Kenya County Climate Risk Profile Series

Climate Risk Profile Nyandarua County

Highlights

- Agriculture is an important source of income, food, and raw materials in Nyandarua County. The sector employs about 69% of the population and contributes approximately 73% to household incomes. Irish potato, peas, dairy cows and local poultry are the most important agricultural value chain commodities in terms of food security, production and income generation.
- Agricultural productivity is generally low and linked with high incidence of pests and diseases, low technology adoption, limited access to credit, markets and market information, a poor road network, and most importantly, climate-related risks (dry spells, intense rains).
- Climate has already been observed to change in the County. Since 1981, the first wet season has experienced a moderate (1 °C) increase in mean temperature and associated reduction in crop cycle, and a slight tendency for increasing precipitation. The second wet season experienced a mild (~0.5 °C) increase in temperature, and no change in precipitation. Looking to the future in the years of 2021-2065, prolonged moisture stress is projected to occur across both seasons of the year analyzed, whereas intense precipitation looks to change little.
- The majority of farmers (98%) have adopted at least one on-farm adaptation strategy to cope with climate hazards (floods and droughts). However, resource constraints and poor market linkages hamper adoption rates significantly.
- Tree planting, water harvesting and agroforestry are adaptation strategies that are widely practised in both livestock and crop sectors.
- In the crop sector, these adaptation strategies include the use of improved varieties, manure, traditional disease control methods, conservation agriculture, irrigation, and shifting planting dates, among others.
- On-farm adaptation strategies for livestock include value addition, fodder conservation, utilization of crop residues, and traditional disease control methods, such as the use of indigenous herbal remedies, among others.
- Farmers are offered off-farm services such as extension and training, early warning information, production inputs and credit to improve their adaptive capacity. These services are facilitated by various actors, including the Ministry of Agriculture, Livestock and Fisheries (MoALF), Tree is Life, financial institutions such as banks and insurance companies, the Kenya Meteorological Department (KMD), and community- and faith-based organizations, among others. Access to these services is low, especially among the youth- and female-headed households. Only 20% of the County's population has access to agricultural technologies.
- Lack of legislation on agricultural issues provides a further constraint to the adoption of adaptation strategies given that most of the policies are bills waiting to be passed, such as the Potato Produce and Marketing Bill, the Pyrethrum Produce and Marketing Bill and the Agricultural Institutions Revolving Fund Bill.
- The successful implementation of climate adaptation strategies requires strengthening of the institutional and financial capacities of key actors to enable them to deliver the necessary resources to the farming community and to provide incentives to keep them engaged in sustainable agricultural activities. As for the farmers, they need the tools to act and the information to understand the urgency of adapting to a changing climate and of mitigating climate risks. Farmers need to have access to critical services such as extension, credit, storage and conservation agriculture in a systematic way.

KAPP Kenya Agricultural Productivity Programme
Republic of Kenya
WORLD BANK GROUP

List of acronyms

AEZ	Agro-Ecological Zone
AFC	Agricultural Finance Corporation
AI	Artificial Insemination
AMS	Agricultural Mechanization Service
ASDSP	Agricultural Sector Development Support Programme
ATC	Agricultural Training Centre
CBO	Community-Based Organization
EMCA	Environmental Management Authority Act
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environmental Facility
HDI	Human Development Index
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPAP	Kenya Agricultural Productivity and Agribusiness Programme
KAPP	Kenya Agricultural Productivity Programme
KCC	Kenya Creameries Cooperative
KES	Kenyan Shillings
KFS	Kenya Forestry Service
KMD	Kenya Meteorological Department
KWS	Kenya Wildlife Service
LPD	Livestock Production Department
MoALF	Ministry of Agriculture, Livestock and Fisheries
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
NFP	National Forestry Policy
NGO	Non-Governmental Organization
NIST	Nyandarua Institute of Science and Technology
NYS	National Youth Service
PELIS	Plantation Establishment and Livelihood Improvement Scheme
SCODE	Sustainable Community Development Services
SCCF	Special Climate Change Fund
VCC	Value Chain Commodity
WCMA	Wildlife Conservation and Management Act
WB	World Bank

Foreword

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

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

In support of this effort to strengthen local capacities of stakeholders to reduce the near-, medium- and long-term vulnerability to current and future climate variability, the Kenyan Government, through the Ministry of Agriculture, Livestock and Fisheries (MoALF) is implementing the Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) project. The project is funded with a grant from the Global Environmental Facility (GEF)/ Special Climate Change Fund (SCCF) through the World Bank (WB). The 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 Nyandarua County, where extreme climatic events have become more eminent than in the past. A record of climatic disasters shows that Nyandarua has experienced extreme events since 1943, with the most frequent ones being heavy rains and droughts (Njenga et al., 2014, Van de Sand, 2012)[1]. Floods in 2013 resulted in losses of more than 1 billion Kenyan shillings (KES) and the destruction of the Nyandarua Institute of Science and Technology (NIST) and farms in the neighbouring areas. More than 800 hectares (ha) of maize, banana, and bean plantations were under water and thousands of residents and internally displaced peoples (IDPs) were left without potable water and susceptible to waterborne illnesses like cholera[2]. In 2015, flooding destroyed the road network of the County, cutting off access to markets and putting farmers' livelihoods at risk, such as the potato and pea farmers who experienced huge losses[3]. Farmers continue to suffer low farm incomes because of the extra costs incurred when dealing with the consequences of unpredictable and extreme weather events, such as increased livestock and crop diseases and frostbite.

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 Nyandarua. In the next section, the main climate hazards are identified based on the analysis of historical climate data and climate projections, including scientific assessments of climate indicators for dry spells, flooding, heat stress, among other key hazards for agriculture. Then it continues with an analysis of the vulnerabilities and risks posed by the hazards deemed to be potentially most harmful to the respective value chains. Based on these vulnerabilities, current and potential on-farm adaptation options and off-farm services are discussed. The text also provides snapshots of the policy, institutional and governance context that can enable adoption of resilience-building strategies, and finally presents potential pathways for strengthening institutional capacity to address potential future climate risks.

1 Floods have been experienced 13 times in the last 50 years; in 1961, 1963, 1965, 1977, 1982, 1989, 1995, 1997, 2002, 2006, 2008 and 2009 whereas droughts have occurred in 1962, 1973, 1976, 1980, 1984, 1989, 1990, 1991, 1995, 2004, 2007 and 2009 (Njenga et al., 2014).

2 As reported by The Star online newspaper (The Star, 2013) and Citizen online newspaper (Citizen, 2015).

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

Agricultural context

Economic relevance of farming

The County of Nyandarua is located in the Central part of Kenya, bordering Nyeri County to the east, Nakuru County to the west, Laikipia County to the North and Kiambu County to the South. It covers about 3,245 square Kilometers (Km2) (GoK, 2013). The major natural resources in the County include 8 permanent rivers namely Malewa, Chania, Kitiri, Pesi, Mkungi, Turasha, Ewaso Narok and Kibiru, and Lake Ol'bollosat, the largest water body in the County. The landscape mainly consists of plateaus that gently slope. Areas that are in the savannah zone are characterized by grass cover.

The temperature in the County ranges between 12^0C (July) to 25^0C (December)[4]. Maximum rainfall of about 1700 mm is received during March and May (which coincides with the wet season, also known as the second season) and minimum rainfall of about 700 mm during September-December (coinciding with the dry season, also known as the first season) (GoK, 2014). The rainfall decreases from East to West.

Agriculture is the main income-earning activity in the County, employing about 69% of the people and contributing about 73% to the household incomes. The major agricultural activities in the County are crop production and livestock keeping. A survey by the Agricultural Sector Development Support Program (ASDSP) in 2013 revealed that about 63%, 88% and 47% of all the adult men, adult female and youth interviewed were employed in crop and/or livestock production respectively[5]. In 2012, the total value for crops in the County was KES 17 billion and KES 7 billion for the livestock sectors[6]. Irish potato and cabbage had the highest contributions to crop income, about 72% (KES 12,205.9 million) and 17% (KES 2,981.1 million) respectively, whereas cow milk and beef contributed the most to livestock income, about 88% (KES 6,260 million) and 6% (KES 422.6 million) respectively[7] (GoK, 2015).

