for irrigation a challenge (see Annex 1 for a description of the administrative division of the county).

The monthly mean temperature in the county is about 12.8-20.8°C (GoK, 2013). Rainfall is bimodal, with the Long rains, normally 1,200 -1,600 mm, coming between March and May and the Short rains, normally 500 -1500 mm, coming between October and December (Ibid)<sup>2</sup>. There are year-to-year variations of amounts of rainfall received as well as variations across regions within the county. Some regions for instance in Agro-ecological Zone LH2, LH3 and LH4 receive trimodal rainfall where the middle rains come between July and August.

- The county is parceled out into 15 agro-ecological zones (AEZs) (Jaetzold et al., 2010) (see Annex 1):
- TA0, which is under National Park (Othaya, Tetu, and Kieni)
- TAI, which is also under National Park (Mt. Kenya; Mathira and Kieni).
- UH0, also known as the Forest Zone, is under Forest Reserve (Othaya, Tetu, Kieni, and Mathira).
- UH1, also known as the Sheep and Dairy Zone, receives about 1080 - 2000 mm of mean annual rainfall and lies at an altitude of 2070-2400 m (Othaya, Tetu, Kieni and Mathira).
- UH2, also known as the Pyrethrum - Wheat Zone (though crops such as onions, cabbage, carrot and kales are also produced in the zone), receives about 2130-2380 mm of mean annual

rainfall and lies between 2130 and 2380 m above sea level (Kieni).

- UH3, also known as the Upper Wheat-Barley Zone, receives 900-1050 mm of mean annual rainfall and lies between 2130 and 2200 meters above sea level (Kieni and a bit of Mathira).
- LH1, also known as the Tea-Dairy Zone, receives 1400-1800 mm of mean annual rainfall and lies at an altitude of 1950-2070 meters (Tetu Othaya and Mathira).
- LH2, also known as the Wheat/Maize-Pyrethrum Zone, receives about 950-1050 mm of mean annual rainfall and lies between 1830 and 2100 meters (Kieni, Tetu, and a small section of Mathira).
- LH3, also known as the Wheat (Maize)-Barley Zone, receives 850-1000 mm of mean annual rainfall and lies at an altitude of 1980-2130 meters.
- LH3-4 is a transitional strip which receives about 830-930 mm of mean annual rainfall and lies between 1900 and 2100 meters above sea level.
- LH4, also called the Cattle-Sheep Barley Zone, receives 770-820 mm of mean annual rainfall and is 1800-1980 meters above sea level
- LH5, also known as the lower Highland Ranching Zone, receives about 650-850 mm of mean annual rainfall and is 1890-1950 meters above sea level (Kieni).
- UM1, also known as the Coffee-Tea Zone, receives 1100-1600 mm of mean annual rainfall and is 1710 -1780 meters above sea level (Othaya and Mathira).
- UM2, also known as the Main Coffee Zone, about 950-1500 mm of mean annual rainfall and is 1460 -1710 meters above sea level (Mukurweini, Mathira, Othaya, and Tetu).
- UM3, also known as the Marginal Coffee Zone, receives about 870-1000 mm of mean annual rainfall and lies at an altitude of 1220-1780 meters.
- UM4, also known as the Sunflower-Maize Zone, receives 850-900 mm of mean annual rainfall and is at an altitude of 150-1780 meters (Kieni and Nyeri Town).

1 This land area is different from the one given in GoK, (2014) of 2475 Km<sup>2</sup> since it includes the area covered by Mt. Kenya and the Aberdare forest.

2 The figures represent annual rainfall.



The agricultural sector is the mainstay of the economy of Nyeri County. Agriculture comprises mainly cultivation of cash and food crops, and rearing of livestock and fish. It employs approximately 66% of the labour force and contributes roughly 57% to household incomes (GoK, 2013). The major cash crops grown in the county include tea, mostly grown in Mathira, Othaya and Tetu, coffee is mostly grown all over the county except in Kieni, and horticultural crops (carrots and kales) mostly in Kieni. The major food crops grown in the county include maize, Irish potatoes, beans, and vegetables whereas the major livestock kept include dairy cattle, poultry, goats, pigs, sheep and donkey. In 2012, crop produce in the county was valued at 6,937.59 million Kenya Shillings; the biggest portions of - 42, 21, and 16% came from horticulture, maize and Irish potatoes respectively (GoK, 2014). The livestock produce in the same year was valued at 4.76 billion Kenya Shillings, the largest contributions coming from cow milk (74%) and beef (15%) (Ibid).

Arable land in the county accounts for 70% (987.5 km<sup>2</sup>) of the total land area (GoK, 2013). Agricultural production in Nyeri is mainly for subsistence purposes. The average farm size is between 4.5 ha for small-scale farms and 22.5 ha for large-scale farms, though the land holding is larger in areas such as Kieni (GoK, 2014). A majority of farmers (85%) have title deeds, a factor that might be traced back from independence (Nyeri being one of the white settlement areas in Kenya) as well as the sedentary lives of the people in the county. Secure land tenure is an incentive for farmers to invest in long-term soil and water conservation measures.

## People and livelihoods

Nyeri County had a population of 707,003 persons, with almost equal percentages of females and males (51 and 49% respectively) in 2012 (GoK, 2013). A large proportion (87%) of this population is rural given the small number (six) of urban areas in the county (GoK, 2013). The population is projected to be 721,791 in 2017, growing at an average rate of 1.5% based on the 2009 census<sup>3</sup> (GoK, 2014). This growth rate is relatively smaller compared to the national rate of 2.9%, a factor that can be attributed to the high acceptance (63%) of birth control measures.

Nyeri County falls under the bottom ten counties with regard to poverty indicators given that approximately

28% of the people live under the poverty line (KNBS, 2013a). Poverty rates are higher in the urban areas (57%) compared to the rural areas (32%) (GoK, 2013). This is despite the fact that the unemployment level stands at 21% (Ibid). Low incomes from the economic activities undertaken in the county may be a contributing factor to the high urban poverty level. Nevertheless, the county is characterised by a high quality of life given that the Human Development Indicator (HDI) is higher than the national figure (0.58 and 0.52 respectively). The high HDI is as a result of relatively high access to electricity considering that approximately 26% of the households use electricity for lighting (KNBS, 2013b), though only 1% of the population uses electricity for cooking (GoK, 2013); better access to health services; and relatively fewer people (12%) with no education, making the county rank third last with regard to people without education. The climate vulnerability for the county is 0.245, which is among the lowest in all the counties (GoK, 2013c). This makes it clear that farmers' welfare and quality of life are instrumental factors that promote the adaptive capacities to climate change.

Food poverty in Nyeri is estimated at 26%<sup>4</sup>. The relatively low percentage may not necessarily mean that the county is well off in terms of food security. There are variations in the county with some areas such as Kieni being more prone to food insecurity. According to a survey by the Agricultural Sector Development Support Programme (ASDSP), approximately 70% of the households interviewed did not have enough food in 2013. Female- and youth-headed households were the most affected (GoK, 2014). The cases of food insecurity may be attributed to fluctuations in agricultural production due to unfavourable climatic conditions such as frost and unreliable rainfall, diseases such as the Maize Lethal Necrosis, and low incomes from alternative livelihood activities.

## Agricultural activities

Out of the total arable land in Nyeri, 61% (60,662 ha) is under food crops whereas 22% (21,593 ha) is under cash crops<sup>5</sup> (GoK, 2014). In 2014, maize occupied approximately 62% of land under food crops whereas Irish potatoes occupied 7%<sup>6</sup>.

Agriculture in the county is largely dependent on rainfall since only 16% of the potential land for irrigation has been exploited (Kenya Open Data). Some of the factors

3 These figures for the projected population in 2017 are slightly different from those in GoK (2013) of 720,708. The growth rates in the CIDP of 0.48 significantly with the mentioned rate of 1.5.

4 This is the percentage of people who are unable to get nutritious and enough food due to financial constraints.

5 This is slightly different from what is mentioned in GoK (2013a).

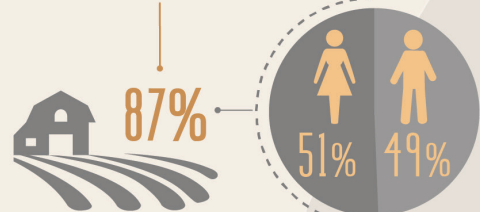
6 The percentages were obtained from data provided in GoK (2015).

# Livelihoods and agriculture in Nyeri

## Demographics

1.8% Of Kenya's population

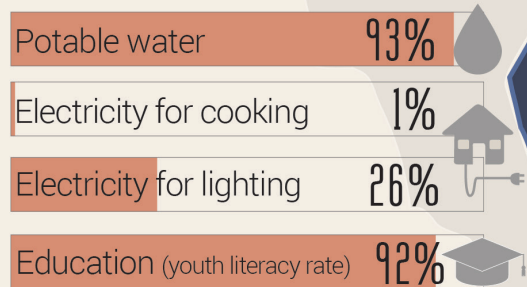
707,003 inhabitants



87% Live in rural areas

## Access to basic needs

29% of the population lives in absolute poverty



## Food security

26% of the population suffers from food poverty

ND of household income spent on food

ND People undernourished  
21% Children stunted  
3% 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 98,750ha (30%)

66% of the population employed in agriculture production

85% of farmers have title deeds ND% are women

## Farming activities

Food crops



Cash crops



Livestock



Cattle (heads) 176,375  
Chicken (heads, indigenous) 300,000  
Goat (heads) 88,310

Of county's agricultural land

## Farming inputs

### Water uses



### Fertiliser types (% of households)



64% Organic manure  
66% Basal fertiliser  
39% Top dress fertiliser

### Pesticide types (% of households)



20% Field pesticides  
46% Storage Pesticides  
10% Herbicide

limiting full exploitation of the irrigation potential include the rugged terrain and decline in water levels in most of the water bodies/reservoirs. The use of agricultural inputs in the county is relatively low with an exception of basal fertiliser which approximately 66% of the farmers have adopted. The male-headed households are more likely to use agricultural inputs in both the Long and Short seasons compared to the youth- and female- headed households (GoK, 2014). For instance, about 31, 6, and 3% of the farmer households using top dress fertiliser were male-, female-, and youth-headed respectively in 2013 (Ibid). This factor may be attributed to the fact that men have better access to resources such as credit and are the custodians of the household resources. Interventions such as Input Subsidy Programmes should therefore be more targeted to benefit the gender and age groups that are most disadvantaged. This may be done through addressing contributing factors to low input utilization like high input prices and unavailability of certified seeds.