People and livelihoods

There were about 596,268 people living in Nyandarua in 2009 (GoK, 2010). The population is projected at 710,752 by 2017 (GoK, 2013), growing at a rate of 2.2% with almost equal gender distribution (51% women, 49% men). The age group between 15 and 34 years is anticipated to constitute about 32% of the total population in 2017. A high use of contraceptives (about 67%) might be the explanation for the lower population growth rate compared to the national growth rate of 2.9%. The County is also characterized by a low child mortality rate of about 0.9%. This can partly be attributed to the wide coverage of immunization standing at about 86%. The population is largely concentrated in rural areas (about 97%) with equal distribution across the genders, yet the share of rural people is expected to change due to the increased migration of people to urban areas (Engineer, Njambini, Ol'kalou and Mairo-inya) in search for employment.

The proportion of people living below the absolute poverty line is relatively high (46%) with that in the urban areas being higher compared to rural areas (49% and 43% respectively). The County's high unemployment rate of 83% (GoK, 2013) together with low agricultural productivity are the likely reasons for this. This is notwithstanding the high literacy (those who can read and write) levels in the County of about 84% (KNBS, 2013). Skill mismatch and lack of innovativeness are some of the hindering factors to development. The problem is aggravated in urban areas through increased rural-urban migration, especially among the youth. Despite the fact that the County had a higher Human Development Index (HDI) of about 0.6 in 2009 (GoK, 2013) access to social amenities such as electricity is very low in the County as only 11% use it for lighting and barely 1% for cooking. The majority of the people (79%) use firewood (KNBS, 2013).

Food poverty rate in the County stands at 39% and is worse in urban populations with respect to rural populations (49% and 34% respectively)[8]. Female-headed households are the most affected probably because of lack of production inputs resulting from cultural practices that marginalize women in terms of asset ownership. In terms of malnutrition, 35% of children below five years are stunted, and 16% underweight. This is partly attributed to low dietary diversification as a result of culture. There is a high dependency on Irish potato despite the fact that

4 Temperatures can be as low as 1oC according to the County Integrated Development Plan.

5 In this survey adult men and female were people above 36 years. Youth is anyone between 18-35 years.

6 1 USD is an equivalent of 90 KES.

7 The percentages were calculated from data GoK (2015).

8 Food poverty in this case means the population of people who do not have enough food to meet their daily requirements.

products such as milk and eggs are produced in the County. Low agricultural productivity and relatively high poverty levels may be potential factors contributing to food insecurity.

The main livelihood activities in the County are livestock keeping, crop farming, small businesses (retailing) with minimal mining, tourism and industry. The main livestock types in the County are dairy cattle, local poultry and wool sheep. Crop farming is mainly for subsistence where about 52% of the cultivated land is under food crops (maize, Irish potatoes, carrots and peas). The major cash crops include cut flower (grown in both small and large scale), wheat and fruits like plums and pears. Wheat occupies almost 99% of the total area under cash crops.

Agricultural activities

Land in Nyandarua is categorized into arable (201,100 ha, equivalent to 62% of the total land area in the County, and 3% of Kenya's total arable land), non-arable (123,430 ha, equivalent to 38% of the County's total area), and forestland (49,916 ha, equivalent to 15% and 12% of the County's and country's area respectively). Water mass covers about 33,500 ha an equivalent of about 10% of the County's area (FAO, 2015).

The County is categorized into seven agro-ecological zones (AEZs) (Abdi, 2004; Jaetzold et al., 2010) (Annex 1), namely:

- UH1 (North and South Kinangop), that receives relatively high rainfall
- UH2 (North Kinangop), that falls in the high rainfall zone
- UH3 (Olkolou, Kinganop)
- UH4 (Ojororok, Kipipiri)
- LH3 (Olkalou), receiving a moderate amount of rainfall
- LH4 (Ndaragwa, Kipipiri), in dry in the ranching zone
- LH5 (Ndaragwa), that is largely dry

Farming is mainly rain fed and farmers mostly practice mixed farming, combining crops and livestock. irrigation is as low as 1,755 ha (barely 1% of total arable land). The mean landholding size is about 3.5 ha, and farm sizes range between 1.2 ha (for small-scale farmers) and 24 ha (large-scale farmers). About 93% of the farmers in the County have title deeds[9] (GoK, 2013). Farming is mainly for subsistence purposes though there is production for commercial purposes mostly in the horticultural sector for example cut flowers, cabbages, carrots and snow peas.

Farm sizes are anticipated to decrease rapidly owing to population increase and urbanization. A survey by the ASDSP in 2013 (Gok, 2014) showed that male-headed households had larger land parcels with respect to female- and youth-headed households (4.2, 2.9 and 3.7 ha in that order). In addition the male-headed households are more likely to have title deeds than both the female- and youth-headed households. This is mainly because culture permits the male members to be the custodians of land and other household assets.

Agricultural input utilization for herbicides, basal fertiliser and organic manure in Nyandarua is relatively high: 27%, 68%, 43% of the households during the First Season and 21%, 66% and 42% in the Second Season. Nevertheless, high prices due to a poor road network, counterfeit fertilisers and seeds, lack of markets for the major crops such as Irish potato and peas specifically during the rainy season are some of the factors hindering agricultural input utilization. Male-headed households are more likely to use inputs such as basal fertilisers, pesticides and foliar compared to female- and youth-headed households (GoK, 2014)[10] Lack of access to productive assets by women and youth is attributed to their lower wealth. In addition poor targeting and distribution of subsidized inputs such as fertiliser in the County may be skewed towards men hence giving them better access to the fertilisers.

9 According to the Kenya National Bureau of Statistics (2005), this figure was about 78%.

10 The input utilization was with regard to the value chain commodities promoted by the ASDSP.

Livelihoods and agriculture in Nyandarua

Demographics

1.6% Of Kenya´s population

596,268 inhabitants

98% Live in rural areas

51% 49%

Access to basic needs

46% of the population lives in **absolute poverty**

Potable water	ND
Electricity for cooking	1%
Electricity for lighting	11%
Education (youth literacy rate)	ND

Food security

39% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

35% Children **stunted**

7% Children **wasted**

ND: No data

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

Nyandarua

Farming

County´s farming area 201,100ha 62%

73% of the population employed in agriculture production

78% of farmers have title deeds

ND% are women

Farming activities

Food crops 32%

Cash crops 29%

Of county´s agricultural land

Livestock

Cattle (heads)	232,083
Sheep (heads)	23,640
Goat (heads)	578,975

Farming inputs

Water uses

ND ND ND

Fertiliser types (% of households)

NPK

43% Organic manure

68% Basal fertiliser

37% Foliar feed

Pesticide types (% of households)