### Agricultural value chain commodities

Nyeri County is famous for the production of an array of agricultural commodities (value chains). Various value chains have been prioritized for development interventions by different government organizations and programmes such as the Agricultural Sector Development Support Programme (ASDSP), the Kenya Agricultural and Livestock Research Organization (KALRO), the University of Nairobi survey, and the Kenya

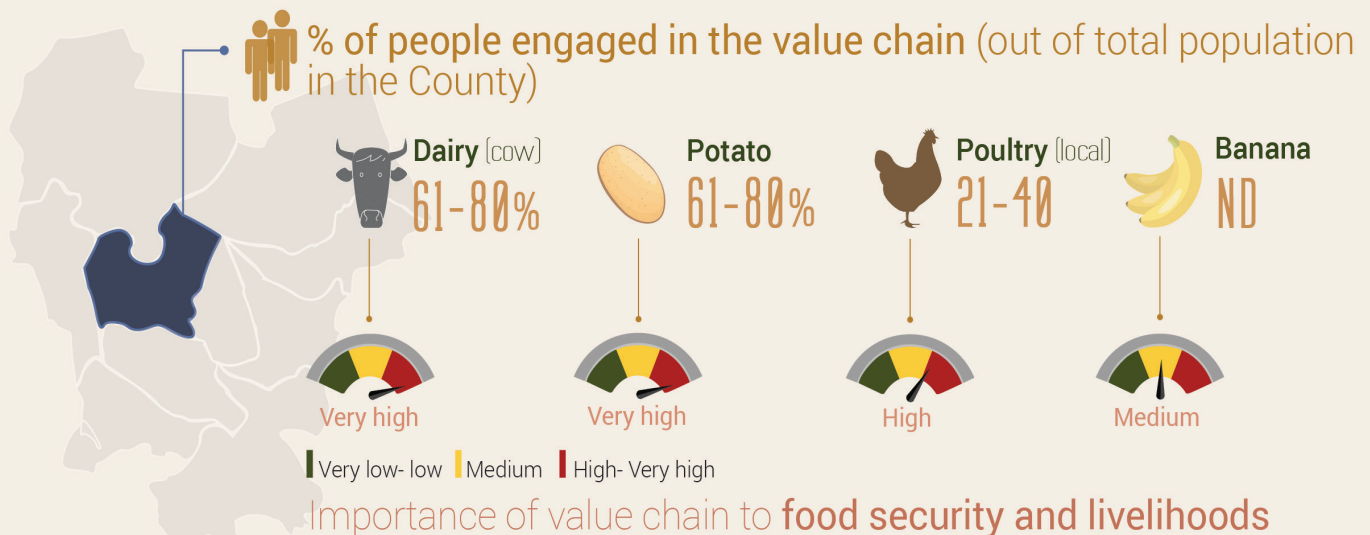
Agricultural Productivity Programme (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics, and importance to the economy. These VCCs, validated by local stakeholders, have been selected from a list compiled from the above-mentioned documents, using the following prioritization indicators: harvested area (hectares), production (90-kg bags where relevant), variation in production (in the past five years), value of production (KES/bag), dietary energy consumption (Kcal/capita/day), protein content (g of protein/100 g of product), iron content (mg of iron /100 g of product), zinc content (mg of zinc/100 g of product), and Vitamin A content (IU Vitamin A/100 g of product). The selected value chains were dairy, Irish potato, banana, and local poultry.

### Dairy (cow)

The dairy cow is a vibrant value chain in Nyeri especially in Nyeri South where every household has at least a dairy cow - either local, interbreed and/or exotic breeds (mostly Friesian, Guernsey, Jersey, and Ayrshires. The dairy cow population in the county was estimated at 173,075 in 2014, with a production of 175,747,872 kg of milk (GoK, 2015). Dairy production in Nyeri is mainly under zero grazing given land constraints.

Of all the total milk produced, approximately 27% is consumed, 62% is sold, 7.7% fed to calves, and about 3.5% lost during handling (Nassiuma and

## Agricultural value chain commodities in Nyeri



Nyoike, 2014). The common marketing outlets include processors like the New Kenya Cooperative Creameries, Brookside Wakulima Dairy and Raka, traders and individual consumers. Approximately 37% of the farmers sell directly to processors and about 32% sell to traders (Ibid). There exist a number of marketing channels for milk in the county, where the producer may sell directly to the consumer, or producer to hawker to consumer or producer to processor to consumer. It has been observed that the shorter the channel the better the prices for the producers and the consumers.

Productivity has been observed to be highest among the female-headed households. For example, in 2013, female-headed households had the highest productivity in both the Long and Short rain seasons compared to the male- and youth-headed households. This was despite male-headed households having better access to livestock technologies, extension, veterinary and Artificial Insemination (AI) services (GoK, 2014). This may be due to the fact that women are the ones most involved in activities such as feeding and milking, making them more conversant with farm operations. Some of the major challenges include diseases such as mastitis and decline in pasture quantity and quality especially during periods of rain scarcity. It has been observed that feed scarcity can lead to up to 60% reduction in milk production in the county.

## Irish Potato

Irish potatoes are mainly grown in Kieni East and West, and Mathira West and East. Production is dominated by small- scale farmers, who grow for both household consumption and income earning. However, more than 60%<sup>7</sup> of their produce is mainly for selling (Muthoni et al., 2013); farmers sell mostly to brokers.

Farmers use recycled planting material; the local varieties are the most preferred due to lack of certified seeds. In 2013, productivity was highest among the female-headed households in the Short rain season (3433 kg/ha) and among the male-headed households during the Long rain season (5580 kg/ha) (see Annex 2). The higher productivity among the male-headed households in the Long rain season was likely due to the high input utilization (GoK, 2014).

The major challenges to the value chain is lack of planting material and the pest Tuta Absoluta that can cause up to 50% decline in yields. The pest is

becoming hard to control, considering that it can stay in the soil for up to 30 years. Due to land fragmentation, farmers are not able to practise measures such as crop rotation. Marketing is also a challenge, more especially in packaging. By law, potatoes are supposed to be packed in 50-kg bags and sold at 2000 Kenya Shillings each, but most of the time, brokers use bags that weigh more than 100 kg hence exploiting farmers.

## Local poultry (chicken)

The poultry sector ranks third in the county after dairy and beef sectors in terms of income generation in livestock production (GoK, 2014). The chickens are kept for eggs as well as meat. Farmers are mostly small scale (all over the county); every household has at least a chicken, though production is concentrated in Othaya. Input suppliers are mostly small scale with a few exceptions of companies such as Kenchic, Kuku Chick, and Brade Gate (supplying chicks) and Maisha Millers who supply feeds. In 2014, there were about 298,666 local poultry chicken in the county; production in the same year was 250, 471 kg of meat and 9,345,349 trays of eggs<sup>8</sup> (GoK, 2015).

Productivity varies across age and gender due to different levels of access to markets and resources by the different groups. For instance in 2013, youth-headed households had the highest number of eggs sold for the indigenous chicken (2,596), whereas male-headed households sold the most eggs for improved indigenous chicken (103) (GoK, 2014). The high number of eggs sold by the youth-headed households is attributable to the likelihood of having contractual arrangements for selling the eggs as shown in the ASDSP survey of 2013. It also shows that the age group is more dependent on local poultry compared to the female-and male-headed households. Ability to purchase and utilize commercial inputs may be a contributing factor for the many improved indigenous chicken eggs sold by the male-headed households.

Value addition activities undertaken in the value chain include de-feathering, differentiation of parts, fertilizing eggs, and boiling. The major challenges for the poultry sector include diseases such as Newcastle, Gumboro, fowl pox, and coccidiosis. Scarcity of chicken feeds especially when there are no rains is a major problem for the value chain. The alternative is for farmers to use commercial feeds, which are sometimes unavailable and expensive.

7 This is in contrast with the figure (19%) given in GoK (2014) pp 28.

8 A tray contains 30 eggs



## Banana

Bananas are mainly grown in Mukurweini Tetu, parts of Othaya, Mathira East and West, Nyeri Central and some parts of Nyeri South mostly on small-scale. The common banana varieties include Gikanda, Grand-Nain, Williams, and Ng'ombe Nusu, though local varieties such as Gikanda are the most grown. Farmers are starting to embrace tissue culture banana like in Karima and Chinga locations of Othaya. Brokers and local markets are the major output markets with exceptions of a few groups such as Nyeri County Banana Farmers Cooperative Society and Urumwe Self Help Group who undertake value addition through making banana flour and selling to a local bakery (Kenyan Woman, 2016). Other value addition activities for the value chain include ripening and solar drying.

Farmers rarely pay attention to their bananas so yields are low. For example, in 2013, productivity was found to be highest among the male-headed households (1047 kg/ha) compared to the female- and youth-headed households (704 and 951 kg/ha respectively) (GoK, 2014). This difference in production may be associated with the likelihood of male-headed households to use inputs such as basal and top dressing fertilisers (which both the female- and youth-headed households never used), and more manure (14543 kg/ha) relative to the quantities used by the youth and female headed households (3347 and 440 kg/ha respectively) (Ibid). Poor access to resources by the youth- and female-headed households is a contributing factor to the low input utilization. Therefore interventions in the value chain should seek to promote input access mostly to the youth and the adult females.

The major challenges for the value chain include high pest (banana weevil and nematodes) and disease (cigar end rot and fusarium wilt) incidences, lack of certified disease-free planting material, and post-harvest losses.

## Agricultural sector challenges

In the past, Nyeri County was among the counties that received food aid, despite its agricultural potential. This potential has not been achieved yet due to institutional, economic, political, geographical and climatic challenges.

Unfavourable climatic conditions impose serious consequences on the agricultural sector in Nyeri. This is worsened by over-reliance on rainfall amid weather unpredictability especially in areas such as Kieni where

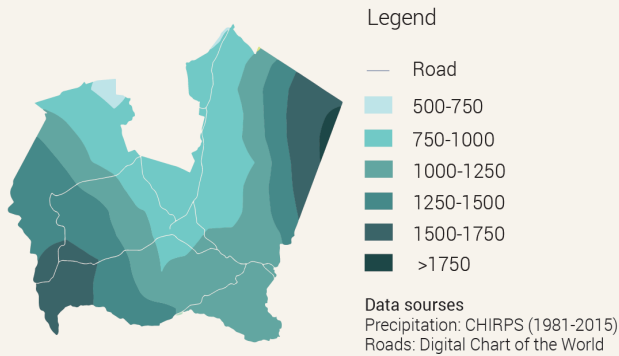
droughts and floods are common. Extreme weather events tremendously reduce the quantity and quality of produce, factors that not only compromise food security and income generation capacity in the area, but also reduction in cultivated land. For example, it has been observed that areas under potato, wheat, sunflower, and beans have been reduced by 40, 70, 30 and 40% respectively due to unfavorable weather (GoK, 2013). This factor is likely to increase rural urban migration and unsustainable exploitation of natural resources for alternative livelihoods. Inasmuch as unfavorable weather is a problem in the county, good weather is equally disastrous as over-supply results in market distortions. Lack of adequate storage facilities, given that there are only eight main storage facilities in the entire county and lack of capacity to add value aggravates the problem since farmers cannot store their produce.

Population growth in the county has led to sub-division of land into small pieces that cannot permit sustainable rain-fed agriculture (Ekin et al., 2009 pp10). This is more evident in the wetter areas of the county such as Mathira, Nyeri central, some parts of Mukurweini and Othaya where the population densities are very high (648, 711, 470 and 501 persons/km<sup>2</sup> respectively) (GoK, 2013). The women and the youth are the most affected; women in the sense that culture sidelines them when it comes to inheritance and youth in the sense that they have limited access to land since the male-headed households are the ones who own title deeds. Consequently, the youth are forced to depend on leased land that constrains undertaking long-term soil and water conservation investments. Agricultural intensification through practices like irrigation is also challenged by the rugged terrain and lack of financial and technical capacity by most of the small scale farmers.

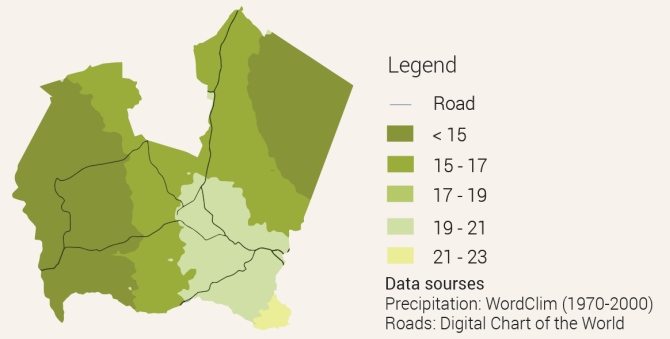
Pests and diseases challenge agricultural production in the county. The common pests include Tuta Absoluta that attacks mainly potatoes and tomatoes. The pest caused about 50% reduction in potato yields in the county in 2016 (Farmers trend, 2016). Millipedes resulted in a decline in cultivated land in Gakawa, Naro Moru, and Kiamathaga in Kieni West and in the lower areas of Kieni East in 2014 (NDMA, 2014). Crop diseases common in the area include the bacterial wilt and potato blight that mainly attack potatoes. Livestock diseases include foot and mouth disease (FMD), East Coast Fever (ECF), Anaplasmosis and Newcastle diseases (NCD). The diseases and pests increase the cost of production and reduce the quantity and quality of produce.

# Past and future impacts of climate hazards in Nyeri

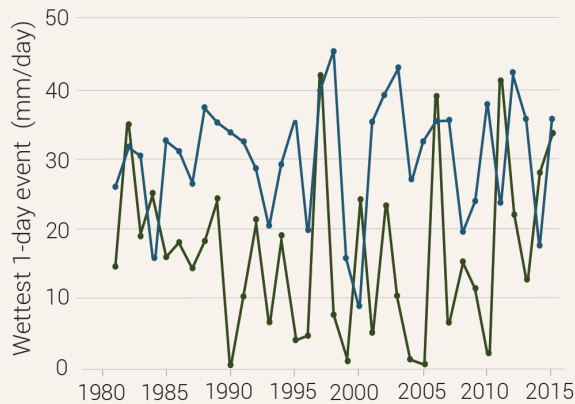
## Historical annual mean precipitation (mm/year)



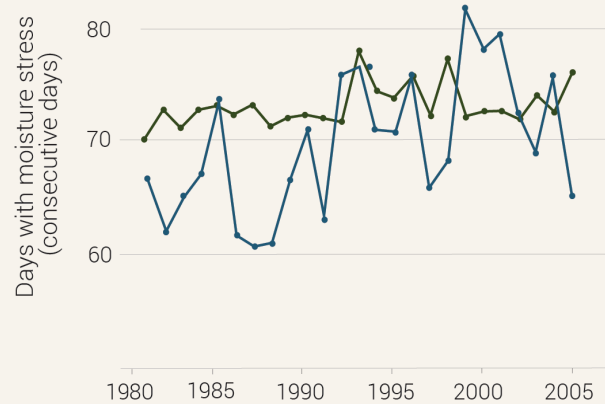
## Historical annual mean temperature (°C)



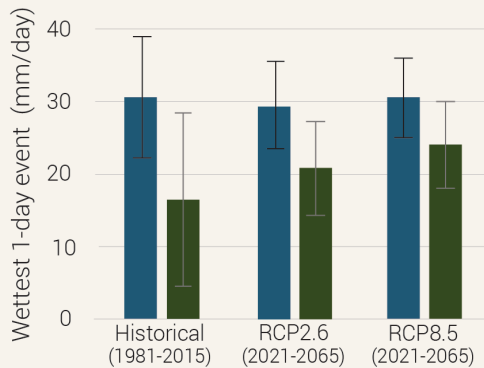
## Historical extreme flood events



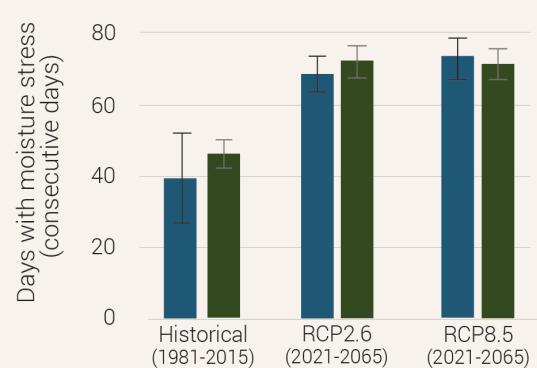
## Historical drought stress events



## Historical and expected extreme flood events



## Historical and expected drought stress events



■ January - June ■ July - December

Poor access to agricultural services such as AI, credit, extension and inputs especially by the female- and youth-headed households is a hindrance to high agricultural production. According to the ASDSP survey of 2013, male-headed households had better access to the services, a factor that may be attributed to better access to resources (GoK, 2014). Poor access to credit persists in spite of the large number of financial intermediaries in the county (Kalunda, 2014). This has been mainly attributed to lack of financial literacy among farmers and the allegedly high interest rates which make farmers shun seeking credit. This therefore calls for farmer sensitization on credit. Access to extension is expected to improve owing to the contracted extension service delivery strategy by the Kenya Agricultural Productivity and Agribusiness Programme (KAPAP) that has so far benefited 10,107 farmers in the county (Ngugi et al., 2014).

Poor farmer organization also deprives farmers of bargaining power that can facilitate efficient marketing. As a result, farmers mostly sell individually especially for horticultural crops such as cabbages, potato, and kales, and hence get exploited by middlemen. Due to the poor organization, legislations like the Potato Production and Marketing Bill of 2014 are never adhered to as farmers still fall victim to the extended bags preferred by brokers. Mismanagement of most of the cooperatives for cash crops such as coffee and tea that leads to delayed payment has significantly contributed to farmers uprooting the crops hence reducing productivity. Therefore, farmers should be encouraged to add value and to organize into groups to facilitate access to agricultural services as well as markets. In addition, poor road conditions in the county that impair transport during the floods season is also a contributing factor to poor access to the services and markets.

## Climate change and agriculture risks and vulnerabilities

### Climate from the farmers' perspective

Climate variability is a reality in Nyeri that has manifested itself in many forms as farmers reported. Remarkable manifestations include prolonged cold seasons, increased incidences of frost (mostly associated with dry spells), extended rainy seasons in some areas such as Mukurweini that result to mudslides whereas others

like Kieni experience prolonged drought, and extreme temperatures. In the past, the cold season spanned July to August, but now it begins in May through August. Temperatures have become higher now especially during dry spells unlike in the past. Rain distribution is becoming unreliable and unpredictable. For example, the long rains of 2013 were delayed by 2 weeks in Kieni, and about 70% was received in April alone. These changes are in tandem with accounts that have been made in other forums such as the consultative stakeholder workshop on the development of the national climate change response strategy action plan (GoK, 2012) and Roncoli et al. (2010).