8% Field pesticides

6% Storage Pesticides

27% Herbicide

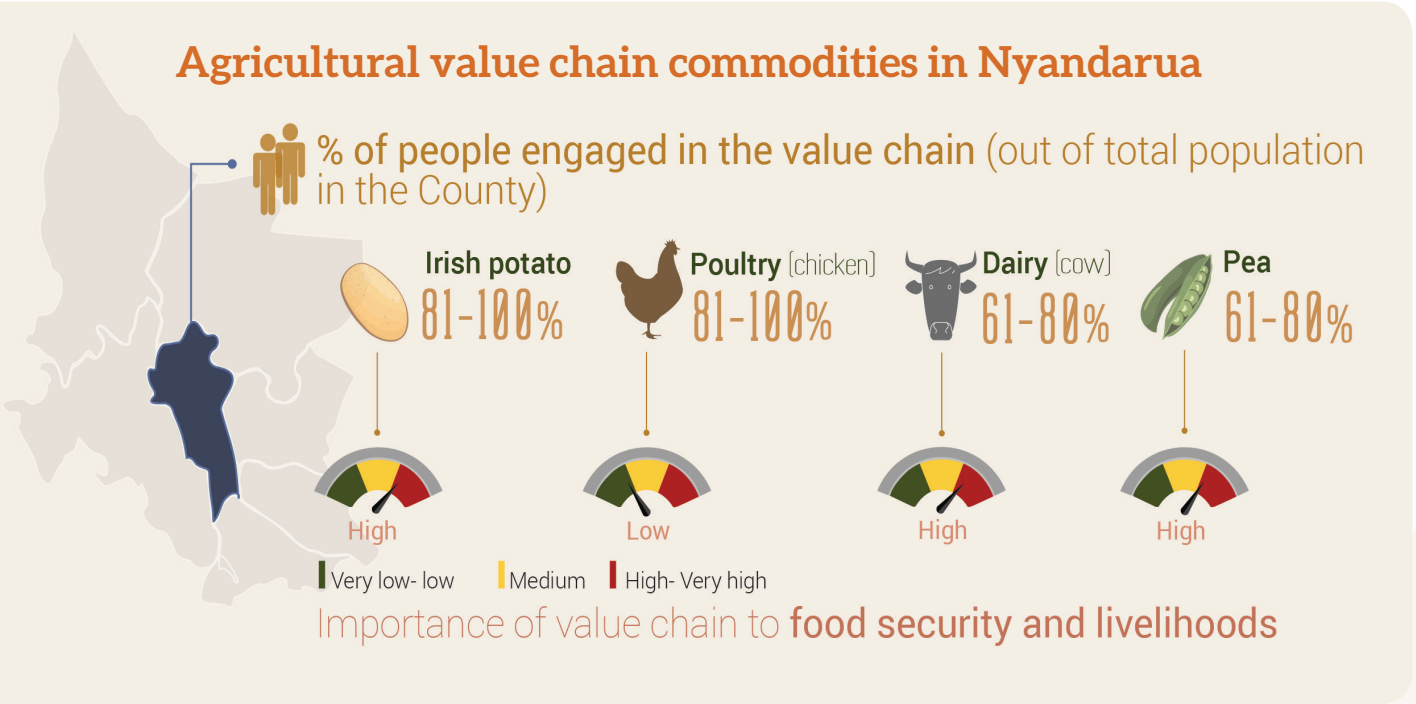
Agricultural value chain commodities

There is a rich diversity of crops grown in Nyandarua County. Some of the crops have been prioritized for development interventions by different government organizations and programs, such as the ASDSP, the Kenya Agricultural and Livestock Research Organization (KALRO), the University of Nairobi survey, and the Kenya Agricultural Productivity Program (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics and importance to the economy. These VCCs have been selected by local stakeholders from government and non-government organizations (NGOs) and farmers, from a list compiled from the above-mentioned sources as well as the Economic Review of Agriculture (ERA) (GoK, 2015) using the following prioritization indicators: harvested area (hectares), production (90 kg bags and litres for milk), variation in production (in the past five years), value of production (KES), dietary energy consumption (Kcal/ capita/ day), protein content (gr of protein/ 100 gr of product), iron content (mg of iron/ 100 gr of product), zinc content (mg of zinc/ 100 gr of product), and Vitamin A content (IU Vitamin A/ 100 gr of product). The VCC selected are dairy, local poultry, peas (including both garden peas and snow peas) and Irish potato. Annex 2 summarizes the indicators per the selected value chains.

Irish potato

Irish potato is grown mainly for subsistence. It is a major component in almost every dish/ meal for the people. Commercial production is common in AEZ UH1 (South Kinangop) and UH3 (Olkalou, Oljoroorok and Ndaragwa). The crop is grown in both the dry (first) season (usually extending from September to December) and the wet (second) season (usually extending from March to May) by small-scale farmers who depend on rain and family labour. Productivity is highest among the male-headed households (3,031 kg/acre) compared to youth- and female headed households (2,930 kg/acre and 2479 kg/acre respectively) in the first season, and female-headed in the second season according to the ASDSP survey of 2013 (Annex 3). Despite the fact that women registered the highest productivity during the long season, this is below the County's potential. This can be attributed to lack of access to inputs. Low productivity among men during the long season is associated with shifting interest to livestock (dairy).

Over 80% of the population in the County is engaged in the Irish potato value chain. Most of the actors - input suppliers, farmers (with farms ranging between 1-5 hectares) and wholesalers (middlemen) - are small scale. Planting is normally done by all family members; harvesting is done by women and spraying and transporting mostly by men. Farmers mostly use recycled planting material due to the unavailability and



high cost of improved planting material. The common varieties in the County include Shangi, Nyayo, Rudolf, Jerry and Carruso. Shangi is the most preferred by the farmers since it attracts higher prices. Value addition activities include chips making (mostly for hotels and other small food outlets), packaging (mostly by the youth), bulking (to reduce transport costs) and transportation by private contractors. There are only two Irish potato processing plants in the entire Nyandarua County, namely Midland and Eldoville.

The major challenge faced by Irish potato farmers in the County is marketing. Most of the Irish potato is sold to middlemen who not only offer very low prices but also use extended bags (normally 110 kg compared to the required 50 kg bags) in purchasing the potato. Lack of storage facilities, the poor transport network, and increased incidences of pests (for example Potato Cyst Nematode, whitefly, and potato moth) and diseases (potato blight) significantly increase production costs throughout the value chain. The crop also gets severely affected by frost and intense rain.

Peas

There are two types of peas grown in the County namely garden peas and snow peas. Garden peas are very important in terms of food security (major source of proteins), while snow peas are mostly grown for income generation (export) mainly in Ngano region. Pea production is found in North and South Kinangop and Olkalou by small-scale farmers, with farm sizes ranging from 0.5-2 ha.

The value chain involves 61-80% of the population in the County. On-farm production is done by both gender groups. The likelihood of farmers using recycled seeds in the first season compared to the second season is very high (9% and 44% respectively). This might be attributed to high returns during the second season as a result of adequate rain. Highest productivity has been reported among the male-headed households in the first season (drier), given their increased access to irrigation, and female-headed households in the second season (wetter) (Annex 2) (GoK, 2014).

Value addition activities for the peas include bulking at buying centres, sorting, grading, and transporting. There are no processing plants for peas in the County, and as such, the major marketing channels are middlemen and the local market (either at farm gate or roadside markets) for garden peas and exporter (Duncan) for snow peas[11]. Due to the small scale production, farmers have organized into farmer groups (for both gender) so as to meet the quantity demands by buyers. Unfavourable weather conditions, the poor road network, counterfeit inputs and market access (mostly for garden peas) are factors which pose serious challenges to pea production.

Dairy (cow)

Dairy is an important sector in terms of food security and income generation in Nyandarua. Production is carried out throughout the entire County. In 2014, the dairy cow population was approximately 292,191 animals. The major breeds kept are Friesian, Jersey, Ayrshire, and cross breeds. Productivity tends to be highest among male-headed households (for exotic cattle) and youth-headed households (for local cattle) in the two seasons (Annex 3). High productivity among the male-headed households for the exotic cattle can be attributed to the men's capacity to purchase inputs. Production activities such as feeding and milking are mostly done by women and youth. The youth also supply the majority of hired labour in the livestock sector. Income from milk and ownership of cows is normally associated with adult men.

The dairy sector employs 61-80% of the population (GoK, 2014). The majority of input suppliers are mainly individual agro vets (small scale), with a few cooperatives such as Umoja Dairy. Small-scale processors in the County include Umoja, Delight, Muki and Eldoville. Large-scale processors namely Brookside and Kenya Creameries Cooperative (KCC) are located outside the County. Value addition activities are dominated by men since they have more capacity in terms of resources. Nevertheless most of the milk is sold raw due to farmers' low capacity in terms of capital and know-how on value addition.

The major marketing channels include the local markets, cooperatives (which sell to the processors), and middlemen. Value addition activities include fermenting, making yoghurt, ghee, cooling, boiling, bulking and transporting.

The major challenges to the dairy sector include incidence of diseases like Rift Valley Fever, *Mastitis and Salmonellosis*, scarcity of feeds during the dry

11 Snow peas are produced under contractual arrangements between the farmers and Duncan (exporting company).

season (resulting from drought and frost) and wet season (floods). The poor road network also worsens the marketing situation in the County mostly during the wet season.

Local Poultry

Local poultry are kept all over the County for both meat and eggs. Production is small scale with every household having at least a chicken mainly for consumption purposes. In 2014, there were about 242,563 indigenous chickens in the County. The meat and egg production in the same year was 18,740,900 kg and 31,829,900 trays respectively.

More than 80% of the population is engaged in the local poultry value chain. The main actors in the value chain are farmers - who keep between 1 and 18 chickens - and the input suppliers, who are also small scale (private agro vets, millers and chicken suppliers such as Ken chick, Kuku Chick and Muguku). Local poultry production is mainly ensured by women. Men are responsible mainly for the construction and maintenance of housing structures and value addition activities (mainly defeathering, grinding, packaging, boiling), but also selling of poultry products.

Agricultural sector challenges

Despite its potential, productivity of main agricultural systems remains low in the County. Irish potato yields reach 50 bags/ acre compared to a potential of 80 bags/acre, dairy yields remain around 7 litres/ cow/day compared to a potential of 12 litres/cow/ day, peas yields 1560 kg/acre against a potential of 3000 kg/acre and current laying percentage of poultry is 30% against a potential of 75%. Since production is largely rain fed, unfavourable weather conditions resulting from climate change/variation impact heavily on productivity. Cases of total crop failure are very common, resulting from either destruction by frost, pests and diseases (for example the lethal necrosis in maize), and/or drought and floods/intense rain. As a result, farmers are required to use more inputs such as pesticides, herbicides and fertilisers. This does not only increase the cost of production but also leads to more soil degradation (causing the soil to be more acidic). In cases where the farmers cannot afford the inputs (chemicals for preventing for instance damage from frost, and manure), they harvest prematurely either to avoid the climate risks or to take advantage of good prices in the market. It was reported that the use of manure makes crops more resilient to droughts.