It was agreeable among farmers that the changes have mostly been brought about by human activities such as clearing of the Aberdare and other forests in the county and cutting down of indigenous trees such as mugumo, muiri, mutundu, and muringa (which they believe attract rainfall) for human settlement and burning of charcoal or replacing them with exotic trees like the eucalyptus. The farmers are aware that climate change has brought about a change in the ecosystem, where some species of insects which were not common for instance millipedes and centipedes have in the recent past increased and others like the safari ants disappeared. The farmers also reported that there has been substantial loss of plant biodiversity evident from the declining pasture land. This factor, together with decrease in water volumes in many water reservoirs has resulted in increased human wildlife conflict, an example of which was reported in the news<sup>9</sup>. It was reported that some water ways like river Gathanji in Mahiga location, river Gichanga in Kagere location and River Kahuro in Mwanda location have dried up.

Farmers also associated societal problems such as food insecurity and increased cases of domestic violence with climate variation. This mainly arises from the low productivity, for crops and livestock alike which translate into low household incomes. Incidences of human diseases such as malaria have increased, following increasing mosquito populations in the region. This account together with those already mentioned agrees with scientific knowledge that climate variation if not checked can have serious implications on the ecosystem and human livelihoods.

9 <http://www.standarddigitalworld.co.ke/ktnnews/video/watch/2000087680/-human-wildlife-conflict-in-aberdare-forest>

## Climate vulnerabilities across agriculture value chain commodities

A number of climatic hazards are evident in Nyeri as discussed above, the most remarkable being drought and extremely low temperatures. The most problematic with regard to the prioritized value chain were identified as drought and variations in extreme temperature/frost. These hazards affect the value chains differently as discussed below.

### Dairy (cow)

Drought and extremely low temperatures/frost are the most problematic hazards to the dairy cow in Nyeri County. The consequences of drought on the dairy cow are severe in all the value chain stages viz, input supply, on-farm production, post-harvest handling, and marketing. During dry spells, the quality and quantity of major fodder crops like Napier grass, fodder maize stalks, and in some cases oats, leucaena, and calliandra tremendously decrease due to scarcity of water. This requires farmers to use alternative strategies such as commercial feeds (supplements) and hay which are not always affordable, considering that feeding takes approximately 70-80% of the production cost (Mbugua et al., 2012). Due to poor feeding, milk yield decreases and quality deteriorates. The cow also gets more prone to diseases such as FMD due to low immunity, consequently increasing costs incurred on veterinary services. The low quantities produced impair marketing as they increase transport costs making farmers resolve to sell directly to consumers. The high temperatures associated with dry spells have also been associated with interruption of the oestrus cycle of cows, hence reducing fertility.

Extremely low temperatures/frost on the other hand also affect input supply severely, whereas the impact on on-farm production and post-harvest losses is minor to severe, and moderate to severe at the marketing stage. Extremely low temperatures/frost, also lead to poor performance of fodder crops. For instance in 2013, frost damaged 60% of Napier in Kieni East, leading to feed scarcity. Disease and pest proliferation was also reported to be common during periods of extremely low temperatures/frost. Cold temperatures also reduce milk production since the cow utilizes more energy in regulation of body temperature instead of producing milk hampering marketing, and increasing transport costs.

Low resource base for instance land is a major factor that is making farmers poorly adapt to the hazards. For example, farmers are not able to undertake fodder conservation due to lack of capital which also makes farmers lack the capacity to comply with the requirements for having a certificate as milk vendors. This factor, coupled with poor farmer organization, limits marketing options. In addition, the poor road network in the county and lack of coolers are factors that impair value addition for milk in Nyeri.

### Irish Potato

Irish potato in Nyeri is mostly affected by extremely cold temperatures (frost), and drought. The impact of frost on input supply is minor to major, moderate on on-farm production, major on harvesting and storage and minor to major on output marketing. Frost reduces the quality of planting material, causing poor establishment when planted. As a result, planting material becomes unavailable due to increased demand. On-farm activities affected include land preparation and disease control. It was reported that land preparation and disease control costs increase significantly during the cold season due to harsh working conditions and an upsurge of pests (millipedes) and diseases (bacterial wilt, early and late blight). Consequently, farmers are required to use more fungicides, or harvest prematurely to salvage the crop, with the yields being below normal and of poor quality. The prematurely harvested potatoes are of poor quality and hence cannot be stored. Low produce volumes increase the per unit packaging and transporting costs.

Drought on the other hand causes a major decrease in availability and quality of planting material at the input supply stage. At the on-farm production stage, the effect can be major to severe, affecting mostly land preparation due to hardening of the soils (black cotton soils), and pest and disease control as costs increase due to increased disease and pest incidences. Farmers bypass the challenge of fertiliser use normally by using organic fertiliser and manure. Notwithstanding, these factors compounded result to low yields and poor quality produce; exposing the farmer to the same transport challenges as during extreme cold.

Lack of certified seed potato and the capacity to add value are some of the factors making farmers adapt poorly to these hazards. In addition, due to land

fragmentation in the county, farmers are unable to adopt measures such as crop rotation in disease and pest control.

### Local chicken (Poultry)

The effect of drought on local chicken is moderate to severe at the input supply stage. The most affected activities at this stage are seeking veterinary services and procurement of chicks. The cost incurred for the veterinary services significantly increase due to more demand created by high disease incidences (Newcastle disease) and deterioration in quality of the vaccines. Mortality rate of chicks purchased from distant hatcheries normally increase during drought, a factor that may be associated with high temperatures common during dry spells. Severity on on-farm production, mostly feeding, is moderate. Dry spells normally result in scarcity of feeds, hence reduced feeding and low egg production. Consequently, farmers are required to use commercial feeds which increase the cost of production remarkably. High temperatures associated with drought also lead to a moderate reduction in the shelf-life of eggs and meat<sup>10</sup>, a problem that is aggravated by the lack of storage facilities in the county. Effect at the output market is severe to major, mostly during selling. Farmers lack bargaining power due to the low production as they have to sell to individual consumers in the local markets with an exception of a few cases where farmers sell the eggs collectively.

Extremely low temperatures (frost) inflict the same consequences as drought on the value chain with a moderate to severe effect at the input supply stage, a moderate to severe effect on on-farm production, a moderate to major effect on harvesting and storage, and a major to severe effect on marketing. In addition to resulting in feed scarcity at the farms, extremely cold temperature increases chick mortality rates. This is mostly common among farmers who cannot afford equipment such as incubators. Low production during extreme temperatures also impairs marketing as farmers lack bargaining power. The same adaptation strategies used during drought are also used during periods of extremely low temperatures. Lack of capital to enable farmers purchase equipment like incubators, little know-how on good husbandry methods, and lack of storage facilities are some of the major hindrances to farmers' ability to adequately adapt to the hazards.

### Banana

The banana plant is known to be very sensitive to changes in the environment (Turner et al., 2007). Drought and extremely low temperature/frost are the most problematic hazards to the crop in Nyeri County. Drought severely affects the banana at input supply, on-farm production, post-harvest handling and marketing stages. At the input supply stage, the most affected activity is acquisition of planting material as drought reduces the quality of the seedlings. Poor establishment of the seedlings when planted requires farmers to purchase more planting material hence more costs. Due to the hard nature of the soil during dry spells, banana root establishment is greatly impaired. This factor coupled with scarcity of water in the banana pseudo-stem results in collapsing of the stems. Drought has also been associated with weight loss during transportation, especially when the bananas are transported over long distances, a situation worsened by lack of specialized transportation trucks. The low productivity and poor quality associated with these consequences pose marketing challenges; transport costs increase owing to the low volumes and farmers receive lower prices due to poor quality. Some of the adaptation options used by farmers include using certified planting material, water harvesting and small scale irrigation, establishment of collection centres, and group formation to facilitate value addition like making banana flour.

The magnitude of the impact of extremely low temperatures/frost on the input stage is minor, minor to severe on the on-farm stage and severe on both the post-harvest and product marketing stages. Extremely low temperatures influence input prices, especially those of planting material. This arises from high demand for the input as a result of poor on-farm establishment. In addition, manure quality is likely to be low when temperatures are extremely low. This may be attributed to the poor quality of feed that animals feed on when temperatures are extremely low. As a result, banana productivity declines, considering that farmers mainly depend on manure for soil replenishment for banana. Storage of banana is also a challenge since it is highly sensitive to temperature; higher temperatures result in quick ripening and low temperatures cause rotting. Farmers therefore have to sell to local markets either as whole bunches or banana hands; the latter increases profit margins.

<sup>10</sup> It has been observed that refrigerated eggs have a longer shelf life of 30-45 days compared to the 7-10 days for those stored at room temperature. <http://articles.mercola.com/sites/articles/archive/2013/12/07/refrigerating-chicken-eggs.aspx>

## Adaptation to climate change and variability

In general, farmers' capacity to cope with and adapt to these changing conditions in climate has been impaired by the wider social, institutional and geographical context they live in. Due to human and livestock population growth, pressure on natural resources has increased. This, coupled with the loss of land and water resources to other livelihood activities, has impaired their traditional ways of coping with drought, floods and frost. For livestock farmers these include fodder conservation, rearing improved breeds, feed supplementation, livestock intensification (zero grazing) and planting drought-tolerant fodder crops. For crop farmers these include improved seed varieties, changing the cropping calendar, use of indigenous information in controlling diseases, irrigation, and use of greenhouses. Strategies such as water harvesting and value addition are undertaken by both crop and livestock farmers. Production for subsistence by most of the small-scale farmers reduces their accessibility to credit since most financial institutions are more skewed towards cash crops in addition to requiring collateral. Adaptive measures such as irrigation are impaired by the rugged terrain. Poor investments in infrastructure, including road networks and poor maintenance of for instance milk coolers is obstructing their opportunity to access markets and add value to their products which would allow them to receive better prices and improve incomes. Poor farmer organization limits collective production and marketing as a strategy for reducing transport costs and increasing bargaining power. Lack of access to inputs such as planting material and adulteration of others like fertilisers also erode farmers' adaptive capacity.

In spite of these challenges, Nyeri County is among the counties with the highest adaptation of strategies such as water harvesting (Syomiti, 2015). Results from the ASDSP survey of 2013 showed that at least 72% of the farmers have adopted several on-farm and off-farm adaptation strategies. At least 74% of male-headed households, 68% of female- and 60% of youth-headed households have some adaptation to climate change (Annex 4) (GoK, 2014). Male-headed households are more likely to apply climate change adaptation strategies on their farms. This is because they have higher access to productive resources such as land, extension and training. Adult males also have more decision-making power on household resource utilization compared to women and youth. Some adaptations are specific to certain value chains whereas others cut across value chains.

## On-farm adaptation practices

Increasing scale of climate impacts presents to farmers the urgency to address climate change adaptation more coherently. Barriers to effective adaptation such as poor marketing systems, high cost of production, weak linkages between participating stakeholders to support advocacy, poor policy and coordination, limited or no access to credit facilities, low scale investment in technology, inequitable linkages between selected value chain actors and poor dissemination of climate-related information have impaired farmers' capacity to effectively cope with the changing climatic conditions. These negative outcomes have instigated the use of adaptation strategies such as early planting, using tolerant varieties, and applying indigenous knowledge on disease and pest control

In spite of these barriers, both livestock and crop producers have considered the use of small water harvesting techniques to conserve water for irrigation and consumption during drought. For instance, two water pans have been constructed in Kieni West and East. Value addition in milk through activities such as fermenting and making yoghurt and solar drying and frying in potatoes to make crisps and chips has helped to increase the profits for their commodities despite these erratic weather events. According to the ASDSP household survey of 2013, value addition (30.5%) was more practised as compared to soil and water conservation (12.8%). This may be attributed to the high perishability of the agricultural produce and inadequacy of storage facilities. Adding value through activities such as solar drying increases the shelf life of these commodities, which counters the lack of proper infrastructure to support postharvest processes.

Potato producers have adopted practices such as using certified improved seeds and clean planting material from research institutions (such as KALRO), use of soil and water conservation measures and use of water harvesting channels especially for high water-sensitive crops such as bananas. Farmers have adjusted their cropping systems through alteration of inputs such as use of varieties/species that have increased tolerance or resistance to low and high temperatures, alteration of fertiliser rates to reduce wastage or to maintain the fruit, grain or tuber quality, timing of planting and harvesting dates and sometimes even changing the cropping locations to escape the adverse effects of these climatic hazards. Control of pests and diseases is done through use of the so much valued indigenous knowledge or by use of pesticides and fungicides. Farmers also undertake sustainable land management practices to reduce the negative impacts through



diversification e.g. crop rotation, intercropping, mulching, and terracing.

Adaptation strategies within the livestock and poultry sub-sectors vary depending on the climatic hazards. However, certain strategies such as modification of feeding times, matching the stocking density to the amount of feeds available, supplementation using minerals and reducing the stocking density through culling are widely used between these two sub sectors. For extremely low temperatures (frost) in poultry production, farmers have had to reconsider the chicken housing and install heating equipment or use saw dust to reduce the negative effects of the low temperatures on the productivity. These investments increase production costs. In response to these adverse effects, local poultry farmers keep cross-breeds that are tolerant to diseases, use conventional treatment such as aloe vera for disease control, and feed the chicken on left-overs.

At the product marketing level across all value chains, farmers with financial capacity add value to their produce which in turn translates to higher profit margins. To cushion the high costs of transportation and marketing costs they sell their produce collectively through farmer groups and in smaller quantities to increase the prices so as to fetch better income.

There is substantial room for improvement in the capacity to assess, plan for and manage climate-related incidents so as to ensure that farmers are better prepared for any future climatic hazards. This will help improve access to inputs as well as planning and scheduling of on-farm production activities. Effective marketing of agricultural products is dependent on the creation of a conducive environment. Services such as development of aggregation centres as well as collection points at the ward level can facilitate market access. Interaction between the value chain actors to reach regional and national markets should be promoted.

## Off-farm adaptation practices

Off farm services such as Early Warning Systems (EWS) provided by NDMA and supported by KMD help to improve farmer preparedness through monthly bulletins and seasonal forecasts. Participatory Scenario Planning (PSP) facilitated by ASDSP enhances farmer knowledge on future climatic events and allows them to engage with the experts in selection of intervention. Farmer extension programmes, vaccination services, Artificial Insemination (AI), storage facilities, market

information systems, credit and financing, climate-related information, are offered to farmers to increase their adaptive capacity in the reality of increased unpredictability of climate. These services are offered by the county government, private organizations, and non-governmental organizations (NGOs).

According to the ASDSP survey 2013, about 50% of the households accessed agriculture-related services from the public and private sector institutions. Over 50% of the households in the county were satisfied with the major agriculture-related services with respect to research, veterinary, Artificial Insemination, and other services (GoK, 2014). However, the crop and livestock productivity was low despite these high satisfaction levels from the respondents, an indication that the actual adoption of services offered is quite low.

In terms of postharvest services, the most common practices exist within the households and farming communities. These practices rely on the farmers' knowledge which is not efficient and has often led to major postharvest losses due to the use of inadequate storage facilities.



Market information systems and savings were the most common financial services used by the respondents with at least 53 and 40% of the households accessing each respectively. Disaggregated by gender, at least 55% of adult male-headed households and 45% of adult female-headed households accessed market information services. At least 60% of youth-headed households accessed savings compared to approximately 40% of adult male- and female-headed households.

Insurance services in Nyeri county remain limited. Only 11% of adult female-headed households accessed insurance services compared to approximately 23% of adult male- and youth-headed households. This being a developmental challenge, it decreases the farmers' financial resilience to adapt to climate shocks in the future. Agricultural credit was shown to be the least-accessed financial service with only about 10% of youth-headed households and 15% of adult male-headed households accessing it. Less than 2% of the female-headed households interviewed indicated having accessed agricultural credit (Figure 1). This may be attributed to lack of available agricultural credit services or a rigorous process of applying for the services, or farmers have found it safer and cheaper to get the same services from their cooperatives and groups.

# 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
 <p><b>Extreme variation of temperatures</b></p>	<p>Reduced quality and quantity of pasture; increased feed and water intake; high demand for drugs to treat against pests and diseases</p>	<p>Low quality milk; stunted growth; mortality of animals; heat/cold stress; low production due to cold; high production cost due to procurement of drugs and specialised labour</p>	<p>High storage costs; low volumes of produce to be transported; high risk of contamination due to use of antibiotics</p>	<p>High prices due to high cost per unit of milk; brokers and middlemen maximise on the high prices at the expense of the farmers; loss of market due to antibiotic contamination</p>
<p><b>Magnitude of impact</b></p>	Severe	Minor-Severe	Minor-Severe	Moderate-Severe
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Use of feed supplements; increased use of locally available feeds; using conventional drugs to treat conditions (vaccines)</p>	<p>Use of supplements; delayed breeding; reduced milking frequencies; use of traditional methods of pest and diseases control</p>	<p>Traditional preservation for household consumption; use of farmers groups and community based organisations to store and transport produce</p>	<p>Delivery to high-value markets such as hotels; farmers negotiate milk prices and sell directly to the consumers-informal market systems</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Use improved fodder varieties; protection of animal from cold (comfortable/protected sheds); vaccination routines at county level; water harvesting; hay bulking and fodder conservation</p>	<p>Promotion of improved fodder, forages and feed; promote improved livestock breeds and animal husbandry; County-wide training on prevention and treatment of diseases; training farmers on fodder conservation and dry season feeding</p>	<p>Value addition of milk and milk products; setting up collection points close to production areas to save on transport costs; identify opportunities for community post-harvest processing to add value</p>	<p>Reducing costs per unit of product by bulking and selling as organised unit (cooperative); provide accurate and timely market information; farmer associations and branding</p>
 <p><b>Drought</b></p>	<p>Lack of feed (fodder and pastures); calving rates go down; increased pests and disease incidences; increased demand for veterinary services which increases production costs</p>	<p>Reduced grass vigour and growth rate; reduced milk production (calving increases production); high cost of production from procurement of drugs and specialist services due to dystocia</p>	<p>Reduced milk quantity and quality; high storage cost per unit of produce; increased risk of milk spoilage from antibiotic contamination; increased cost for milk refrigeration</p>	<p>Loss of contract market due to low grade and volumes of dairy products; high cost of dairy products; rejection by buyers in case of contamination</p>
<p><b>Magnitude of impact</b></p>	Major-Severe	Severe	Severe	Severe
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Supplement feeding; halting/timing breeding to ensure births occur during favourable weather conditions; using traditional methods for diseases and pests control, culling</p>	<p>Small scale water harvesting or supplementation; use bull service; use of artificial insemination; hand spraying</p>	<p>Household level consumption; immediate sale to prevent household storage</p>	<p>Sale to neighbours in small quantities for higher prices; formation of common interest groups and farmer cooperatives to improve aggregation</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Plant heat tolerant fodder; use improved reproductive technologies e.g. embryo transfer and sexed semen; conduct routine vaccination; campaigns to reduce disease burden; disease surveillance</p>	<p>Promotion of improved fodder, forage and feed for livestock; promote improved breeds and tolerance to such weather related risks; rehabilitate existing infrastructure e.g. cattle dips; hay bulking</p>	<p>Value addition at local level; promote access to refrigerated storage structures; small-scale cooling facilities; training on how to handle dairy cows under drug treatment; separating milk from diseased and healthy animals</p>	<p>Drawing of milk purchase contracts to set quality and quantity levels and prices; strengthen cooperatives through capacity building; training of treatment of dairy cows</p>