The arable land is drastically reducing due to human settlement. Land has been subdivided into very small parcels that have been overutilized resulting in serious degradation. Leaching, which comes as a result of torrential rains, aggravates the low productivity of both crops and livestock. High rates of abortions in livestock have been attributed to water contamination (through leaching) due to increased agricultural input utilization.

The poor road network in the County is another important challenge to the sector as farmers are not able to transport their produce especially during the rainy season. Irish potatoes, milk, peas and flowers are highly perishable commodities that require ready markets. Lack of capacity to add value to the commodities and insufficient storage facilities (at County level as well as farm level) exacerbate the problem, as most of the produce go to waste (The Standard, 2011) or is sold to middlemen at throwaway prices. A lack of ready markets discourage farmers to venture into new production technologies. The poor road network and inadequate electricity supply are disincentives for investors in the agricultural sector and also increases the costs of agricultural inputs (fertilisers).

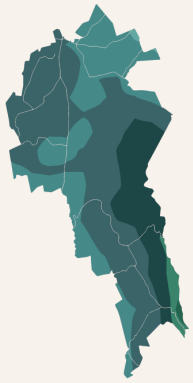
Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Nyandarua County is reasonably cool with most of the County < 15 °C annually, and ranges in annual precipitation from quite high (>1250 mm per year) along the eastern edge to drier along the eastern and northern edges (<750 mm per year). The first wet season of the year (January-June) tends to be 1-2 °C warmer and about 25% wetter than the second wet season on average, however seasonal precipitation varies substantially from year to year. Due to this strong gradient in climate throughout the County, dry spells, intense precipitation, and heat stress, are all hazards that contribute to agricultural risk in the County.

Past and future impacts of climate hazards in Nyandarua

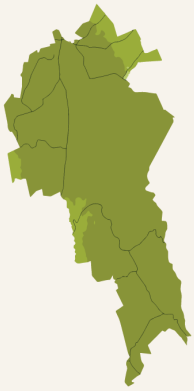
Historical annual mean precipitation (mm/year)



Legend
- Road
- 500-750
- 750-1000
- 1000-1250
- 1250-1500
- 1500-1750
- >1750

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

Historical annual mean temperature (°C)



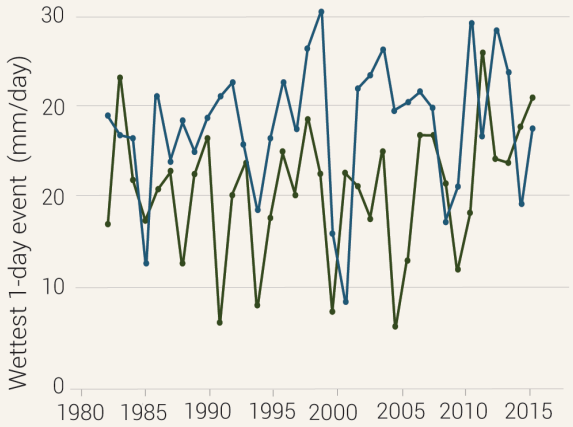
Legend
- Road
- < 15
- 15 - 17
- 17 - 19

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

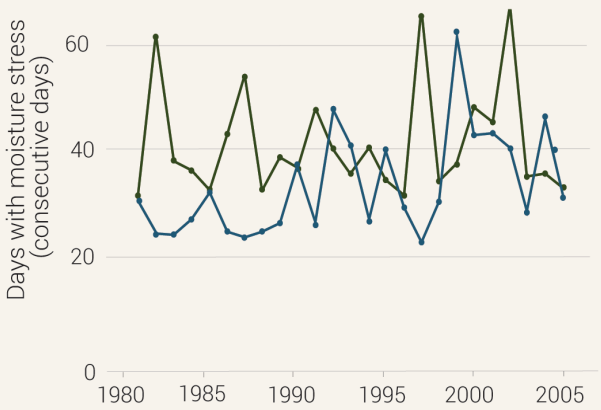
Flood hazards

Drought hazards

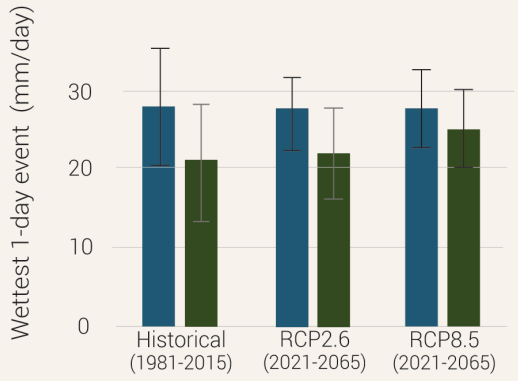
Historical extreme flood events



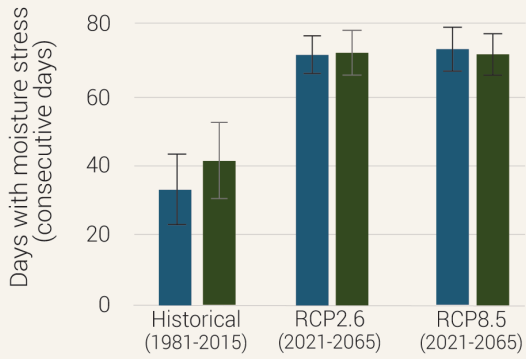
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



January - June July - December

Historic analysis of weather in Nyandarua County shows that both dry spells and extreme precipitation are hazards in the County. Dry spells are longer during the second wet season averaging just over 40 consecutive days of moisture stress, but ranging from 30 to 65 days in any given year. The first wet season only experienced just over 30 consecutive days of moisture stress, ranging from under 25 to over 60 in any given year. Extreme precipitation and flood risks moderate in both seasons, being about 25% greater in the first season. In the first season, approximately 50% of the years from 1981-2015 had a day that received greater than 20 mm of precipitation, whereas this only occurred in three years during the second season.

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

Looking to the future in the years of 2021-2065, prolonged moisture stress is projected to occur across both seasons of the year analyzed, whereas intense precipitation looks to change little. Within 30 years (by the early 2040's) temperature is projected to increase by 0.3°C, with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to decrease by 0.3% in the first wet season, and 6 % in the second wet season. Consecutive days of moisture stress is projected to double in the first wet season from approximately 35 days to 70 days. Similarly, moisture stress in the second wet season is projected to increase from approximately 40 days to 70 days. These projections of future climate change under the two climate scenarios—RCP 2.6 and RCP 8.5—show some small differences, but generally show the same future projections, suggesting climate change impacts will be fairly similar during this time frame no matter the greenhouse gas emissions that occur.

Climate vulnerabilities across agriculture value chain commodities

Agriculture in the County is largely rain fed. As such, climate change and variation poses serious risks on the sector. The major climate hazards frequently experienced in Nyandarua County are drought - associated with moisture, heat stress and high temperatures - intense rain, and frost - associated with flooding in the lower regions and erosion in the sloppy areas. The prioritized value chains are affected differently by the different hazards.

Irish potato

Irish potato value chain is affected by both drought and intense rain. These become even more of a problem as the weather is becoming increasingly unpredictable. The rains come when they are least expected, while dry spells are abnormally long and more frequent. All the actors along this value chain are adversely affected: producers (farmers who cannot adapt to the harsh weather events due to limitations in resources and knowledge) receive low returns from production; workers doing land preparation and weeding under unfavourable conditions receive lower wages and transporters and bulkers lose their jobs. Actors in potato growing areas that are more prone to droughts and floods such as Ndaragwa are the most affected.

Farmers rarely plant during dry spells, not only due to water scarcity but also because they lack planting material. The early maturing varieties are too expensive for the poor farmer to afford. The quality of the Irish potato tremendously deteriorates during the dry spells since farmers harvest prematurely to take advantage of the high prices in the markets. In addition, there is limited utilization of pesticides in case of diseases, since chemicals scorch the crop during this period. Production costs significantly increase during the dry spells due to hardening of the soil, requiring more time and labour in land preparation and low yields which make activities like transporting, packaging and bulking more costly.