# Potato



	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
 <p><b>Very low temperatures (frost)</b></p>	<p>Plant seedling chilling injury; increased disease incidences; increased use of fungicides; low quality of planting material</p>	<p>Cold air and soil can lead to premature harvest or crop failure; high cost of labour for land preparation and crop management; increased costs of production from increased use of fungicides</p>	<p>Reduced potato quality and quantity; high unit cost of storage; high unit costs of transportation</p>	<p>Increased packaging and transport cost per unit of packaging from overall low production; high market prices for end consumers</p>
<p><b>Magnitude of impact</b></p>	Minor-Major	Moderate	Major	Minor-Major
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Use tolerant potatoes varieties; early planting; use of certified seeds, stocking of seeds; use of organic manure to improve growth</p>	<p>Improve soil fertility and plant nutrition through use of organic fertilisers; protecting crop from cold by laying grass over soil and crop (mulching)</p>	<p>Application of indigenous technical knowledge; selling the produce immediately after harvesting to reduce the storage costs</p>	<p>Selling in smaller units; Use of cheaper transport means (pickups); using brokers to off take their produce to the market</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Develop local frost forecasts (promotion of Early Warning Systems); capacity building on timely and appropriate use of fungicides; construction of communal planting seed storage structures; provide financial mechanisms to purchase inputs</p>	<p>Adjust planting dates to escape frost damage; remove obstacle to cold air movement and drainage within the farm; apply potassium based fungicide to assist tissue recovery after frost; application of foliar feeds with potassium nitrogen</p>	<p>Initiate Public- Private -Partnerships to provide affordable forecast services; construction of high quality and modern storage facilities</p>	<p>Support development of cheaper packaging material; expanding market by developing range of potato products; reduce distance to market by developing collection points and markets at ward level; advocacy for standard packaging and branding</p>
 <p><b>Drought</b></p>	<p>Reduced supply of fertiliser; low supply of seeds, low quality of seeds; increase in pesticides demand</p>	<p>Less soil moisture, becomes difficult to plough; increased cost of production (increased use of pesticides); increased pest incidence; high labour requirements; reduced labour efficiency</p>	<p>Poor grades in terms of sizes; low yields</p>	<p>Increased cost per unit of packaging; increased marketing cost per unit of produce; high cost of transport per unit of produce</p>
<p><b>Magnitude of impact</b></p>	Major	Moderate-Severe	Moderate-Severe	Major
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Use of organic fertilisers; purchase of certified seeds and select in the subsequent seasons; reduce the use of pesticides to save costs</p>	<p>Use of manure; application of indigenous technical knowledge; reducing hired labour for farm management activities to lower costs; use of irrigation and integrated weed management</p>	<p>Use of local knowledge; mixing grades to sell at high price; storage of most of the produce for home consumption</p>	<p>Selling in smaller quantities; farmers sell produce at higher prices to increase their profit margins; use of cheaper transport (carts and motor bikes, pick-up trucks)</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Use certified/clean planting material; use of drought tolerant seeds with high yield; subsidise the costs of certified seeds; capacity build on Integrated Pest Management in farms to reduce on chemical use; fertilizer subsidies</p>	<p>Practising water harvesting; conservation agriculture; introduce new technologies that harmonise with farmers local knowledge; train extension agents to establish, improve or support pilot/demonstration plots; out scaling integrated weed management</p>	<p>Promote the use of Integrated Weed Management; improved storage facilities (pests and rodent free)</p>	<p>Support farmer communities to develop equitable linkages with VCC actors and markets; adopt crop insurance to protect from crop failure; increase the markets and collection points to reduce transportation; branding</p>

# Poultry (chicken)



## Extreme variation of temperatures

Higher costs due to increased demand for veterinary services; increased mortality rate for chicks; high cost of feeds

Decreased feeding; increased diseases incidences; reduced cleaning rates; reduced hygienic conditions; increased demand for extension services; high feed intake, low egg production

Increased perishability of eggs and meat; reduced slaughter activities due to stress; reduced slaughter due to reduced growth rates

Low bargaining power in the markets; extra feeding costs due to decreased slaughter; refrigerated trucks are required to reduce produce spoilage

## Magnitude of impact

Moderate-Severe

Moderate

Major-Moderate

Severe-Major

## Farmers' current strategies to cope with the risks

Use local disease control methods such as herbs and home made remedies; localised cross breeding of chicken to set superior traits e.g. weight gains, acquire disease tolerance

Feeding the chicken early in the morning to avoid high temperatures; feed chicken from household kitchen waste and available cereals; farmers have improved dust masks

Farmers store eggs on sawdust to reduce temperature; slaughter on order; use of sawdust or trays

Farmers sell their eggs and chicken locally individually due to low volumes; selling to the middlemen individually

## Other potential options to increase farmers' adaptive capacity

Vaccination should be done when there are foreseen drought or other hazards risks; promote chicken hatcheries within the sub-counties; promote the planting of various raw materials for on-farm feed formulation (sunflower); routine vaccination; reduction of raw material costs

Educate farmers on improved ventilated housing and bulk the seeds for the feeds (easy to grow varieties); access to early warning advisories (timely vaccination) develop professional breeding programs; subsidize the cost of dust masks

Develop cooling stores by aggregation centres within the wards; develop/construct satellite slaughter house in every sub-county; improve the feeding to get quality eggs to last longer; better access to cage facilities for marketing

Educate contract farming guidelines and procedures to farmers; County support to explore better market outlets; develop aggregation centres at the ward levels; branding



## Drought

Reduced shelf life of vet drugs rather; death of chicken on transit from far hatcheries; low supply of materials for feed formulation; high cost of feeds

High mortality of chicks while in transit from hatcheries; increased incidences of diseases; malnutrition and weight loss; reduced hygienic conditions due to dust; water harvesting

Low volumes of production; increased perishability of the eggs and meat spoilage; loss of eggs due to breakage; high energy requirements

Increased in chicken sale prices (scarcity); extra costs for easier transportation and preservation; reduced market activity/linkages

## Magnitude of impact

Major-Severe

Minor-Moderate

Minor-Severe

Major-Severe

## Farmers' current strategies to cope with the risks

Breeding of indigenous poultry resistant to diseases; use of cross-breeds with improved disease tolerance and production attributes

Change feeding times to early in the morning to avoid high temperatures; use chicken housing with improved ventilation; feed chicken from household kitchen waste; diet supplement including available cereals; on farm feed formulation and feed rationing

Store eggs on sawdust trays to reduce temperatures; poultry slaughtered on order

Sell products at farmgate to the middlemen; traders purchase small quantities from other markets to satisfy the demand; selling the products directly to the consumers from the farm or share the costs with their farmers groups

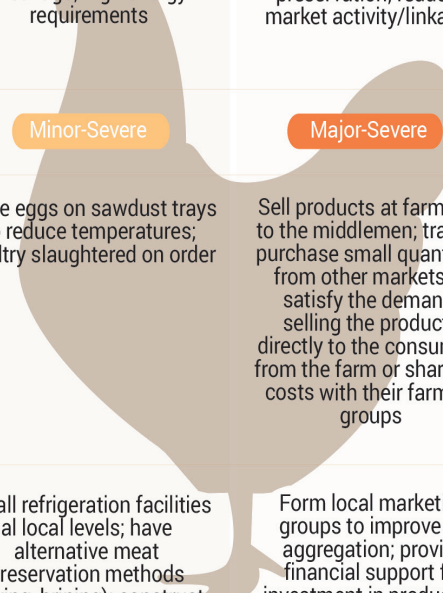
## Other potential options to increase farmers' adaptive capacity

Design and promote appropriate chicken housing for local conditions; set up community/ satellite hatcheries; improve breeding programs; capacity building on feed formulation, routine vaccination and breeding

Plant locally available species as feed sources; build farmer capacity in management of hatcheries; supplement with improved commercial feed; adopt water harvesting (tanks)



Install refrigeration facilities at local levels; have alternative meat preservation methods (drying, brining); construct satellite slaughter house sub-county

Form local marketing groups to improve on aggregation; provide financial support for investment in production infrastructure e.g. hatcheries; value addition to poultry meat (cooking/frying)



# Banana



 <p><b>Extreme variation in temperatures</b></p>	<p>High seedlings prices; slow uptake of nutrients the poor manure's quality; high cost of planting material</p>	<p>Low rates of crop establishment; delay in crop development (longer maturity period); increased incidence of pest and diseases; stunted growth</p>	<p>The quantity and quality of the harvest will be negatively affected; high levels of harvest spoilage</p>	<p>Produce attracts the low value markets due to low quality; loss of high-value market due to delayed maturity; increases the eventual price of produce due to high cost of production</p>
<p><b>Magnitude of impact</b></p>	<p>Minor</p>	<p>Minor-Severe</p>	<p>Severe</p>	<p>Severe</p>
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Use cheaper planting materials; planting around kitchen waste water drain point; use of mulch (grass/hay)</p>	<p>Use of soil bands around roots to protect underground buds; timely weeding to reduce competition for nutrients; use of integrated pest and diseases management (cultural and traditional methods) it can reduce production costs</p>	<p>Subdivide banana bunch into banana hands for sale to increase profits; processing to flour or chips to increase market value (value addition); use of improvised makeshift storage structures</p>	<p>Sell produce at the low value markets; consume the produce at household level; sale to local markets at lower prices; sell directly to consumers to reduce costs of transportation</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Strengthen extension services; provision of certified and clean planting material; implementation of water harvesting techniques; promote conservation agriculture</p>	<p>Providing wind and cold protection by planting wind-breaking trees or solid structure such as house; training on integrated weed management; County support (tools and equipment), integrated pests and diseases management</p>	<p>Promotion of weather-index based insurance; setting up of processing facilities at county level; provision of county level cold storage facilities; specialised storage for raw bananas to prevent spoilage</p>	<p>Strengthen existing linkages within the banana VCC, motivating to produce high quality fruits; development of value-added products and markets to maintain demand during harsh seasons; capacity building in strategies to reach regional markets; branding</p>
 <p><b>Drought</b></p>	<p>Poor quality seedlings; water stress; quality of manure is low</p>	<p>Poor root establishment; poor growth and development; banana pseudo-stem collapse; increased incidence of pests and diseases; slow growth rate; water stress</p>	<p>Low banana quality; loss in banana bunch weight; increase in cost due to transporting low volumes</p>	<p>Reduced availability of the product on the market; increased market prices; low quality products</p>
<p><b>Magnitude of impact</b></p>	<p>Severe</p>	<p>Severe</p>	<p>Severe</p>	<p>Severe</p>
<p><b>Farmers' current strategies to cope with the risks</b></p>	<p>Use clean planting materials from certified nurseries (JKUAT, KARLO, Farmer groups); use of improved banana varieties; use of organic matter for fertilisation</p>	<p>Adoption of small scale water harvesting and irrigation techniques; prop banana pseudo-stem using strong physical support; use of cultural and mechanical methods of controlling pests and diseases</p>	<p>Storage for household consumption; create collection and produce processing centres; form farmers groups to share produce transporting costs; value addition through flour and jam making</p>	<p>Consume their produce at household level; farmers sell their produce at farmgate; selling at the open air market; direct produce selling to consumers</p>
<p><b>Other potential options to increase farmers' adaptive capacity</b></p>	<p>Set up tissue culture banana nurseries; set up small scale water harvesting and irrigation systems; training on manure composting; banana hardening nurseries</p>	<p>Increase irrigation frequency during dry season (rain water harvestin); training on Integrated pest and diseases management; Good Agricultural Practices; promote integrated weed management to prevent pests and diseases</p>	<p>Value addition at farm level; educate on methods of produce processing and preservation at the farm level; establish collection points closer to farmers; develop road infrastructure to save on transport costs</p>	<p>Set up financial mechanisms for investments in production and value addition infrastructure; strengthen the cooperatives-capacity building and linkages for financial support; branding</p>

## Policies and Programmes

Policies are key considerations for agriculture decision-making, since they affect actions and outcomes related to resource use. Several programmes aimed at broadly addressing the topics related to climate vulnerabilities have been put in place through the collaboration of local, national, international, governmental, nongovernmental, private and faith-based organizations and the community at large. Some of the major programmes in Nyeri County include

The Agricultural Sector Development Support Programme (ASDSP) started in 2013, running through 2016. It was funded by the Government of Kenya and the Swedish government. Its objective was to transform Kenya's agriculture into an innovative, commercial-oriented, modern industry to alleviate poverty and improve food security. The programme also focuses on environmental resilience and social inclusion. In Nyeri County, the ASDSP is involved in the facilitation and coordination of the Participatory Scenario Planning with key stakeholders with support from CARE International, Kenya. The ASDSP also works with key value chain actors, including cooperatives and county departments, towards developing and strengthening value-added practices in the indigenous poultry, Irish potato and dairy cow value chains.

The Upper Tana Natural Resource Management Project began in 2012 and is expected to run until 2020<sup>11</sup>. This project is funded by the Government of Kenya, the International Fund for Agricultural Development (IFAD), the Spanish Trust Fund and the local community. The ultimate goal of the project is to contribute to the reduction of rural poverty through community empowerment in the Upper Tana River catchment, increase sustainable food production and incomes, and promote sustainable management of natural resources.

Caritas Nyeri is the development arm of the Archdiocese of Nyeri County. Its main aim is to promote all aspects of human development<sup>12</sup>. The target population includes the poor communities in the marginal parts of Laikipia and Nyeri Counties. While Caritas Nyeri operates in the entire Diocese of Nyeri, most of the programmes and activities are concentrated in the semi-arid agro ecological zones of Kieni. Some of these projects/programmes include:

The Rural Water Programme that aims at improving the general living conditions such as health and hygiene status for both the human and livestock populations in the predominantly semi-arid areas of Kieni. The programme

started in 2012 and ended in 2014, and has benefited 4,700 people in terms of reduced water-borne diseases and consistent water supply.

The Keurig-Smallholder Coffee Livelihoods Diversification Project started in 2010 and was funded by Keurig Inc<sup>13</sup>. Its goal is to improve the livelihoods of the vulnerable smallholder coffee farmers mainly by improving their credit access in Muhito, Githi, Rutune, Giathugu, Gakindu, Thanu, and Gikondi of Nyeri County. The project directly and indirectly benefited 1,500 and 18,000 farmers respectively. The Climate Change Adaptation Project is a partnership between Fastenopfer and Caritas Nyeri. It aims to reduce carbon dioxide emissions through promotion of energy-efficient and affordable cooking stoves. The project targets to supply 15,000 stoves in 7 years in the entire Nyeri and neighbouring Laikipia County. The Community Economic Empowerment Programme (CEEP) is solely implemented by Caritas Nyeri to improve the economic status of about 20% of the most vulnerable annually. Started in 2012, the project aims to improve livelihoods of 50,000 vulnerable households in Nyeri by 2017.

In addition to the above-mentioned programmes, the Fish Farming Enterprise Productivity Programme (FFEPP) of the Economic Stimulus Programme (ESP) and Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP) provides extension services, constructs fish ponds, and provides inputs to farmers such as fish feed and fingerlings to enhance commercialization of aquaculture.

Another programme is the Njaa Marufuku Kenya Programme (NMKP) whose main aim is to promote initiatives that improve food security, nutrition, and the livelihoods of 120 vulnerable farmer groups through provision of grants and capacity building.

The Small Holder Horticulture Empowerment Unit Project (SHEP-UP) targeted Kieni East and Kieni West areas. Eighteen farmer groups were trained and retrained on gender mainstreaming, cropping calendar, record keeping, soil fertility technologies, and marketing. The Kenya Agricultural Productivity Programme that was implemented between 2010 and 2015. The programme was funded by the World Bank and was dealing with selected value chains namely rabbits, dairy cow, fish, potatoes, and pyrethrum.

PLANTWISE was started in 2010, and operated in Mukurweini; a collaboration between CABI and the Ministry of Agriculture. The objective of the programme was to

11 <http://www.utanrmp.or.ke/home>

12 <http://www.caritas-nyeri.org/>

13 The organization buys coffee from small scale farmers in Ethiopia, Kenya and Rwanda.

reduce crop losses through disease and pest control. the project is on-going.

Project on enhancing gender responsive services in Kenya (PEGRESS) was funded by both the Government of Kenya and JICA (Japanese International Cooperation Agency). Its main goal is to improve livelihoods of smallholder female and male farmers' pastoralists and fisher folk. This is after recognizing gender mainstreaming as key in agriculture sector development. The initiative is to ensure that gender issues are integrated into policies and development programs. The project is in Mathira Constituency.

East Africa Agricultural Productivity Project (EAAPP) is a World Bank funded, regional research development initiative. It covers Kenya, Uganda, Tanzania and Ethiopia. Enterprises of interest are Dairy, Cassava, Rice and wheat. Its objectives are specialization in agricultural research, collaboration in agricultural training, Technology transfer, facilitate increased transfer of agricultural technology and information and knowledge across national boundaries. In Kenya the focus is on dairy and wheat in Mathira and Kieni Constituency

The policies that are implemented and adopted in Nyeri County include:

The Environmental Management and Coordination Act (EMCA) of 1999 was amended in 2015 and includes climate change considerations. It guides ministries to consider climate change mitigation measures in the actions and budgets, requesting the establishment of environmental departments or designated officers in each county.

Nyeri County Agriculture Development Act 2016 seeks to establish an efficient legal and institutional framework for development in agriculture through regulation and monitoring value addition and authorizing and inspecting books with regard to distribution and/or sale of agricultural produce. The benefits of the bill are yet to be realised considering the challenges experienced in the county in marketing of produce such as milk and potatoes. The same case applies to the Potato Production and Marketing Bill of 2014 that was formulated to guide potato marketing with regards to packaging. The bill stipulates that packaging should be done in 90-kg bags, a rule that is rarely followed as brokers use bags that can weigh up to more than 100 kg. The Bill if well implemented can help farmers maximize returns from potato production.

The county also implements the National Animal Disease Act CAP364 of 1989 (revised in 2012). The statute, which is implemented by the County Veterinary Department, imposes quarantines for disease control during outbreaks.

## Governance, institutional resources, and capacity

There are a number of governmental, non-governmental, private, and faith-based organizations working in Nyeri County to address climate change-related challenges. The government institutions doing interventions in the livestock subsector include the Kenya Dairy Board (KDB), which provides new technologies and regulates the processing and marketing of milk; processing and value addition companies such as Kenya Cooperative Creameries (KCC) and the Kenya Meat Commission (KMC) that provide ready markets for farmers and promote productivity and competitiveness of the sector. The Central Artificial Insemination Station (CAIS) provides AI services and builds the capacity of farmers on breeding methods, whereas the Kenya Veterinary Association (KVA) undertakes mass vaccinations for disease control.