However, production costs are highest during the wet season. The impact of intense rain is high in the Irish potato value chain since the hazard increases both production and marketing risks. On-farm production becomes a challenge as activities such as land preparation, weeding and harvesting are greatly impaired. Production inputs such as fertilisers and pesticides become expensive due to high demand and impassable roads. Poor distribution of subsidy fertilisers worsens the problem. Farmers are also

required to use more inputs during the wet season since fertilisers and pesticides can get washed away by heavy rain before benefitting the crop. Soils degrade due to erosion and become more acidic due to continued leaching as such reducing productivity. In addition, prevalence of diseases such as early and late blight, and pests such as the potato cyst nematode (PCN) and leaf miner increase during the wet season hence increasing demand for pesticides.
Destruction of roads during the rainy seasons worsens the marketing challenges because farmers are not able to transport their produce to the markets. The bulkiness of Irish potato and poor market structures require farmers to take their produce to collection centres more accessible by middlemen. The lack of capacity to undertake value addition because of resource scarcities, high electricity costs and limited storage facilities for Irish potato such as cold rooms make the farmers very vulnerable. Poor farmer organization is also a contributing factor to the low adaptive capacity to the climate risks.

Peas

Peas are severely affected by intense rain along the entire value chain. In terms of input supply, planting material and fertilisers become expensive due to transportation challenges. In addition, the quality of the fertilisers reduces due to poor storage. Supply of labour during the flood season is also low due to the harsh working conditions, resulting in high cost and delayed planting. On-farm production becomes more costly as extra time is spent in preparing land, weeding and spraying. Diseases such as blight and pests like whiteflies and leaf miner are more common during the rainy season. As such farmers who cannot afford pesticides experience crop failures. In addition, excessive utilization of chemicals may result to rejection of the produce by the buyer. Intense rain also increases post-harvest losses due to rotting or sprouting and requires extra time in sorting the peas. Accessing markets also becomes a challenge mostly due to poor roads and production of smaller quantities that may not satisfy buyer demands.

Drought, on the other hand, results to scarcity of planting material (seeds) as well as fertiliser leading to delayed planting. Water scarcity impairs production activities such as spraying making the crop more susceptible to pests and diseases, planting requires more time and labour due to hard soils, and harvesting poor quality crops requires more time and labour as well.

Consequently dry spells result in remarkably reduced yields arising from water scarcity and damage by frost. The low yields and poor quality produce also pose challenges in value addition activities like sorting and grading, and transportation and bulking (mainly due to production of small quantities that increase transport costs). Pricing of the produce is also not viable partly because farmer organizations that could help farmers to increase their bargaining power are limited. As a result, there is minimal market participation.
These factors result in low income which impairs farmers' capacity to be prepared to or reduce the risks through, for instance, irrigation or construction of greenhouses. Lack of access to off-farm services such as credit and early warning information deprives the farmers of an important component for day-to-day farm decision-making.

Dairy (cow)

Dairy cow is adversely affected by drought and intense rain. During dry spells water and feed scarcity are pre-eminent. Water scarcity negatively affects most fodder crops such as maize, napier grass, oats and rhodes grass resulting in feed scarcity. Shortage of pastures and fodder require farmers to opt for commercial feeds which are expensive. As such, the animals become more susceptible to malnutrition conditions such as Beri beri and infertility. Upsurge of other diseases such as Foot and Mouth disease, Lump Skin disease and Rift Valley Fever become common during this period due to immunosuppression requiring more attention in terms of disease control. All these factors result in reduced milk production and subsequently reduced farm incomes. As a result, farmers lack capital to implement adaptation measures such as fodder conservation.

Post-harvest handling activities such as collection, bulking and transporting require more money and time following reduced production. Farmers who are not in groups are the most affected since they bear the cost burden alone and are more unable to engage in value addition activities. Similarly, marketing of the dairy products and participation in promotion activities becomes a challenge due to reduced market access as a result of low production.

Intense rain affects all the stages of the value chain namely input supply, on-farm production, post-harvest and selling. Destruction of roads due to too much rain does not only make inputs such as feeds expensive but also increases the cost of milk collection. The rain also negatively affects fodder crops due to poor germination and low survival rates. Flooding in the lower areas of Kipipiri, Oljoroorok and Ndaragwa due to poor drainage and continued leaching result in water contamination. Cases of diseases such as Salmonellosis and infertility have been reported to be on the rise due to water contamination.

Uptake of technologies such as fodder conservation and fodder crop diversification is very low due to little know-how about the technologies and small capital bases. Farmers rarely use early warning information in planning farm activities. This is partly attributed to claims that the information is never accurate. These factors, together with a poor road network, limited capacity to add value to the milk due to lack of capital to purchase the required equipment and scepticism towards interventions such as livestock insurance and financial institutions make the farmers more vulnerable to the above-mentioned climate risks.

Local Poultry

Drought causes high feed shortage. The costs for veterinary services also increase during dry spells since vaccinations are less effective during this season. The higher incidence of diseases during periods of drought reduces farmers' income because of lower egg and meat production. As a result farmers cannot afford to purchase housing material and better chicken breeds. Cleaning of the housing structures also becomes a problem due to water scarcity.

On the other hand, intense rain is associated with disease outbreaks (New Castle) due to impaired feeding that reduces livestock's immunity. Expenditure on vaccinations also increase. Excessive rain also severely affects availability of chickens as brooding becomes a problem owing to the low temperatures and transport of inputs due to poor road conditions. In addition, extremely low temperatures associated with intense rain lead to increased mortality especially among farmers who do not have special equipment such as incubators. The low temperatures also cause low egg production.

Despite the fact that the poultry value chain is more resilient to climatic hazards owing to adaptive practices such as switching to scavenging feed when there is feed shortage and local disease control measures such as herbs and concoctions, productivity is very low in the County. This can be attributed to a lack of capital to adopt new technologies such as improved breeds, better housing structures and incubators.

Adaptation to climate change and variability

In response to the above-discussed climate risks in Nyandarua County, many farmers have opted for various adaptation strategies. In the livestock sector, these strategies include fodder conservation, utilization of crop residues for feed, breeding using bulls, traditional methods of disease control, construction of drainage channels, and value addition. Crop farmers use strategies such as change of planting calendar, improved varieties, traditional disease control, soil and water conservation, , and manure instead of fertilisers, among others.

Uptake rates and choice of adaptation methods are most frequently influenced by land tenure systems and social and economic welfare (GoK, 2014; Onywere and Kotikot, 2014). Barriers to adoption include poor input quality regulations, poorly organized markets, lack of capacity to add value, a poor road network and low farm incomes all reduce the adaptive capacity of farmers and contribute to low adoption rates.

On-farm adaptation practices

Tree planting contributes to soil conservation and reduce severity of frost damage to crops. It is the most commonly adopted adaptation strategy in the County, especially among male- and youth-headed households (76% and 73% respectively)[12] in areas around the Aberdare, Njabini, Kinangop and Geta regions, where organizations such as Tree is Life and government bodies like the Kenya Forestry Service (KFS) supply farmers with tree seedlings. In addition, programs such as Plantation Establishment and Livelihood Improvement Scheme (PELIS) and Miti Mingi Shambani have encouraged tree planting in Nyandarua, making the County achieve the 10% tree objective set by the Government. The strategy helps in

12 Low adoption of the practice by female-headed households (33%) can be attributed to cultural practices which do not allow women to own or inherit land.

Soil and water conservation measures which include water harvesting, construction of trash-lines, strip cropping, crop rotations, construction of drainage channels (particularly in areas prone to floods like Ndaragwa and Lake Ol'bollosat) and conservation agriculture are also common adaptation strategies among farmers in Nyandarua. Approximately 51% of the households use at least one of the practices. Female-headed households are more likely to adopt such measures, compared to male- and youth-headed households (67%, 50% and 49% respectively).
Some of the soil and water conservation measures are being promoted in the County by different actors. Water harvesting is promoted by organizations such as Tree is Life and Ziwani Mogeko. Financial institutions such as the Agricultural Finance Corporation (AFC) also offer loans to farmers to enable them to construct structures such as water pans, whereas government departments like Agricultural Mechanization Service (AMS) promote conservation agriculture by encouraging minimum tillage over the conventional disc ploughing. Soil and water conservation measures help maintain soil quality by reducing leaching and formation of hard pans.

Fodder conservation is common to the drier areas such as Lower Ndaragwa and Kipipiri. About 26%, 29% and 15% of the male-, female- and youth-headed households practice conserve fodder to ensure feed availability amid increased incidences of fodder crop failure. Adoption rates are generally low, owing to high labour required and high electricity costs. Complementary strategies that could also help curb these adoption barriers include provision of feed supplements and utilization of drought-tolerant fodder crops.

Due to weather irregularities, staggered cropping has also become a common practice throughout the County for crops such as Irish potato and peas (in AEZs UH1 and UH3), and mostly among female-headed households, since women are usually in charge of ensuring year-round food production for household subsistence and have less access to other risk-coping strategies and technologies (GoK, 2014). This also explains why female-headed households are more likely to have more on-farm diversification than both the male- and youth-headed households.

Value addition helps farmers overcome transportation challenges due to poor roads (especially during the wet season), scarcity of storage facilities, low prices offered by middlemen and oversupply in the markets and is reflected in activities such as transporting, processing, bulking and packaging. Approximately 20% of the farmers engage in different value addition activities either individually or in groups (such as Umoja Dairy). Male-headed households have a higher likelihood of adding value (23%) than female- and youth-headed households (19% and 8% respectively) since they are less constrained by resource access. Nevertheless, the full potential of value addition has not been achieved hitherto since most of the produce is sold raw, mostly to middlemen, leaving post-harvest losses rates still high. Lack of capital and know-how are the major impediments to value addition.

To address the upsurge of livestock and crop diseases, farmers use traditional disease control measures such as use of herbs and concoctions and ash (for crop farmers, mostly in potato). This practice is most common during the flood season, when there is limited access to veterinary services. Potential complementary control mechanisms that could be promoted County-wide include provision of and access to disease-tolerant crop varieties and animal breeds and improved disease surveillance systems in the County.

To cope with scarcity of planting material/ seeds and fertilisers, farmers recycle and/or multiply seeds and utilize manure[13] to ensure continuous on-farm supply of inputs in times of extreme weather conditions. However, these adaptation strategies usually turn out inefficient, since seed recycling results to low yields, and most farmers cannot access the Agricultural Training Centre (ATC) for seeds. Improved access to training and more private sector engagement in delivering these services to farmers could maximize the benefits of these currently adopted strategies.

Marketing challenges encountered as a result of low production are bypassed by the farmers through *selling to the local markets and brokers*, though farmers receive very low prices using this strategy. Collective marketing and contract farming, where farmers can obtain better prices, input and technical support, are additional adaptation strategies that could to be explored.

13 Seed recycling and utilization of manure are common in the entire County, whereas seed multiplication is mainly done at Njabini Agricultural Training Centre (ATC).

Off-farm adaptation practices

In addition to on-farm practices, farmers also have access to off-farm services which facilitate uptake of on-farm adaptation practices and improve farmers' preparedness and resilience to climate risks. The services are offered by governmental, non-governmental, private, faith- and community-based lead agencies and include early warning information, extension through trainings, field days and workshops, input provision, and Artificial Insemination (AI) services.

Fodder conservation services which include provision of storage facilities, chopping and pulverizing are mainly offered by the Livestock Production Department (LPD) and AMS. However, most of the farmers are not able to pay for the services due to low farm incomes. Additionally, the Livestock and Veterinary Departments offer AI services to cope with high animal abortion rates and infertility but these are not easily accessible for female- and youth-headed households.

Extension services are offered by almost all the organizations where farmers are taught the importance of using good agricultural practices that promote soil and water conservation, high yielding, early maturing crop varieties and animal breeds and value addition. Nevertheless, only 49%, 41% and 10% of the male-, female- and youth headed households farmers can access extension services (GoK, 2014). This is due to the small number of extension agents in governmental as well as non-governmental institutions compared to the vastness of the County, insufficient finance, and poor infrastructure. In addition, the current demand-driven approach in extension is expensive, which marginalizes most farmers from accessing the services.

Early-warning information which includes weather forecasts (mainly provided by the KMD in collaboration with the MoALF) and disease outbreak warnings (provided by the Veterinary Department) improves preparedness. However, few farmers use the warnings due to the perception that they are unreliable and untimely[14] . In instances where farmers are ready to act on the early warning information, resource constraints deter them from taking precautionary measures.

Financial institutions such as insurance companies, microfinances, banks and AFC offer credit services (e.g. loans and insurance schemes) to farmers. The loans enable farmers to undertake adaptive measures such as water harvesting, value addition, and fodder conservation. The upcoming crop and livestock insurance schemes in the County are aimed at cushioning farmers from unforeseeable risks. Nevertheless, uptake of financial services is extremely low because of poor distribution throughout the County areas and high interest rates, which discourage farmers to approach such services.

14 Imprecision arises from generalizations of weather information for entire Nyandarua County from data obtained from a few poorly distributed weather stations in the County. Lack of modern equipment to capture detailed data in real time is also a contributing factor

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

Irish potato

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Floods	Scarcity and unavailability of potato seed and decomposed organic manures; limited access (availability and high costs) to inputs due to transport challenges	High labour and production costs (logged field conditions, labour scarcity, pests and diseases incidence); agrochemicals leaching; environmental pollution (intense spraying); damaged and unearthed tubers; germination before harvesting	High harvest and transport costs (unfavourable conditions in fields and road networks); Damaged and broken storage structures/ facilities; increased post-harvest loss (quantity and quantity)	Low prices due to low quality of product
Magnitude of impact	Major	Severe	Severe	Severe
Farmers' current strategies to cope with the risks	Seed recycling; purchase from seed multipliers; reliance of informal seed systems (relatives, neighbours); subsidized seeds (from cereal boards); inputs purchase from agro-dealers	Scanty and inconsistent input (fertilizer, chemicals) application at planting and within crop cycle; planting in trenches/ trash-lines (to conserve moisture); strip cropping; manual land preparation; tree planting; water harvesting; staggered planting	Manual packaging based on volumes; product transportation from farm to stores using cheap transport means (donkeys and labourers)	Informal tuber pricing (prevailing market conditions); sale on local markets
Other potential options to increase farmers' adaptive capacity	Farmer training on on-farm seed bulking, engage more seed multipliers; introduction of specialized inputs (fertilizer blends for potatoes); capacity building on compositing; provision of credit facilities to access inputs; mechanisms for bulk sourcing (through groups)	Mechanization (land preparation, tilling planting, spraying); access to protective gear for agronomic practices (spraying); advisory services for planting times and production requirements; conservation agriculture; county support to construct drainage channels	Mechanized harvesting; specialized packing (air-circulating gunny bags); packaging on weight basis; standardized units of weighing (per kg); pooled transportation by farmers from field to stores; improved storage infrastructure; availability of insurance products	Farmer groups to enhance bargaining; formalized marketing (contracts); new market opportunities
Droughts	Scarcity and unavailability of seed and organic manures	Rainfall dependence due to lowered capacity to irrigate; increased production costs (in mechanized and irrigated farming)	Loss of employment opportunities and livelihoods; lack of storage facilities	Product scarcity leading to disruption and/or low market activity
Magnitude of impact	Major-Severe		Major-Severe	Severe
Farmers' current strategies to cope with the risks	Seed preservation, multiplication and bulking from previous crops (government centres); use of FYM (blending with fertilizers); use of traditional chemical control (ash); land consolidation to increase production acreagee	Planting clean seed; planting in deep trenches on fields with higher moisture retention (high soil organic matter); irrigation and water sprinkling to prevent frost damage; mulching; intercropping; agroforestry; staggered planting	Manual grading; packaging in market-determined volumes; storage in dry sheds; pest and rodents control; efficient harvest transportation methods (bikes, lorries)	Tuber sale at farm gate prices (low prices)
Other potential options to increase farmers' adaptive capacity	Promote capacity building and involvement of private sector and smallholders in seed multiplication and bulking (increase acreage in centres); subsidized inputs costs; provision of pest- and disease-tolerant, early-maturing varieties	Mechanization of planting activities; tree planting; promotion of agroforestry and conservation agriculture technologies; promotion of IPM technologies; awareness on proper husbandry practices; irrigation	Mechanized harvesting; weight-based packaging; mechanical loading; value addition	Direct access to processors; contract farming to curb exploitation; farmer associations to facilitate marketing agents

Poultry (chicken)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Input accessibility challenges (inaccessible roads)	Destruction of breeding stock (drowning); increased incidence of disease outbreaks; increased costs of poultry management (feeding, vaccination)	Poor storage facilities (damaged by floods); increased storage costs (disinfectants, storage materials)	Lack of market access due to inaccessible roads; low sales and incomes due to lack of market access; scarcity of eggs and poultry meat in the market
Magnitude of impact	Major	Severe-Major	Severe-Minor	Severe-Moderate
Farmers' current strategies to cope with the risks	Local borrowing (from groups, cooperatives); floor raising using local available material; local breeding	Free range scavenging; minimal sourcing of feeds from millers; indigenous disease control (herbal treatment); use of local disinfectants (ash); culling and re-stocking	Use of local resources to build storage structures; on-farm selling (avoid storage/ reduce transport costs)	Local (markets) and farm gate sales; Individual bulking and pricing; community efforts to repair roads for market access costs)
Other potential options to increase farmers' adaptive capacity	Improved access to credit and to extension expertise (poultry housing designs, feed formulations); widespread use of incubators	Capacity building (feed formulation, disease control and management); enforcement of routine vaccination; access to disinfectants; research on emerging diseases	Improved storage structures/facilities, packaging material; pooling transportation (economies of scale); improved road infrastructure (to reduce transportation damages)	Improve group marketing (saccos/ cooperatives); Introduce poultry insurance schemes (safeguard loss)
Droughts	Unavailability and unaffordability of breeding chicks/ chickens due to high prices; inadequate feeds	Loss in poultry weight due to improper feeding; increased incidence of diseases	Decreased yields (eggs); high transport costs due to reduced economies of scale	Reduced market activities (promotion, marketing) due to scarcity of products
Magnitude of impact	Moderate-Minor	Major-Minor	Major-Moderate	Moderate-Minor
Farmers' current strategies to cope with the risks	Use of locally available material to build poultry housing; local breeding; buying formulated feeds from millers	Livelihood diversification (boda boda); culling diseased chicken; cultural treatment (pest invaded and diseased poultry); fetching water from dams and shallow wells using donkeys	Selection of high yielding breeds; immediate (farm gate) selling of eggs; eggs storage using household resources (containers); value addition (defeathering)	Reduced market activities (promotion, marketing) due to scarcity; sale at farm gate (low prices)
Other potential options to increase farmers' adaptive capacity	Establishment of associations to access credit for purchasing inputs; technical support in construction of poultry units; access to diversified types of building material; improved access to poultry breeds	Farmer capacity building (feed formulations, alternative pest and disease control techniques); enforcement of routine poultry vaccination; provision of piped water; promotion of water harvesting techniques (water pans); alternative enterprises (employment; business)	Use of communal and improved storage facilities; pooled transportation of products (groups, saccos); improved road infrastructure; value addition of poultry products	Farmer groups (groups/-saccos/cooperatives) to facilitate market access; policies for price regulation; contract farming

Dairy (cow)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Poor access to inputs (infrastructure affected by rains); poor pasture quality	Increased pests and diseases incidence; lower milk production due to poor animal feed	Poor road hinder access to storage facilities; damage to fodder and milk storage structures	Reduced incomes from milk production; reduced market activities and opportunities; job losses (processors, transporters)
Magnitude of impact	Major-Moderate	Moderate	Major-Moderate	Moderate
Farmers' current strategies to cope with the risks	Use of locally available breeding bulls; feed conservation; drainage in fodder fields and animal sheds (channels/trenches); use of alternative inputs (traditional herbs/ concoctions); patching of damaged road sections to enhance input access	Use of traditional herbs and concoctions for pest and disease control	Feed conservation in sheds; community efforts at road repair to access pasture fields and storage facilities; value addition (powdered milk, fermentation)	
Other potential options to increase farmers' adaptive capacity	Improved infrastructure to aid input access; provision of relief (aid) dairy inputs (drugs, feed, concentrates); capacity building in fodder production and conservation	Disease and pest surveillance systems and advisories; capacity building in soil and water conservation	Milk processing plants	Community-based milk reserves; access to insurance products to cushion dairy activities
Droughts	Poor quality/ insufficient pasture/fodder; high cost of breeding due to infertility; high cost of feed due to scarcity; reduced access to credit	Increased pests and diseases due to impaired immunity and poor feeding; stand establishment (poor germination/low survival rates)	Increased operational costs (collection of milk and bulking of pastures/fodder)	High operation costs incurred by milk traders in milk sourcing; reduced market/marketing activities due to milk scarcity
Magnitude of impact	Severe-Major	Severe-Moderate	Major	Major-Moderate
Farmers' current strategies to cope with the risks	Use of bulls; use of organic residue for feed inputs; feed conservation; alternative feeding strategies (crop residues, herbs, branches, shrubs, grass)	administration and application of locally available drugs/ointments for pest and disease control; on-farm diversification (crop growing)	Control of milk delivery to bulking centres	Reduced marketing activity due to milk scarcity; sale of milk at low farm gate prices
Other potential options to increase farmers' adaptive capacity	Drought tolerant pastures/fodder; strategic reserves for feeds production and conservation; supply of concentrates to improve fertility; farmers training on fertility cycle monitoring; input subsidies to farmers; improved feed production and conservation strategies; establishment emergency fund to cushion producers; promotion of disease tolerant animal breeds	Access to veterinary services and insurance; disease surveillance systems	Milk processing plants	Niche markets; contract farming; access to insurance products to cushion dairy activities

Pea

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Floods	Increased input costs due to limited access (damaged roads); incidence of planting seed spoilage during transportation	Poor stand establishment; challenges in land cultivation; high production costs (control of weeds ,pest, diseases); high pre-post harvest losses (rotting, disease, sprouting); delayed planting	Seed sorting and grading challenges due to seed rot/spoilage; lack of access to storage facilities after grain harvest	Low farm gate prices due poor quality and low quantity of products
Magnitude of impact	Severe-Major	Severe	Severe-Major	Severe-Moderate
Farmers' current strategies to cope with the risks	Seed transportation (boda boda/ donkeys); use of terraces (drain excess water); seed recycling; local scale seed multiplication	Use of chemicals to reduce labour costs; changing planting calendars; weeding hoes; rogueing (of weeds); field water drainage (trenches, furrows)	Product sorting/ drying (sorting beds); field-to-store transportation (animal/ boda boda/ bicycles); communal road repair to ease transport challenges	Household consumption of products; sale to middlemen for external markets
Other potential options to increase farmers' adaptive capacity	Improved road infrastructure to ease access to inputs; improved seedbed husbandry (raising of seedbed; construction of cut-off drains)	Construction of drainage channels; increased use of IPM technologies; improved weather forecasts	Improved storage facilities; value addition	Improved access to new markets
Droughts	Poor seed quality due to pest infestation	Deteriorated soil properties; increased pest and disease incidences; late planting; increased need for irrigation (drip) facilities; high production costs (labour/ disease control)	Poor harvest (quality and quantity); Increased pest infestation during harvest and storage; high transport costs (low economies of scale)	Low level of product supply
Magnitude of impact	Major-Moderate	Severe	Major	Severe-Moderate
Farmers' current strategies to cope with the risks	Use of pesticides; seed recycling; local seed multiplication; manure utilization	Dry planting; changing planting calendars; conservation agriculture (weed control); agroforestry; cover crops; intercropping; planting without fertilizer; irrigation; livelihood diversification	Cleaning harvested seed; use of "boda boda" for seed transportation to stores; application of storage chemicals	Low sales (farm gate/local markets)
Other potential options to increase farmers' adaptive capacity	Use of IPM technologies; irrigation (to increase fertilizer demand); trainings on compositing and seed multiplication	Conservation agriculture (tillage) and agroforestry practices; increased use of irrigation technologies	Enclosed transport mean (lorries)	Farmer associations/ cooperatives to increase bargaining power

Policies and Programmes

Most national policies around climate change, agriculture, and the environment have yet to be devolved to County level. These include the Environmental Management Authority Act of 1999 (EMCA), the National Climate Change Action Plan (NCCAP), the National Forestry Policy (NFP), the National Environment Policy (NEP) and the Wildlife Conservation and Management Act (WCMA). These legislations are important to the agricultural sector as they help in ensuring conservation of resources (particularly EMCA and NFP) and in addressing human wildlife conflicts (WCMA), among others. Since these policies are not based on the County context needs and resources, the implementation of these turns out ineffective[15].

A few County-specific policies have been identified, including the Potato Production and Marketing Bill, the Pyrethrum Production and Marketing Bill, and the Agricultural Institutional Revolving Fund Bill. To the moment, none of these bills has passed in the Parliament.

The Potato Production and Marketing Bill (initiated in 2014) aims to solve challenges related to certification and standardization of seed, which is usually practices by licenced seed producers/ suppliers, restraining farmers from mixing potato varieties. The policy also regulates marketing, establishing standard guidelines for potato packaging (use of 50 kg bags instead of the 110 kg bags) (GoK, 2014b).

The Pyrethrum Produce and Marketing Bill (initiated in 2014) aims to revitalize the collapsing pyrethrum industry in the County. Some of the critical issues addressed by the Bill is delineation from the Pyrethrum Board of Kenya (PBK) to allow farmers to sell their produce directly to exporters.

Another important legislation in the County is the Agriculture Institutions Revolving Fund Bill (initiated in 2014), developed as an answer to the challenges faced by the ATC and the AMS under the MoALF. The bill therefore was aimed to smoothen operations and sustainability of the two bodies (ATC and AMS) that are run from the Headquarters in Nairobi.

In addition to the initiatives, several programs have been implemented in the County to help farmers mitigate and adapt to climate change risks. The ASDSP, developed in 2010 by the Kenyan Government with support from the Swedish Government, aims to increase agricultural productivity in rural households through capacity building. The program uses participatory scenario planning, where beneficiaries (farmers) of a certain intervention are given the chance to identify the most pertinent interventions as well as the most effective implementation strategies. Access to extension services, which include knowledge sharing and transfer on crop selection, improved seeds and early maturing varieties, has been promoted through development of linkages between farmers and relevant stakeholders in the agricultural sector such as research organizations and input dealers.

KAPAP, which represents the second phase of the Kenya Agricultural Productivity Programme (KAPP) started in 2004 by the Kenyan Government and the WB, has facilitated training of farmers on soil conservation, fertiliser and pesticide use. The program has also funded dairy farmer groups like Umoja and South Kinangop Cooperatives, in buying milk dispensers and coolers. Wealth creation from interventions in the prioritized value chains in the County is estimated at 2.08 B KES. KAPAP was the only program reported to have created awareness on climate change/ variation among farmers.

The major obstacles to effective implementation of the programs and impact include insufficient finances that can enable wider coverage, poor targeting of beneficiaries, poor monitoring and evaluation of the initiatives, lack of engagement of stakeholders, among others. Programs such as Njaa Marufuku, Miti Mingi Shambani, the National Soil and Water Conservation Programme, and PELIS, although with promising impact, have phased out mainly due to lack of funds[16]. Additionally, farmers' preference for abiding unwritten rules[17] reveals a cleavage between formal and informal institutions that has yet to be solved with existing policy efforts.

15 For instance, farmers reported that the WMCA was irrelevant since monkeys, considered a threat to household and agricultural production in some parts of the County, are not included in the category of animals whose damage to households can attract compensation to farmers

16 Njaa Marufuku which was developed from the Special Programme for Food Security mainly funded groups of farmers to undertake activities such as water harvesting. Miti Mingi Shambani was formed to encourage tree plantation. PELIS was piloted in 2008 by the KFS. The program has been reported to be beneficial to the local people since it has provided approximately 2000 ha of arable land to the landless from which about 3 million bags of potatoes among other crops such as maize, cabbages and peas were produced. This helped solve the problem of food security in the County (Odwori et al., 2013).

17 Discussions with farmers revealed that farmers tend to be more aware and respect informal rules such as those prohibiting cultivation and planting of trees such as blue gum close to the rivers, since these are "enforced" by local, community-based administration.

Governance, institutional resources, and capacity

A number of governmental, NGOs, CBOs, private, and faith-based organizations have a direct or indirect engagement in efforts to diminish the impacts of climate change and variability on County's agricultural sector.

The government institutions include the Ministry of Livestock, the National Environmental Management Authority (NEMA), KFS, AMS, KMD, Veterinary Department and the ASDSP. The government agencies mainly provide services such as extension on best production practices and supply inputs such as fertilisers, vaccinations and Artificial Insemination (AI). LPD has improved the adaptive capacity of the farmers through supplying inputs such as improved livestock breeds, fodder pulverisers and promotion of fodder conservation technologies. It has also enlightened farmers on intensive production systems such as zero grazing and biogas utilization to reduce pressure on the already fragile environment. The unit works closely with the Veterinary Department which is mainly responsible for disease control through provision of early warning information on disease outbreaks and livestock vaccination.

The AMS provides conservation agriculture services to the farmers and promotes fodder conservation and water conservation through construction of water pans. In addition, it is responsible for construction and maintenance of feeder roads.

The KMD provides weather forecasts to various stakeholders and collaborates with other actors to enhance preparedness for climate related risks. The KFS mainly encourages afforestation by offering tree seedlings and maintains/constructs feeder roads in collaboration with the National Youth Service (NYS).

NEMA doesn't directly engage in climate related interventions but rather regulates and coordinates various environmental projects throughout the County.

CBOs include Ziwani Mogeko, Sustainable Community Development Services (SCODE) and Kingbird. Ziwani Mogeko promotes water harvesting through construction of water pans and encourages farmers to organize into groups to facilitate value addition and better access to markets and credit. SCODE promotes environmental conservation through capacity building and subsidizing energy-saving technologies whereas Kingbird, formed under the auspices of Tree is Life, enhances credit access and marketing for poultry farmers.

Private organizations include financial institutions such as banks (for example Equity and Kenya Commercial banks) and insurance companies which offer credit services to farmers and exporters that provide technical support to horticultural farmers and link them to markets. Faith-based organizations include Caritas which is a humanitarian arm of the Kenya Conference of Catholic Bishops (KCCB) engages in capacity building, research and increasing the resilience of poor urban and rural households to climate related and other risks.

The private, faith and community-based organizations autonomously select the interventions, location, beneficiaries and approach of implementation of the interventions unless donors have particular demands/ objectives. Conversely, almost all government departments have to operate according to County- (for those devolved such as MoALF) or national government (for those not devolved such as NEMA and KFS) plans, where bureaucracy oftentimes challenged funds allocation and holds up operations.

Coordination/collaboration in undertaking climate related risks interventions by the various organizations and government departments is relatively poor. This is mainly because every organization/department has different timeframes for different undertakings. Lack of an overall body responsible for overseeing and linking climate change interventions in the County leads to duplication of effort. Lack of sufficient funding to engage all stakeholders throughout the whole process of an intervention is also a limiting factor.

Inadequate staffing and technical know-how in addressing climate risks in the various organizations and government departments pose serious setbacks to interventions planning, implementation and monitoring. Lack of political goodwill to ensure proper policy enforcement and poor coordination are also contributing factors to institutional incapacities and hinder the effectiveness of measures that can increase the adaptive capacity of farmers to climate risks.

Synthesis and Outlook

Historic data show that Nyandarua County suffered from several climatic hazards namely drought and intense rain in the past. This has negatively affected crop and livestock production in terms of input supply, on-farm production, post-harvest handling and marketing. Simulation of future climate scenarios suggest increased frequency of such hazards, putting livelihoods and food security at risk.

Farmers have made considerable progress in answering to climate threats, by adopting practices that can increase resilience of their household and livelihoods. Such adaptation strategies include fodder and feed conservation, traditional disease control methods, flood control measures (construction of drainage channels to promote fodder establishment) and cheap transport means (donkeys) for livestock and conservation agriculture, shifting of planting calendars, use of improved varieties, irrigation, seed recycling and multiplication, and value addition for crop production. Likewise, governmental and non-governmental institutions are working towards providing farmers with additional incentives and capacity to adopt such practices, including provision of extension services, weather information, and credit.

In as much as these strategies have proved effective in diminishing climate risks to agriculture, the sector in the County is still characterized by low productivity levels, which impairs marketing and consequently improvements in livelihoods. Adoption of existing practices needs to be scaled out throughout the County, making sure that vulnerable farmers also have the capacity and means to adapt to a changing climate. Likewise, improvements in basic infrastructure, including access to water, electricity, education, and in road network represent a first step towards enabling farmers to be more empowered and ready to engage in agricultural activities, from production to marketing.

Farmers still lag behind in using adaptation strategies that are capital intensive (such as value addition and fodder conservation) but which offer better marketing opportunities and return of investments in the medium run. Therefore a vision that helps actors along the value chain stages to be prepared and cope with climate threats, through exploring new post-harvest, processing, and marketing opportunities would guarantee the sustainable growth of the entire value chain.

Progress at the policy-making level has also been reflected through the formulation of bills that seek to increase productivity and facilitate marketing of agricultural products. While the bills have been developed taking into account the realities and needs of the County, progress towards their enforcement has been slow, since they have yet to be passed by the County Assembly and turned into laws. This highlights the need to improve the policy-making process through more efficient agendas, adequate allocation of funds and staffing, to ensure availability of resources needed for turning plans into action.

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

Annex 1: Administrative units and agroecological zones
Annex 2: Value chain selection indicators
Annex 3: Crop and livestock productivity in Nyandarua County
Annex 4: Adaptation strategies in Nyandarua County disaggregated by gender

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