The government institutions involved in the crop sub-sector include the Kenya Agricultural Research and Livestock Organization (KALRO) that undertakes agricultural research and dissemination of technologies to farmers and a number of higher-learning institutions such as the Jomo Kenyatta University of Agriculture and Technology (JKUAT) that research and provide banana tissue culture planting material to farmers. Other supporting institutions include the National Drought Management Authority (NDMA,) which is in charge of drought management in semi-arid regions of the county (Kieni) through interventions like early warning advisories; the Kenya Forest Research Institute (KEFRI) that promotes conservation of forests through conservation of forest genetic resources and protection of water catchment areas; and the National Environment Management Authority (NEMA) that promotes sustainable environmental management through supervision and coordination of environment-related matters. Lastly, the Kenya National Federation of Farmers (KENAFF) is mainly mandated to train farmers on soil conservation and management and tree planting; and the Kenya Livestock Producers Association (KLPA) which promotes good livestock husbandry and production.

The Non-governmental organizations (NGOs) working towards strengthening the resilience of smallholder farmers to climate change include Farm Concern, African Conservation Tillage Network, CARITAS, which is involved in farmer training in climate mitigation strategies, Plant Wise, and International Centre of Insect Physiology and Ecology (ICIPE), which is researching on pest and disease control in production of crops such as potatoes. In spite of the presence of non-governmental organizations, there is no much influence of donors or organizations which could

be a potential avenue to explore for funding of new project proposals with high priority ranking.

These institutions are curtailed in delivering the interventions due to constraints in human and financial capacity. There is evidence of poor coordination within and without these organizations, a contributing factor to the ineffective delivery of services and other agriculture-related information.

## Synthesis and Outlook

Nyeri County has been depicted to be well off relative to other counties considering, the low poverty levels, the high literacy, better access to health services, high HDI and a low climate change vulnerability index. However, the future of the agricultural sector is bleak following the adverse impact of climatic hazards. The low climate vulnerability index doesn't necessarily mean that the county is well cushioned against the negative impacts of climate variation, considering the high inequality in the county. Fifty-two percent of the land area is semi-arid (Kieni); floods, frost, and droughts have compromised the food security and livelihoods of thousands; and there is a high likelihood of climatic conditions being more unfriendly in the future as seen from climate data simulations. These factors compounded make climate variation an important subject in the county.

Adoption of adaptation strategies to climate change such as water harvesting techniques, soil and water conservation, and value addition has been shown to be relatively high in Nyeri County. However, they are not adequate in addressing the climate shocks. This may be attributed to several factors such as the low utilization of off farm services like extension,

credit, and insurance; land fragmentation; poor road infrastructure; and farmers being more aligned to short-term rather than long-term interventions thus increasing their susceptibility to the climate shocks. The indigenous knowledge system should enable farmers to withstand these climate-related shocks, risks, and other stresses. However, these are not adequate due to the vulnerability of agriculture to recurring climatic hazards. This predisposes them to food insecurity and exacerbated levels of poverty, which weaken their coping strategies. There is the need to integrate indigenous knowledge systems and scientific knowledge to increase acceptability of adaptation interventions

Existing programmes and projects aligned to support of increasing resilience complement and are in harmony with existing frameworks, policies and initiatives in the county. They therefore reinforce climate intervention activities and build the farmers' adaptive capacity to cope with stresses and shocks. These programmes are jointly coordinated and managed by the county government in collaboration with the implementers to ensure shared accountability and sustainability of the progress. However, there is a disconnect between the policies and programmes. For instance, the Nyeri Climate Change Policy Framework could be a platform to improve effective response to climate change adaptation and mitigation as it supports integration of climate change adaptation into the county economic and development policies. The level of its adoption and implementation is unclear and undefined. The same case applies to other legislations such as the Potato Marketing Bill which is rarely adhered to. In addition, collaboration with the key stakeholders in charge of climate risk management is limited.

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

**Annex 1:** Nyeri County map showing agro-ecological zones (AEZs) and administration units

**Annex 2:** Selection of Value Chain Commodities in Nyeri

**Annex 3:** Crop productivity by gender

## Works cited

**Business Daily, 2014.** <http://www.businessdailyafrica.com/Food-prices-up-as-crop-failure-hurts-harvests/539552-2247708-cgy5qwz/index.html>

**Ekin, T.K., Odenda, L., & Wamalwa B. 2009.** Land tenure and property rights assessment. United States Agency for International Development, Kenya.

**Farmers trend, 2016.** <http://www.farmerstrend.co.ke/serious-pest-invaded-potato-growing-zones-nyeri-county/>

**Government of Kenya, 2012.** Consultative workshop on the development of a National Climate Change Response Strategy Action Plan.

**Government of Kenya, 2012.** Animal Disease Act. CAP. 364 of 1989 revised in 2012. [www.kenyalaw.org](http://www.kenyalaw.org).

**Government of Kenya, 2013.** County Integrated Development Plan 2013-2017 Nyeri County.

**Government of Kenya; United Nations Development Programme, 2013c.** Kenya National Development Report; Climate Change and Human Development.

**Government of Kenya, 2015.** Economic Review of Agriculture. Ministry of Agriculture, Livestock and Fisheries.

**Government of Kenya; Ministry of Agriculture Livestock and Fisheries, 2014.** Agricultural Sector Development Support Programme Nyeri County.

**Jaetzold, R., Schmidt H., Hornetz B., Shisanya C., 2010.** Farm Management Handbook of Kenya, Vol. II – Natural Conditions and Farm Management Information – 2nd edition.

**Kalunda, E. 2014.** Financial inclusion impact on small-scale tea farmers in Nyeri County, Kenya. *World*, 4(1).

**Karienyee, K. D., Mwangi, G. P., Kagwai, W. I., Waweru, E., & Muthoni, M. D. 2012.** Impact of Climate Variability on Food Security and Biodiversity Conservation in Nyeri County, Kenya.

**Kenya National Bureau of statistics, 2014.** Statistical Abstracts.

**Kenya National Bureau of Statistics, 2013a.** Exploring Kenya's Inequality. Pulling apart or pooling together. National report.

**Kenya National Bureau of Statistics, 2013b.** Exploring Kenya's Inequality. Pulling Apart or Pooling Together, Nyeri County.

**Kenya News Agency, 2014.** <http://kenyanewsagency.go.ke/en/over-150000-people-face-starvation-in-kieni-constituency/>

**Kenya Open Data.** <https://www.opendata.go.ke/Agriculture/Proportion-of-Parcels-under-Irrigation-County-Esti/jxdm-i7j5>

**Kenyan Woman, 2016.** <http://kw.awcfs.org/article/banana-venture-serves-to-keep-self-help-group-a-float/> Mbugua, J.N., Njoroge, F.K., Muchemi, K., & Mwaniki, P.N. 2012. Strategic and value chain study of the smallholder dairy sector in Central Kenya, final report.

**Muthoni, J. J., Shimelis, H., & Melis, R. 2013.** Potato production in Kenya: farming systems and production constraints. *Journal of Agricultural Science*, 5(5), 182.

**Nassiuma, D., & Nyoike, N. 2014.** Milk production and marketing in Kenya; Preliminary survey 2013 report.

**National Drought management Authority Nyeri County, 2014.** Drought early warning bulletin for July 2016.

**Ngugi, J., Muigai, S., & Muhoro, F. 2014.** Transforming agriculture through contracted extension service delivery systems: the case of Kenya's Agricultural Productivity and Agribusiness Project. *African Crop Science Journal*, 22, 905-915.

**Orre, S., Muriithi, B., & Obondo, V. 2013.** Nyeri County 2013 long rains food security assessment report 29th July -2nd August 2013.

**Star, 2015.** [http://www.the-star.co.ke/news/2015/12/19/kieni-residents-camp-at-chiefs-office-over-floods\\_c1263339](http://www.the-star.co.ke/news/2015/12/19/kieni-residents-camp-at-chiefs-office-over-floods_c1263339)

**Turner, D. W., Fortescue, J. A., & Thomas, D. S. 2007.** Environmental physiology of the bananas (*Musa spp.*). *Brazilian Journal of Plant Physiology*, 19(4), 463-484.

## Acknowledgements

This study is the product of the Ministry of Agriculture, Livestock and Fisheries of Kenya (MoALF), with assistance from the International Center for Tropical Agriculture (CIAT) and the CGIAR Research Programme on Climate Change, Agriculture, and Food Security (CCAFS), as part of the Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) project, supported by a grant from the Global Environmental Facility (GEF)/ Special Climate Change Fund (SCCF) through the World Bank (WB).

The document has been developed under the coordination of Robin Buruchara (CIAT) and Francis Muthami (National Project Coordinator, MoALF-KAPP), under the technical leadership of Evan Girvetz (CIAT) and with contributions from (in alphabetical order): Harold Achicanoy, Colm Duffy, Jessica Koge, Ivy Kinyua, Miguel Lizarazo, Elizabeth Mbau, Vail Miller, John Yumbya Mutua, Caroline Mwongera, An Notenbaert, Andreea Nowak, Wendy Okolo, Jamleck Osiemo, Julian Ramirez-Villegas, and Boaz Waswa. Infographics and layout: Fernanda Rubiano and Carolina Rubiano.

We acknowledge the contribution of the KAPP team: Mary Maingi, Edwin Caleb Ikitoo, Naomi Migwi, and Jane Kahithe Ndungu. We also express gratitude for the following institution for providing information to this study: Kenya Agricultural and Livestock Research Organization (KALRO).

This document should be cited as:

**MoALF. 2016.** Climate Risk Profile for Nyeri. Kenya County Climate Risk Profile Series. The Kenya Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya.