

Kenya County Climate Risk Profile: Narok County

Highlights

- Agriculture is one of the main sources of livelihood in Narok County (Figure 1). It engages over 46% of the population. The county has an absolute poverty rate of 34%, and 12% of the population experiences food poverty.
- The county's agro ecological zones range from highlands, which experience sufficient and reliable rainfall, to lowlands, which experience little and unreliable rainfall..
- In the last 20-30 years, climate change has affected Narok County, with rainfall seasons becoming more unpredictable.
- Prolonged dry spells and droughts negatively affect crops like maize and livestock like sheep, dairy cow, and local chicken.
- Intense precipitation over short duration causes flash floods that destroy crops and property.
- Narok County farmers adapt to climate change effects by adopting water harvesting and pasture development, planting early-maturing and drought-resistant crops, and using improved breeds of livestock.
- Early warning systems, protection of water sources, range rehabilitation, climate and weather advisories, extension services, food and non-food aid services, and insurance can support the County adapt to climate change.
- Research, training, health, sanitation and nutrition interventions can also foster adaptation to climate hazards and vulnerabilities.
- Poor coordination between various local and national institutions, coupled with limited synergies in policies and programs hinder climate adaptation efforts.
- Non- food aid interventions need to focus on building human and financial capital.

Figure 1: Map of Nandi County

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List of Acronyms

ASDSP	The Agricultural Sector Development Strategy Program
CDD	Consecutive Dry Days
CIAT	International Center for Tropical Agriculture
GDP	Gross Domestic Product
GoK	Government of Kenya
Ha	Hectare
KNBS	Kenya National Bureau of Statistics
KSh	Kenyan Shillings
LGP	Length of Growing Period
MT	Metric Ton
NARIGP	National Agricultural and Rural Inclusive Project
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NDMA	The National Drought Management Authority
NT35	Number of Days with Maximum Temperatures Greater Than or Equal to 35°C
P5D	Average Amount of Precipitation over 5 Days
USD	United States Dollar



Narok

Foreword

The mandate of the Ministry of Agriculture, Livestock, Fisheries and Co-operatives is to create an enabling environment for sustainable development of agriculture and co-operatives for economic development. This objective underpins our desire and commitment to transform Kenya into a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment as envisaged in our development blueprints, the Kenya Vision 2030, the Big Four Agenda and the Agricultural Sector Transformation and Growth Strategy (ASTSG 2019 – 2029). The sector remains high on the national development agenda in terms of food and nutrition security, income generation, employment creation, saving and investment mobilization and export earnings. To realize the country's aspirations of food and nutrition security, the Government through this Ministry is implementing the National Agricultural and Rural Inclusive Growth Project (NARIGP) with the support of the World Bank. The development objective of the project is to increase the agricultural productivity and profitability of targeted rural communities in 21 counties and in the event of an eligible crisis or emergency, provide an immediate and effective response.

The agriculture sector is however, highly vulnerable to the impacts of climate change and extreme weather events. Responses that would enable the country to cope with these risks are outlined in the Kenya Climate-Smart Agriculture (CSA) Strategy and in the commitments of the Kenya Nationally Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC). In 2010, the Government developed the National Climate Change Response Strategy (NCCRS) which recognized the impacts of climate change on the country's development. This was followed by the development of the National Climate Change Action Plan in 2012. The focus of these initiatives include the development of county-level climate risk profiles to mainstream climate change perspectives in programs and development plans at county level. The Ministry has developed county climate risk profiles in 31 counties and NARIGP is supporting the development of profiles for an additional 14 counties. The purpose of the profiles is to inform county governments and stakeholders on the climate change risks and provide opportunities for integration into respective county development plans and processes.

This climate risk profiles study will be used as a basis to climate proof projects or any other developments in fourteen counties (Samburu, Turkana, Kitui, Narok, Kirinyaga, Kiambu, Muranga, Bungoma, Trans Nzoia, Nandi, Vihiga, Kisii, Nyamira and Migori). The study provides information on current and possible future climate scenarios, climate-related vulnerabilities and risks for key major agricultural value chains, policy landscape and the institutional capacity to deliver adaptation programs. Each profile presents adaptation and risk reduction options that can transform and reorient agricultural systems in the counties to increase productivity, enhance smallholder farmers' resilience and mitigate against climate change.

Finally, I call upon all stakeholders for their cooperation and support for adoption of CSA production practices that maximize the triple wins: increases productivity, enhanced resilience and reduced greenhouse gas (GHG) emissions. Through the adoption of new technologies and improved practices, we will realize the desired goal of Kenya being a food and nutrition secure country, fostering socio-economic development and improved livelihoods of Kenyans.



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1. Introduction

Climate change is becoming one of Kenya’s most serious threats. The country is susceptible to climate-related events, and projections indicate that climate-related events will continue to affect Kenya in the future. In many areas, extreme weather is now the norm. Rainfall is irregular and unpredictable; some regions experience frequent droughts during the long rainy season or severe floods during the short rainy season. Arid and semi-arid areas are particularly vulnerable to these extreme changes, putting the lives and socio-economic activities of millions of households at risk.

The Kenya Vision 2030 is a national blueprint that seeks to transform Kenya into a middle-income country that provides a high quality of life and a clean and secure environment to all its citizens by 2030. This blueprint has identified the agriculture sector as a key means to contribute to Kenya’s economic growth. However, the agriculture sector is constrained by inadequate access to quality goods, marketing inefficiencies, a subpar investment environment, decreasing soil fertility, insufficient mechanization, land fragmentation, and - most significantly - climate change.

In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS) which recognized the impact of climate change on the country’s development. This was followed by the 2012 National Climate Change Action Plan (NCCAP), which provided a means for implementing response strategies and highlighted the country’s priorities. These two initiatives are focused on the national level, but the response to climate change also needs to be integrated into county-level policies, programs, and development plans. Initiatives need to be locally relevant and actively involve local stakeholders.

Through the Ministry of Agriculture, Livestock, Fisheries, and Cooperatives, the Government of Kenya is implementing the National Agricultural and Rural Inclusive Growth Project (NARIGP), with support from the World Bank. This project aims to increase the agricultural productivity and profitability of targeted rural communities in selected counties. To address climate change-related risks, the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) was engaged to do a climate risk profile assessment. The aim of this assessment is to provide information on current and future climate scenarios, identify vulnerabilities and risks, identify possible adaptations, and assess the feasibility of these adaptations.

This assessment aims to educate governments and stakeholders on climate change-related risks and opportunities. This report will help governments and stakeholders integrate climate change perspectives into their development plans.

The Alliance implemented the assessment through a set of interrelated stages (Figure 2). It first initiated a desk review of the conceptual and analytical context of climate change risks at national and county levels. Efforts were made to involve a wide range of institutions that have past and ongoing work on climate change at national and regional levels. The team used globally available data sources as well as collected data from relevant government departments (e.g., Department of Resource Surveys and Remote Sensing (DRSRS), the Kenya Meteorological Department, Drought Monitoring Center, county development plans) and data portals (e.g., Kenya Open Data Portal). Data was also collected through focus group discussions, interviews with key informants, climate modeling and three-day-long, sub-national stakeholder workshops. The final reports were then presented to and validated by national- and county-level stakeholders.

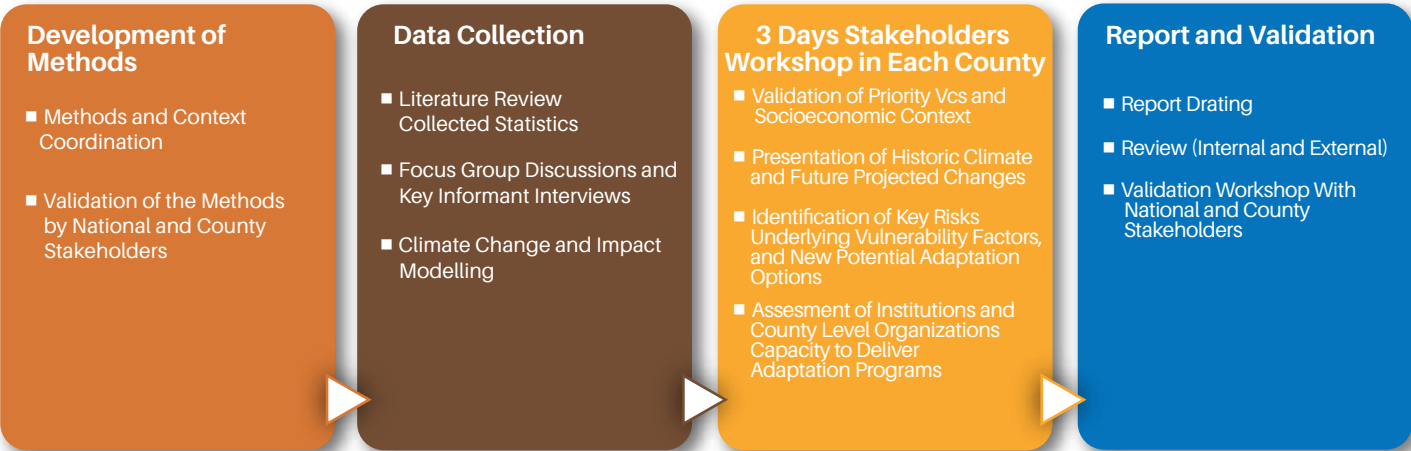


Figure 2: Climate risk profile (CRP) development process.

This document presents the Climate Risk Profile for Narok County. It is organized into six main sections, each reflecting an essential analytical step towards understanding current and potential adaptation options in key local agricultural value chain commodities. The first section offers an overview of the agricultural commodities that are key to food security and livelihoods in the county, and then lists major challenges to agricultural sector development in Narok. In the second section, it identifies the main climate hazards, based on an analysis of historical climate data and climate projections. These include scientific assessments of climate indicators for dry spells, extreme rainfall, moisture stress, and heat stress, among others. Third, the report continues with an analysis of vulnerabilities and risks posed by these climatic hazards to the identified value chains. Based on these vulnerabilities, the fourth section discusses current and potential on-farm adaptation options and off-farm services. In the fifth section, the report provides snapshots of the enabling policy, institutional, and governance contexts for the adoption of resilience-building strategies. Finally, the sixth section presents pathways for strengthening institutional capacity to address climate risks.

2. County Context

Narok County, located in the Great Rift Valley of Kenya, covers 17,933 km². It is the 11th-largest county in Kenya. It borders Bomet, Kisii, Migori, and Nyamira Counties to the west, Nakuru County to the north, Kajiado County to the east, and the Republic of Tanzania to the south. Narok County consists of Narok North, Narok East, Narok South, Narok West, Trans Mara West and Trans Mara East sub-counties. It lies between latitudes 0° 50' and 1° 50' South, and longitudes 35° 28' and 36° 25' East. Narok County is home to numerous volcanic landforms and major geothermal activities (GoK, 2018).

Narok County has two dominant agroecological zones: the lowlands, which are suitable for pastoralism, and the highlands, which are suitable for rain-fed agriculture. Grassland, shrubs, and forests are the dominant vegetation in the lowland areas of Mara, Transmara, Osupuko, Loita, Narok South, Suswa, and Narok North sub-counties. They are therefore suitable for livestock farming and protecting wildlife. The forest's main threat is encroachment and tree-felling for settlement, charcoal burning, firewood, and logging.

Narok County's agroecological conditions are influenced by altitude, soil type, rainfall pattern, vegetation, and human activities. The lowlands have low agricultural potential due to unreliable rainfall. The Ewaso Ng'iro South basin and the Lake Victoria South basin dominate the county's drainage system (CIDP, 2013-2017). These basins include the Ewaso

Ng'iro river that originates from the Mau Escarpment and drains into Lake Natron, the Mara River that transverses Maasai Mara Game Reserve and drains into Lake Victoria, and the River Mogor, which feeds the Sondu River (GoK, 2018).

The Mau escarpments form the highland areas, and they lie 3,100m above sea level. The escarpments form a majority of the county's farming areas (GoK, 2013). These highlands are also the source of several of the county's major rivers. This determines, to a large extent, the county's settlement patterns. Most of the agricultural activities in Narok County occur on arable land, which makes up approximately 47% of the county. These agricultural activities are extensive in the Narok South, Narok East, Narok North sub-counties, the Mau region, the northern part of the Narok West sub-county, and most of the Emurrua Dikikir sub-county (GoK, 2018). Narok County also includes conservancies, the Maasai Mara Game reserve, and national park, and urban land (GoK, 2018).

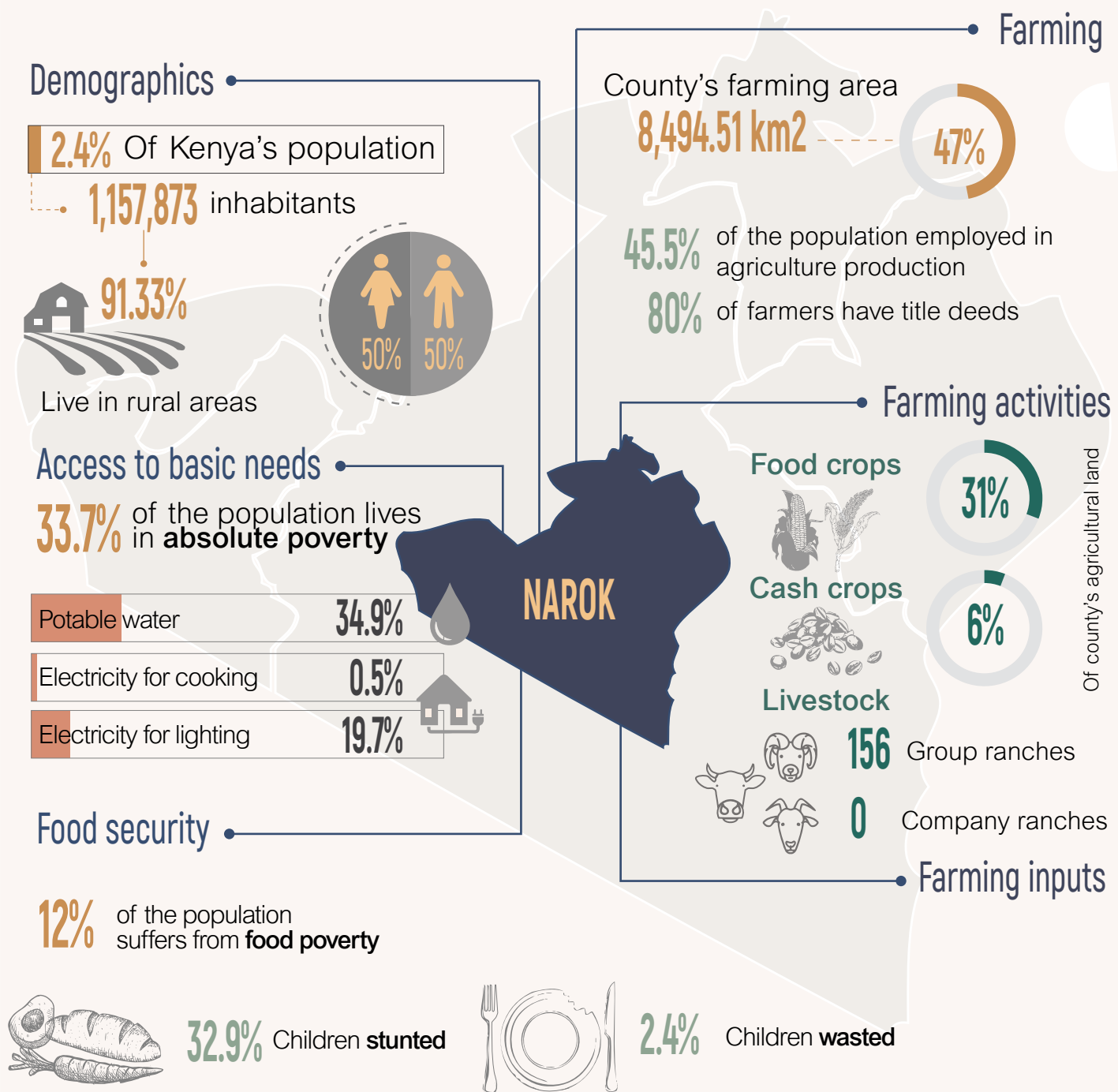
2.1 Economic Relevance of Farming

Narok County practices agriculture on both a subsistence and commercial basis. Over 46% of the county's population derives their livelihood from agriculture (GoK, 2018). Approximately 252,880 ha of Narok County's land is used for crops like wheat, barley, maize, beans, sugarcane, Irish potatoes, finger millet, pigeon peas, cowpeas, sweet potatoes, and cassava, and horticultural crops like tomatoes, potatoes, cabbage, French beans, onions, and indigenous vegetables. Farmers also keep dairy cows and poultry for subsistence.

Approximately 4% of the total land in Narok County is used for cash crops like maize, barley, wheat, coffee, tea, pyrethrum, and sugarcane. Wheat and maize are the highest income-earners in Narok County (GoK, 2018). The county farms an average of 148,812 tons of wheat and 220,462 tons of maize each year. In 2015, the 271,158 tons of maize that the county produced was valued at 7 and a half billion Kenyan Shillings (KSh)¹. The 132,172 tons of wheat that the county produced was valued at roughly KSh 4 and a half billion (GoK, 2018). The county keeps cattle, sheep, goats, poultry, donkeys, rabbits, bees, and fish for commercial purposes. There are about 1 and a half million cattle, a little more than 1 million sheep, and almost 1 million goats in the county (GoK, 2018). Fish farming is on the rise. In 2020, there were 467 fish farmers in the county. There are about 425 fish ponds. There are 366 fish ponds in the Transmara West and East sub-counties, with others spread across other sub-counties (GoK, 2018). Fish production has increased from 8,078 kg in 2011 to 31,352 kg in 2015. In 2015, the total value of the fish that was harvested was about KSh 11 million (GoK, 2018).

¹At the current exchange rate as of 11/30/2020, KSh 109.50 equals US\$ 1.

Livelihoods and agriculture in Narok



Infographic based on data from the County Integrated Development Plan (GoK, 2013-2017), the Agricultural Sector Development Support Program (GoK, 2017), and Kenya National Bureau of Statistics (KNBS, 2019)

Figure 3: Agriculture and Livelihoods in Narok County

for irrigation. 12,400 ha could ostensibly be used for irrigation, but only 3,160 ha is currently used for irrigation (GoK, 2018).

Fish farming was initially promoted under the government's economic stimulus program to create jobs for youth, reduce poverty levels, and improve food insecurity. About 320 fishponds were constructed in the Transmara West and Transmara East sub-counties through this program. However, due to various factors, including the fact that the government owns the ponds, the ponds have been neglected. 160 ponds are currently active as per the Fisheries Department of Narok County. These ponds cannot meet the demand for fish, and farmers supplement their yield with fish from rivers and dams. The Fisheries Department is involved in fish consumption campaigns, and has also initiated efforts to revive the neglected ponds.

2.4 Agricultural Value Chains

Several of Narok County's agricultural commodities are prioritized in the county's integrated development plan and development programs such as the National Agricultural Rural Inclusive Growth Project and the Agricultural Sector Development Support Program, and government institutions such as the Kenya Agricultural and Livestock Research Organization. Researchers compiled a list of the county's major agricultural commodities, or value chains, by assessing criteria such as productivity, harvested area, production, production variations in the past five years, economic value, calorie content, protein content, iron content, zinc content, and vitamin A content. This list was further honed by stakeholders, who judged criteria such as the value chain's resilience to climate change, the percentage of the county's population who are involved in the value chain, and the value chain's effects on economically and socially vulnerable groups. The four value chains which were selected for this report are maize, dairy cows, sheep (meat), and local chicken.

2.4.1 Maize

Maize is a major crop in Narok County. 61-80% of the population is involved in the maize value chain. It is among the highest-earning cash crops in Narok County. It is produced in all six sub-counties. Maize is mainly grown during the long rainy season. Sometimes it is grown during the short rainy season, if farmers decide to plant early. Large-scale farmers and medium-scale farmers produce maize as a cash crop. Small-scale farmers and some medium-scale farmers produce maize for subsistence.

On average, the county produces between 200,000 mt and 250,000 mt of maize annually. About 110,000 ha of land in Narok County are dedicated to growing maize. This level of production brings in over KSh 6 and a half billion each year. Maize production fluctuates

due to sporadic rains and diseases like maize lethal necrosis disease. For example, production dropped from 462,981 mt in 2013 to 271,158 mt in 2015 (GoK, 2018). This dropped profit from roughly KSh 9 and a half billion (87 million USD) in 2013 to KSh 7 and a half billion (68 million USD) in 2015. In 2012, 116,605 ha of land in Narok County grew maize. In 2016, this number reduced to 110,079 (GoK, 2018).

On large-scale farms, maize is the only crop grown. On small-scale farms, it is grown with other crops. Male-headed households produce higher amounts of maize than female-headed or youth-headed households, probably because they often have more capital to purchase inputs that put them at an advantage (GoK, 2013). Although men are the major decision makers in this value chain, women and youth are engaged across different stages of the value chain. For example, women dominate the production stage, while male youth are heavily involved in transporting maize, loading and unloading maize, and marketing.

The main activities at the input stage of the value chain include acquiring land, inputs, equipment, and tools like tractors, hoes, seeds, fertilizer, pesticides, and herbicides. Farmers face several challenges at this stage. For example, due to high demand for fast-maturing and drought-tolerant maize seeds, dealers now sell locally-manufactured, low-quality varieties that often result in low yields. Men are highly involved in the input stage, while women and youth are sometimes involved. This is because men often have more financial capital to purchase inputs. Agrovets, who operate as input suppliers in this stage, mostly operate on medium-scale capacity. Some farmers purchase inputs directly from manufacturers, but most purchase from local agrovets. Activities in the on-farm stage of this value chain include land preparation, planting, and crop husbandry. Men, women, and youth are all involved in this stage, with most farmers combining family labor and hired labor.

At the post-harvest stage, the maize is dried, stored, and milled. Due to cultural norms, women and youth are highly involved in this stage, while men are seldom involved. Maize processors operate in small-scale and medium-scale capacities. At the output market stage, men are highly involved in packaging, branding, and transportation activities. Youth and women are rarely involved in these activities. Wholesalers and retailers operate in small-scale, medium-scale, and large-scale capacities. The National Cereals and Produce Board, which buys maize from farmers, operates on a large scale. Cooperative societies operate on a medium scale, while local cereal traders, who comprise the majority of Narok County's cereal traders, operate on a small scale. Although most farmers still sell their produce to brokers, a good number of Narok County's farmers have shown interest in joining agricultural cooperatives. These cooperatives offer the farmers better marketing opportunities and increase their bargaining power, as customers can only buy from the cooperatives at a set price.

2.4.2 Dairy (Cow)

Dairy farming is an important value chain in Narok County and involves 81-100% of the population. Almost every household keeps dairy cows. Dairy cattle are mainly kept for commercial milk production under small-scale, mixed-crop systems. Most of Narok County's dairy cows do not graze. There are not many free-range systems in Narok County, as the land is highly subdivided. Each household has an average of 2 to 5 milk-producing cows. Currently, the average household produces 5 liters of milk per cow per day. The county aims to reach 10 liters per cow per day by the end of 2022 (GoK, 2018). Narok County also exports milk to other counties. There are close to 300,000 heads of dairy cattle in Narok County. Exotic and cross breeds are mostly kept in the agro-pastoral areas of the county and in the highlands. Narok County also hosts extensive pasture establishment and conservation activities.

The input stage of the dairy value chain requires feed artificial insemination services, and extension services. These services are supplied by the Department of Livestock and programs like the Agriculture Sector Development Support Program and the **National Agricultural and Rural Inclusive Growth Project**. Input suppliers, agro-dealers, and agrovets supply feeds, supplements, and vaccines, and operate on a medium scale. Because men have more financial capital, they are highly involved in this stage, while women and youth are seldom involved. At the on-farm stage of the value chain, women are highly involved in feed formulation, pasture establishment, heat detection and insemination, feeding, cleaning, milking, vaccination, spraying, and deworming. Despite men being the owners and decision makers of the dairy cattle value chain, they are only somewhat involved in the on-farm stage. Youth are highly involved in this stage.

At the postharvest stage, youth are highly involved in milk transportation, processing, and storage. Men are seldom involved at this stage, but women are highly involved, especially in processing and storing. At the output market stage, youth are highly involved in promotion, branding, and linking farmers to buyers. Men and women are seldom involved in these activities.

The major challenge facing the dairy value chain is water shortage and reduced pasture. This occurs during increasingly prevalent dry spells. With sufficient pasture and supplement, milk production can rise to 10-15 liters per cow per day, but the prevailing conditions and agricultural practices in Narok County can only support the production of lower than 6 liters per cow per day. Farmers who preserve pasture in the form of hay are better-prepared for droughts. Milk is usually collected and marketed through cooperatives, and this provides fairer pricing for farmers. Currently, there are 30 dairy cooperatives in Narok County.

Cooperative support is rapidly growing. It is expected that Narok County's dairy cooperatives will soon be able to provide farmers with extension, breeding, marketing, financial, and insurance services (GoK, 2018).

2.4.3 Sheep (Meat)

Between 81-100% of Narok County's population is involved in the sheep meat value chain, as almost every household keep sheep as a major source of livelihood. In 2015, there were 1.2 million sheep in Narok County (GoK, 2018). In other parts of the county, sheep are kept with goats and managed in much the same manner. Sheep are kept in mass for commercial purposes by the county's pastoralists. In other regions, sheep are kept under mixed farming systems, solely in highly productive areas.

At the input stage of the sheep value chain, farmers require capital, feed, and veterinary services. Consequently, men are highly involved at this stage, as they often have high financial capacity. The input suppliers at this stage operate on a medium scale. Farmers at the on-farm stage usually operate on a large scale, and their main activities include deworming, vaccinating, and feeding. Men and male youth are highly involved in the on-farm stage, while women are sometimes involved.

At the post-harvest stage, collection, transportation, and slaughtering are important activities. Men and male youth are highly involved in these activities, while women are seldom involved. At the output stage, processing, linking farmers to buyers, and selling creates income for farmers. At this stage, men are highly involved, youth are sometimes involved, and women are rarely involved. Meat processors operate at a small-scale level. The butcheries in Narok County are usually small to medium in scale, with most butcheries located in town centers. The wholesalers and retailers of this value chain also operate on a small-scale. Sheep are usually sold locally, and there is no major institution that governs pricing, marketing, and selling within this value chain.

2.4.4 Local Chicken

Local chicken is an important value chain in Narok County. Between 81-100% of the population is involved in this value chain. Almost every household in the county keeps chicken as a major source of white meat and income. The chickens are usually kept for household consumption, but eggs are also sold during peak laying season. Local chicken farming usually happens under small-scale, free-range systems, with only a few large-scale farmers operating near major urban centers. Some birds are used as pest control on farms. Eggs and meat are consumed in the household, and excess is sold to local kiosks and hotels.

Most farmers in Narok County are small-scale, as most birds are reared with very little input and for domestic consumption. At the input stage, farmers buy chicks, feeds, and bird-housing materials. Men are highly involved in this stage, as they purchase inputs and build chicken houses. Women and youth are seldom involved in this stage. Input suppliers are medium-scale and can be found in easily-accessible local centers. At the on-farm stage, women and youth are highly involved in cleaning the poultry houses, feeding, and vaccination. The men are seldom involved in this stage, due to cultural norms. At the post-production stage, men, women, and youth are all involved in transportation, slaughtering and storage. Chicken processors operate at a medium scale level in Narok County. At the output market stage, men, women,

and youth are all involved in pricing, linking farmers to buyers, and selling.

Local chicken farming mostly involves women and youth. They are involved across all stages of production, from cleaning chicken houses to feeding, egg selection and grading, sales, and processing chicken meat.

The marketing and sale of local chicken is carried out locally. The beneficiaries are usually middlemen and brokers who purchase the birds at very low prices and then sell them for profit. However, youth have begun to market birds through online platforms. This practice is promising, as it allows them to reach a wider market. Many farmers are receiving reasonably-priced orders from hotels and restaurants.

Agricultural value chains in Narok

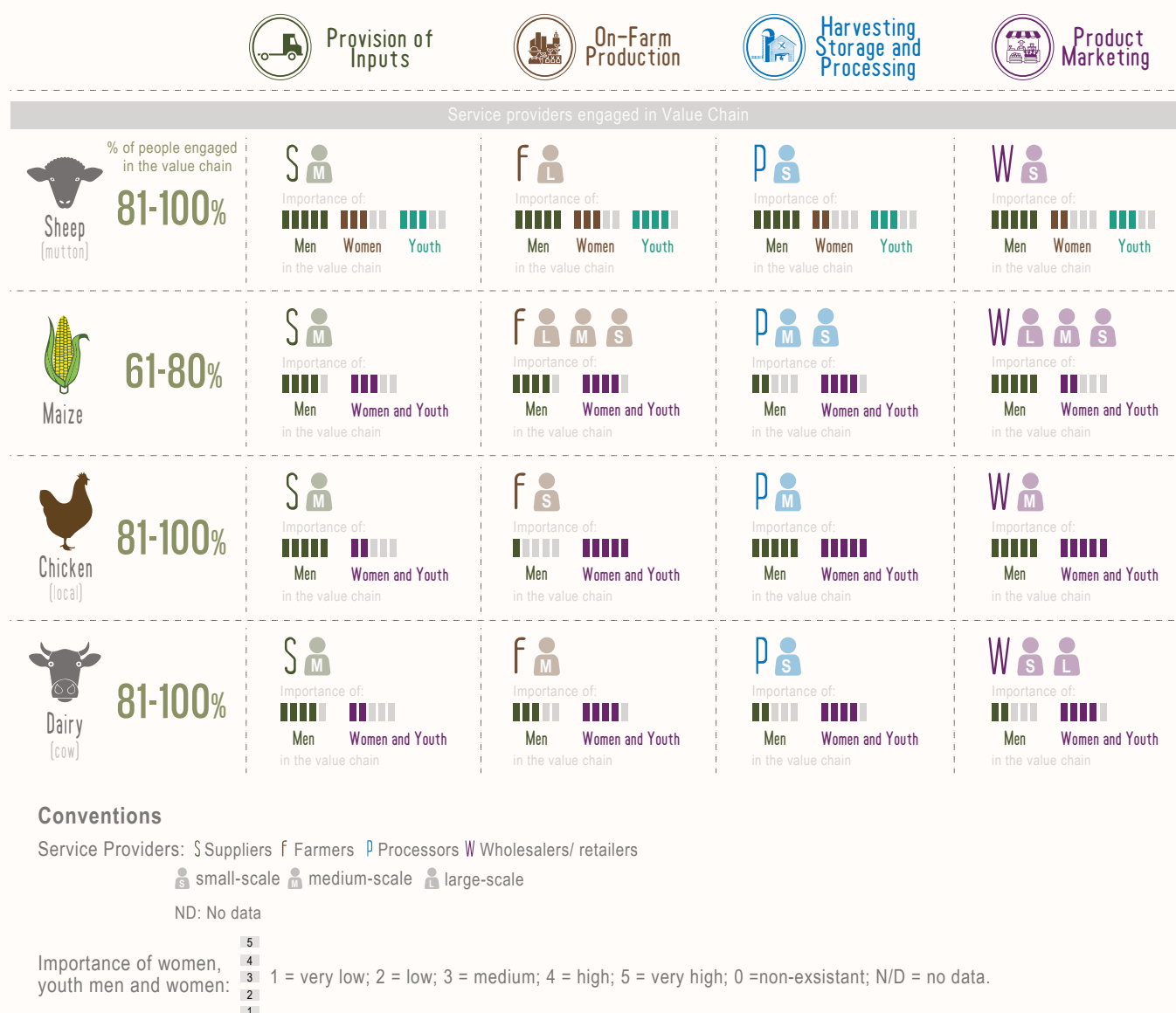


Figure 5: Characterization of Selected Value Chains in Narok County

2.5 Challenges to the Agricultural Sector

Narok County is vulnerable to climate change. It is one of the drier counties in Kenya. The regions of Narok County that lie near the Mau Forest and the highlands are the only areas of the county that experience heavy rainfall. This means that the lowlands experience water shortages. This puts pressure on the available water resources. The county's reliance on rain-fed agriculture, especially in the lowlands, leads to crop failure. This leads to food shortage and sometimes starvation, which forces some to rely on food donations and other forms of relief from neighboring counties. During droughts, livestock go without pasture and water.

Another major challenge to Narok County's agriculture is flash floods. Heavy downpours coupled with heavy winds erode fertile lands, destroy farm structures, and displace people. This affects agricultural productivity. Floods occur almost every year during the long rainy season. Narok North sub-county, which is home to Narok town, is one of the sub-counties that is hardest hit by floods. During these floods, roads become impassable and market areas become flooded.

Expensive inputs are a major hindrance to Narok County's agriculture. Inorganic fertilizers, improved seed varieties, breeding stock, artificial insemination technology, and livestock feed are some of the important inputs in Narok County. However, they are expensive and inaccessible. This means that farmers often do not have these inputs at the beginning of the planting seasons. This, coupled with other factors, often leads to low productivity.

Emerging diseases, parasites, and unfavorable weather all pose a challenge to livestock farmers. For example, in the poultry value chain, farmers have opted to bring their birds into their homes during extreme weather. Local chickens are adapted to warm weather, but extreme temperatures and periods of drought and heat stress have affected the value chain negatively. Chick mortality is high due to extreme heat. During periods of drought, less food is available for the chickens, and fewer eggs are laid.

Value-addition activities, meant to prolong the shelf lives of perishable crops, are inadequate in Narok County. For example, milk and other perishable crops like tomatoes and potatoes usually go bad during transportation. Farmers record post-production losses of over 25% due to poor handling and inadequate storage facilities (ASDSP, 2020).

Poorly developed marketing and promotion systems also contribute to post-production losses. Furthermore, the high cost of transportation affects farmers. Since farmers need to reach markets quickly, inadequate access to market facilities worsens the situation. Furthermore, bad roads, coupled with sporadic rainfall, often negatively affect maize, tomato, and Irish

potato farmers. Rainy periods usually coincide with agricultural activities, which exacerbates the problem.

Conflict is also a major issue in Narok County. The county experiences resource conflicts, tribal conflicts, and human-wildlife conflicts. For example, the Water Resource Authority recommends that households access river water first, followed by livestock farmers and irrigation farmers. However, farmers upstream often retract huge amounts of water using irrigation pumps, leaving people downstream with little water. This causes tension between upstream and downstream households. Human-wildlife conflict in unprotected areas has led to injuries, livestock losses, crop damage, and death.

Another major challenge to Narok County's agricultural sector is inadequate extension and veterinary services. This is mostly due to low staffing. The Narok County Agricultural Department attests that it is understaffed, and that this limits their capabilities. They also report that they do not have the adequate financial and transport resources to service the whole county.

Inadequate policy implementation is a major issue in Narok County. Policies often contradict each other, and county departments have unclear roles. For example, there are few policies that regulate market prices. This leads to price fluctuation and instability. Middlemen set low and exploitative prices, which negatively affects farmers.

3. Climate Change and Agriculture: Risks and Vulnerabilities

In generating this profile, we assessed past trends and future projections of precipitation- and temperature-related hazards, such as extreme hydrological events (including flash floods), drought, moisture stress, heat stress, and the start and length of the growing seasons. The growing season was defined as follows: the first season (long rains) is the 100-day wettest period from January to June, while the second season (short rains) is the 100-day wettest period from July to December (KMD, 2020).

To assess drought and dry spells, we focused on the maximum number of consecutive dry days (CDD) taken as days with rainfall less than 1mm/day (precipitation < 1 mm day⁻¹). Heat stress was determined by measuring the total number of days with maximum temperatures greater or equal to 35°C (NT35). The start of the growing season was determined by 5 consecutive growing days, while the length of the growing period (LGP) was determined as the total number of growing days. Growing days are those days during a season when average temperatures are greater than or equal to 5°C and precipitation exceeds half the potential evapotranspiration.

For each season, heavy precipitation events were captured with a 5-day running average of rainfall (P5D), indicative of floods, and the 95th percentile of daily precipitation, indicative of extremely high rainfall over a short period of time that can lead to events like flash floods. The 95th percentile of daily precipitation distribution based on the 100 wettest days per season per year was calculated for each pixel.

To assess the degree to which rainfall and soil moisture levels meet the potential water requirements for agriculture, focus was placed on drought stress, represented by the number of consecutive days in each season where the ratio of actual to potential evapotranspiration (ETa/ETp) is below 0.5. This was calculated for each pixel per season per year by evaluating soil's water capacity and evapotranspiration to define the number of days that could undergo a level of stress.

We used Representative Concentration Pathway (RCP) 8.5, one of the four-greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. Future climate projections were generated based on an ensemble of multiple CMIP5 models (Taylor et al., 2012), using RCP 8.5 for two future periods: 2030 and 2050.²

3.1 Climate Change and Variability: Historic and Future Trends

Narok County's climate is highly influenced by certain physical features and the county's altitude. Two-thirds of the county's land is classified as semi-arid and characterized by frequent dry spells and poor rainfall distribution (GoK, 2018). Narok County receives between 600 and 1600 mm of precipitation per year. The north-western region of the county receives more than 1500 mm of precipitation per year. The north usually experiences the most rain (Figures 6).

An analysis of temperature trends shows that Narok County usually varies between 10 and 28°C. The eastern part of the county is significantly drier and colder than the rest. The long rainy season, which falls between February and June, is significantly wetter than the short rainy season, which falls between August and December. The dry season, which experiences less than 50 mm of rainfall, falls between July and October. The month of April experiences the most rainfall, with more than 150 mm (Figure 7).

The total annual rainfall trends showed a slight decrease of precipitation for the period 1985-2015 which will continue until 2040 during the long rainy season. In the opposite the short rainy season is becoming wetter since 1985 (Figure 8). The annual mean temperatures are increasing for both rainy seasons since 1985 and are projected to continue to raise in the future (Figure 9).

Our analysis of historic trends also shows that during the long rainy season, most of the county experiences fewer than 25 consecutive dry days (CDD) (Figure 10). CDD serve as an indicator for risk of drought. In the future, the county will experience an overall increase up to 10 CDD, suggesting a slightly greater risk of dry spells. During the short rainy season, the county has historically experienced fewer than 50 CDD. In the future, the county is projected to experience fewer than 25 CDD during the short rainy season.

Flood risk is measured by the average level of precipitation over 5 days (P5D) (Figure 11). In Narok County, P5D has historically remained below 25 mm during the long rainy season. Our projections indicate that the P5D value will increase, principally in the northern part of the county, by 15 mm or more, suggesting higher risk of floods in the north. The P5D will also increase by more than 15 mm in the southern areas of the county.

Heat stress is measured by the total number of days during one season with a maximum temperature greater than or equal to 35°C (NT35). In the long rainy season, Narok County's levels of heat stress have been low, with no days above 35°C. Projections indicate that heat stress will marginally increase in some regions of Narok County and that some regions will experience extreme heat events in the future.

Moisture stress is measured by the number of days during one season where the ratio of actual evaporation levels to potential evaporation levels is less than 0.5. Higher levels of moisture stress negatively affect crops during the growing season. Current trends indicate that levels of moisture stress are expected to increase across the county.

Historically, the county's long rains season lasts less than 4 months. Projections indicate that the LGP will shorten by a month or two. The short rains season will shorten by almost a month in the western and northern edges of the county and lengthen in the rest of the county.

²For historical precipitation and temperature trends, we used the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) and Climate Hazards Group Infrared Temperature with Stations (CHIRTS). For future climate projections we used an ensemble of downscaled Coupled Model Intercomparison Project Phase 5 (CMIP5) (Taylor et al., 2012, Navarro-Racines et al 2020), specifically the MOHC_HADGEM2_ES, CESM1_CAM5, GFDL_CM3, MPI_ESM_LR, and MIROC_MIROC5 models.

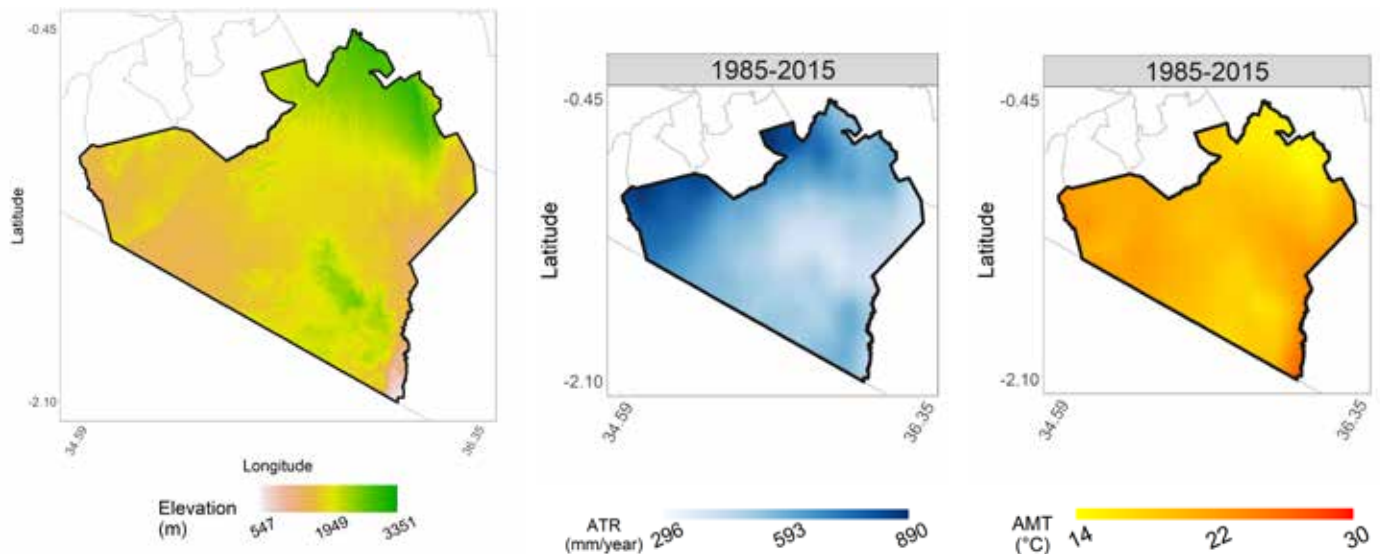


Figure 6: Elevation (left), historical (1985-2015) annual mean precipitation in mm (center), and historical (1985-2015) annual mean temperature in °C (right) for Narok County for the long rainy season

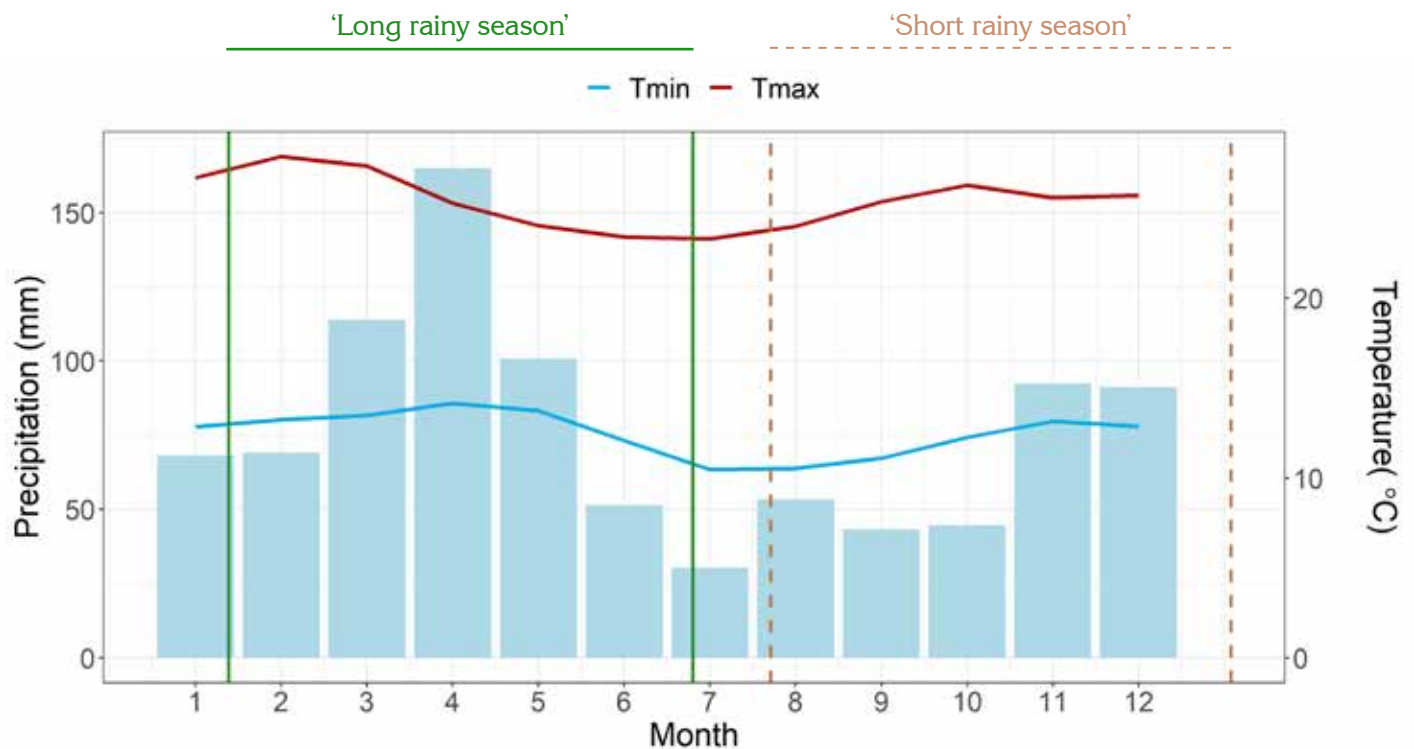


Figure 7: Historical monthly mean temperature and precipitation (average 1985-2015) in Narok County. The first long rainy season is the 100-day wettest period from January to June, while the second, the short rainy season is the 100-day wettest period from July to December. Bars represent total monthly precipitation, whereas red and blue lines represent maximum and minimum monthly mean temperatures, respectively.

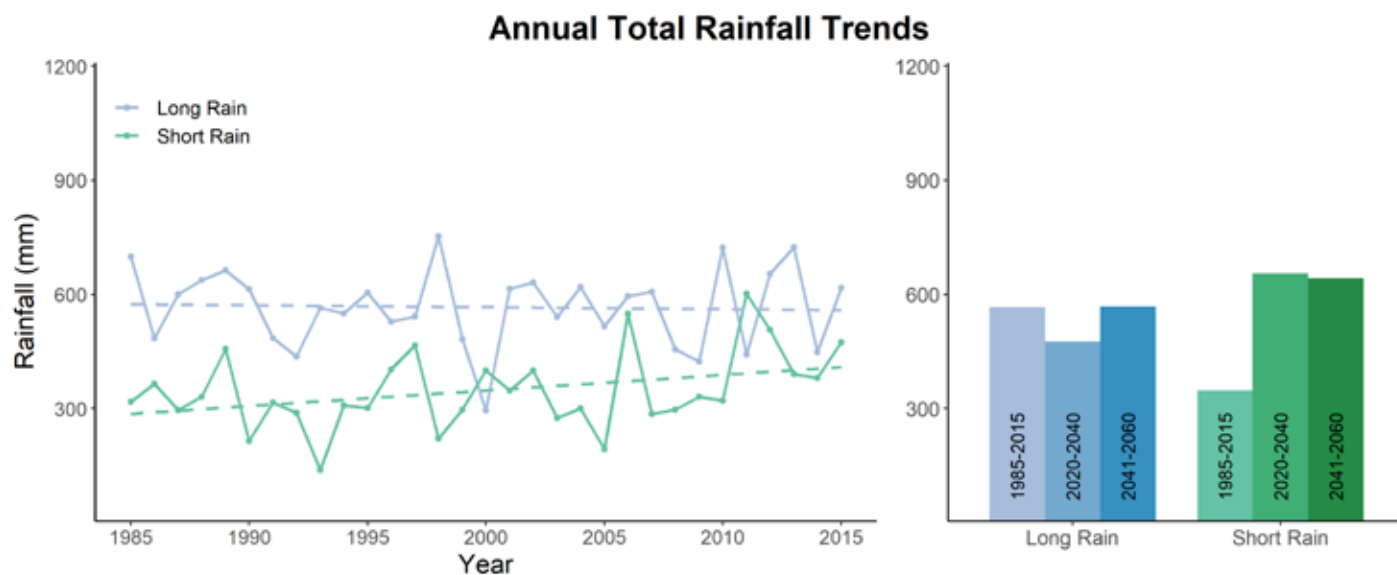


Figure 8: Annual total rainfall trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060)

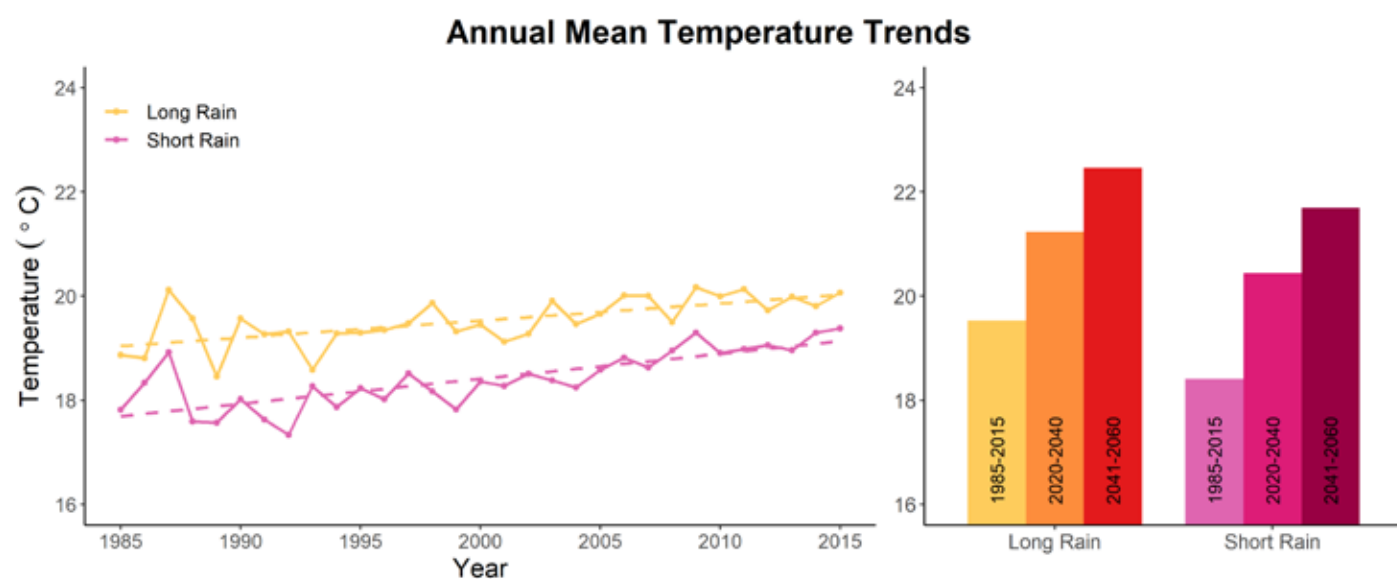


Figure 9: Annual mean temperature trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060)

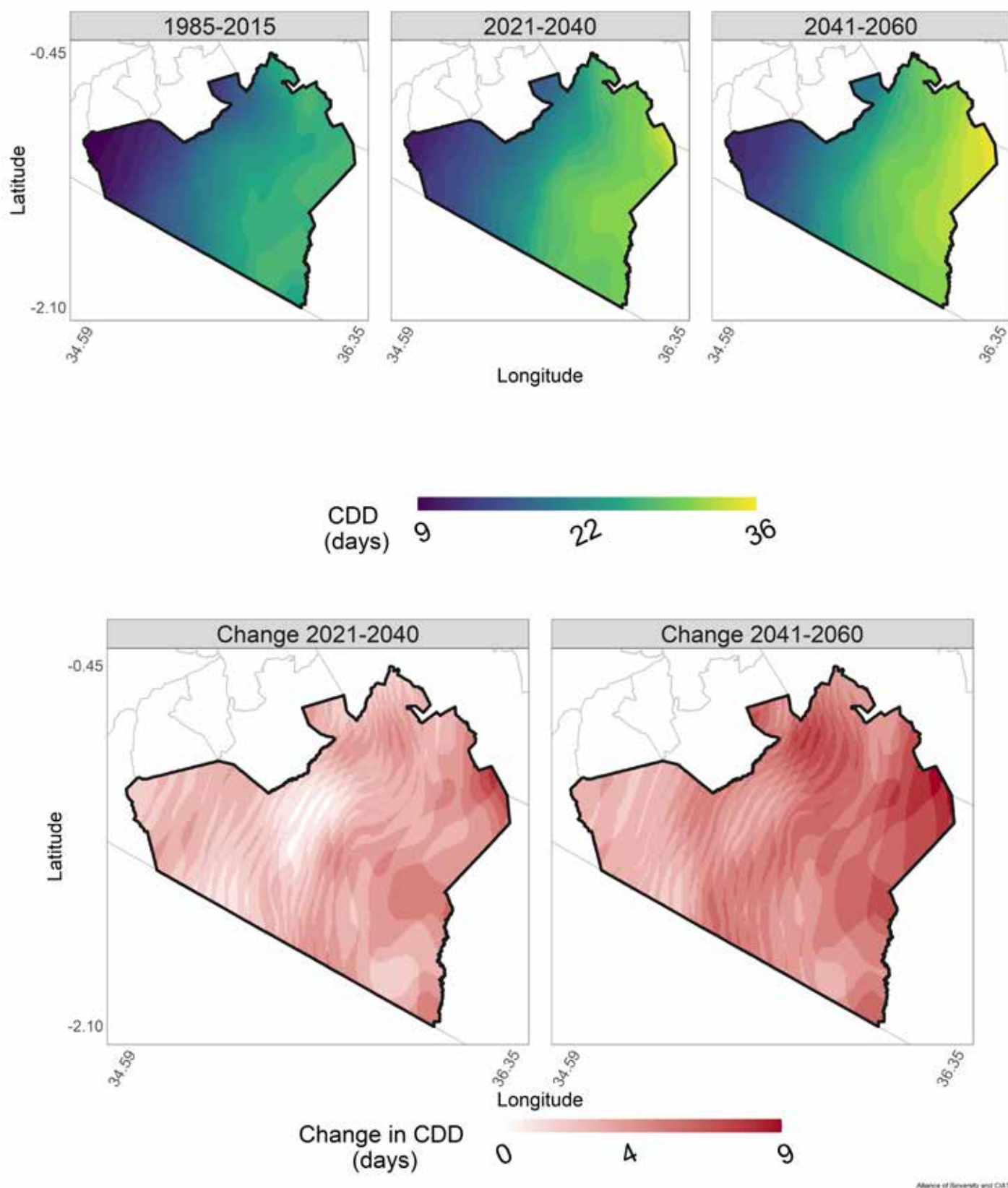


Figure 10: The average total number of consecutive dry days: historical (left), future projected (center), and projected change (right) in Narok County for the long rainy season

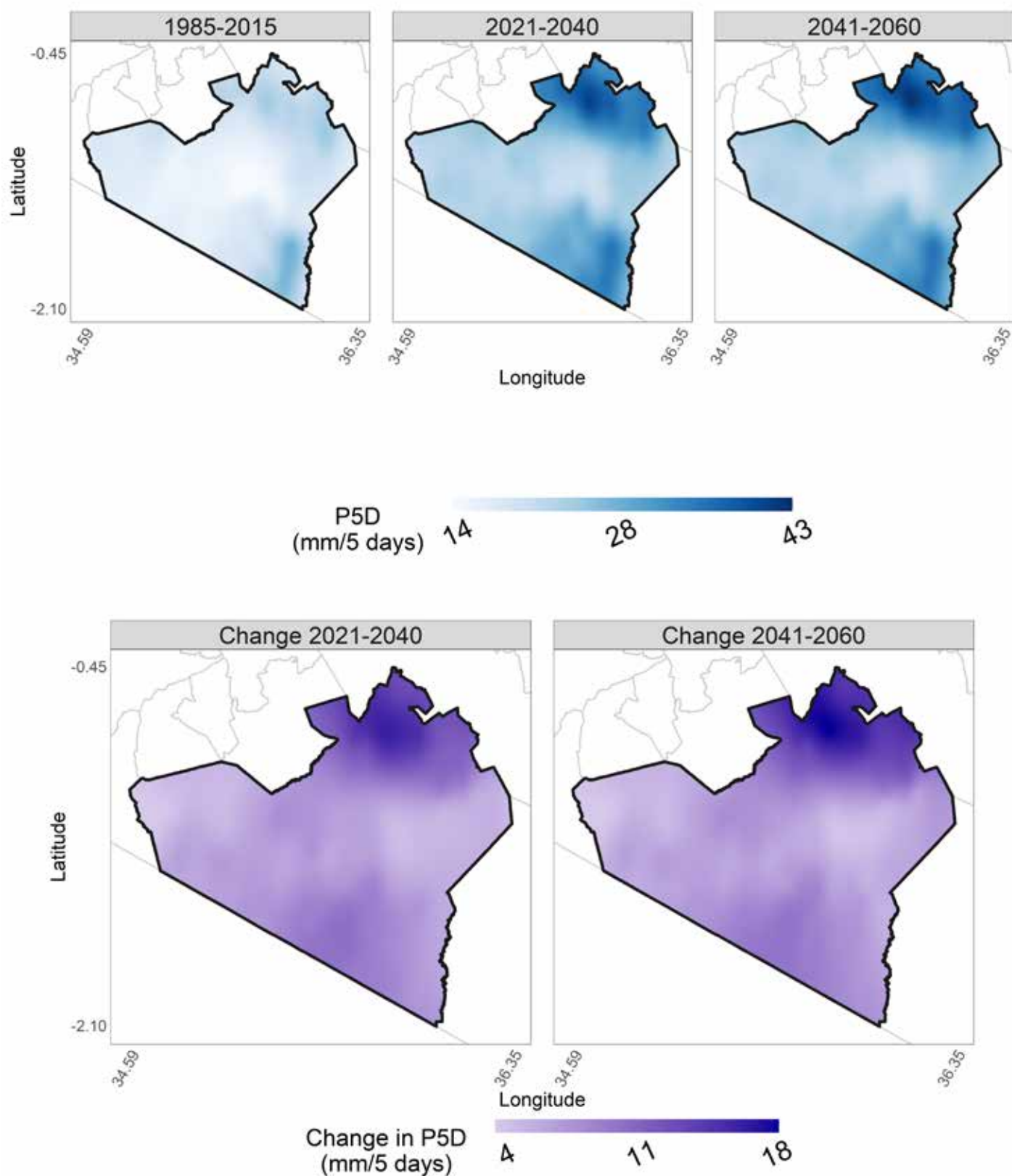


Figure 11: The average maximum 5-day running average precipitation in mm: historical (left), future projected (center), and projected change (right) in Narok County for the long rainy season

3.2 The Climate from Farmers' Perspectives

Narok County farmers believe that climate change is a natural occurrence that has been enhanced by human activities like deforestation and pollution. Farmers attest that they used to plant their crops at specific dates, but that the seasons have become unpredictable to changing weather patterns. The dates of the rainy seasons have also changed. Farmers now have to wait for the onset of the rains to begin to plan their planting.

The major rivers in Narok County, which once flowed permanently from the highland areas, are becoming seasonal and drying up. Streams and tributaries are also becoming more seasonal. This means that water has become less available for domestic and agricultural practices. Prolonged dry spells and periods of drought have reduced the availability of pasture, and farmers are now struggling to feed their animals. Pasture preservation is also threatened by increasingly warmer weather.

Water shortages have resulted in changing roles within homes. Increasingly, men go in search of water for livestock. This is traditionally a job for women. Farmers have also attributed the emergence of some pests and diseases to climate change. For example, maize lethal necrosis disease and tuta absoluta, a disease that affects tomatoes, are now common.

Flooding has increased in the lower zones of the county, including in Narok town. This causes massive soil erosion and crop destruction. In extreme cases, there have been incidences of hail. This disrupts agricultural activities and destroys crops. Floods have destroyed property, livestock, and farmlands, and have even killed humans. Farmers have also reported a notable increase in temperature. This had negatively affected some value chains, like those of poultry and horticultural crops. In extreme cases, heat stress reduces production and leads to death in cows, goats, and sheep. Farmers have also reported increasing problems with poultry parasites.

3.3 Climate Vulnerabilities across Value Chains

Climate change is expected to pose serious threats to Narok County's value chains in the future. These threats include moisture stress, heat stress, unpredictable seasons, drought, and intense rainfall. Moreover, while not a historically significant hazard, Narok has in the recent past faced the menace of the locust invasion. It is reported that especially in Narok North, the swarms have raided farms, open spaces and grazing fields causing unprecedented destruction on crops and pastureland. The swarms have reduced crop yields and pasture putting food security and livestock life in question (Citizen News, 2020; FAO, 2020).

The sections below highlight the major climate risks that they pose to the major value chains.

3.3.1 Maize

The maize value chain is affected by drought and extreme rainfall. During periods of drought, farmers struggle to acquire and lease land that is suitable for maize production, as suitable land is limited and very expensive. Furthermore, farmers in the drought-prone lowlands opt to lease land in the highlands. High demand means that farmers struggle to acquire machinery and land preparation services, which are necessary, especially if hardpans have formed on the soil's surface. Removing hardpans, which are caused by drought, is difficult and requires both tractors and expertise. Hardpans also render the soil difficult to break, which makes land preparation still more difficult. Other inputs, like seeds and fertilizer, also become difficult to access during droughts, as demand increases.

Farmers use less inorganic fertilizer when there is less moisture in the soil. During drought, farmers require less labor as there is little land preparation and crop husbandry activity. This negatively affects casual laborers who depend on this work to support their families. At the post-production stage, low output means reduced collection, bulking, and transport activity. This results in reduced drying, storage, and processing activity, which affects workers at this stage. At the output market stage, drought results in low output, reduced transportation, and reduced packaging & branding activity. This affects workers.

Extreme rainfall, on the other hand, causes reduced land leasing and acquisition activity, reduced land preparation activity, and reduced input buying. At the on-farm stage, activity such as land preparation, planting, and crop husbandry also reduces as farms become waterlogged. Prices also increase. At the post-production stage, rains make it difficult to sun dry maize. This affects storage and milling activity. Rains also contribute to post-production losses by causing rotting and molding. At the output market stage, extreme rainfall reduces packaging, branding, and transportation activity, due to reduced yields and poor road conditions.

3.3.2 Dairy (Cow)

The dairy value chain is dependent on pasture such as fodder and hay. The natural grass that farmers use for free-range cows is affected by climate change and is no longer adequate. Pasture is mainly rain-fed and is severely affected by drought. Drought affects the input supply stage by reducing fodder. Drought also affects the dairy cows' health, which increases both demand for and costs of veterinary services. At the on-farm stage, drought reduces supplies of the raw materials that are needed for feed formulation, as some of these materials are produced on-farm. Additionally, drought

leads to poor animal body condition and reduces the demand for artificial insemination services because animals are weak or likely to be sick.

At the post-production stage, drought causes poor hygiene, as it becomes difficult to properly clean milking equipment. This causes diseases and lowers the quality of the milk. Low milk supply means job loss for transporters and collectors. It also decreases bulking and storage activity. At the output stage, low milk supply results in increased market prices. This results in low quality milk, and diluted milk at the market. Branding and production costs increase due to reduced volumes of product and high prices.

Flash floods destroy pasture and pasture fields. They also reduce access to service providers and destroy infrastructure. At the on-farm stage, flash floods increase the cost of the raw materials of feed, as some of these raw materials are cultivated on-farm. The dairy animals' heat periods are also affected as their diets become irregular. Veterinary activities like vaccination, spraying, and deworming services become inaccessible as infrastructure like road networks are destroyed. Structures like cattle dips are also destroyed during flooding. Respiratory diseases proliferate, well as worm infestations in the wet and cold conditions.

At the post-production stage, delays in milk delivery cause major losses. These delays are due to poor transportation and handling and bad roads. The wet and cold conditions of flash floods cause mold that compromises the quality of feed and conserved pasture. In extreme cases, storage facilities are destroyed. At the output stage, markets become inaccessible. Milk prices moderately increase as farmers pay higher transportation and processing costs. Prices rise to reflect these costs, but not enough for farmers to make a regular profit. The bad roads also create poor farmer-customer links.

To ensure maximum quality and quantity of milk in the Dairy VC, farmers need quality fodder, feeds, supplements and water.

3.3.3 Sheep (Meat)

The sheep value chain is most affected by extreme rainfall and drought. At the input stage, extreme rainfall raises the lamb mortality rate and renders markets, veterinary services, extension and AI services inaccessible due to poor roads and high costs. At the on-farm stage, pest and diseases proliferate in the cold and wet conditions. Additionally, heavy rains destroy feeder roads and hinder access to deworming and vaccination services. This increases incidences of diseases like blue tongue and pneumonia.

At the output stage, heavy rainfall decreases transportation, collection, slaughtering, and processing activity, due to poor road infrastructure. At the output stage, heavy rains cause poor market links and a decrease in promotion, pricing, and selling activity.

Drought negatively affects the input stage of the sheep value chain. For example, during periods of drought, farmers often bring severely sick and emaciated lambs to the market. Additionally, during droughts, farmers lose livestock and pay increased prices to maintain their stocks. During periods of drought, feed supplies diminish and farmers must move in search of pasture and water, which often results in human/wildlife conflicts. The price of and demand for vaccination, extension, veterinary services, and dependence on food and non-food aid increases during droughts. At the on-farm stage, drought decreases deworming, vaccination, and feeding activity. This is because drought reduces the availability of pasture and feed. Because animals develop poorly during droughts, they have poor body condition and are also at higher risk of contracting diseases. At the post-production stage, drought decreases transportation activity and forces animals to migrate long distances in search of pasture and water. At the output stage, prices decrease as farmers destock. Destocking also necessitates increased slaughtering and processing activity. However, the emaciated animals' have low quality and low quantity meat that fetches low prices at the market.

3.3.4 Local Chicken

The local chicken value chain is affected by drought and extreme rainfall. Drought is associated with chick scarcity, reduced feed, and severe increase in the prices of chicken house construction materials like timber. At the on-farm stage, drought results in inadequate water. This makes it difficult to clean chicken houses. Drought also severely reduces the availability and quality of chicken feed. It also augments the price of feed.

At the post-production stage, drought and extreme rainfall mean that there are fewer birds to transport. This decreases slaughtering activities and increases egg spoilage. At the output market stage, the supply of birds, eggs, and byproducts increase demand and moderately raise prices. The reduced supply also reduces market links.

Extreme rainfall has significant impact on all stages of the local chicken value chain. Extreme rainfall has been associated with less chick-buying, due to impassable roads and extreme cold. The production of and access to feed is also challenging. As chicken houses are destroyed in extreme rainfall, demand for replacement materials increases. At the on-farm stage, heavy rainfall necessitates frequent cleaning, vaccination, and treatment, due to moisture-related infections. Heavy rains also reduce the accessibility of feed.

At the post-production stage, there has been a moderate reduction in slaughtering due to bad weather. This weather leads to poor distribution of chicken and chicken products and damaged packaging materials. At the output stage, farmers suffer losses as they are forced to reduce prices in order to minimize spoilage.

Poor weather and poor roads also lead to less market accessibility and a severe reduction in sales.

4. Climate Change Adaption

4.1 Factors that Determine Future Vulnerabilities to and Impacts of Climate Change

In the maize value chain, poor, small-scale farmers are vulnerable to climate hazards, as they are not able to diversify their farms or buy high-cost inputs. Farmers in the lowlands are also vulnerable during periods of drought. Farmers who live far from extension workers, or in regions with poor road networks, are also vulnerable, as they do not receive timely information. Illiterate farmers, who cannot decipher newsletters or text messages, are also vulnerable.

Although climate hazards affect all dairy farmers, illiterate farmers, poor farmers, women, and youth are more vulnerable, because they have inadequate access to resources and information.

Similarly, in the sheep value chain, poor farmers, women, and youth are vulnerable to climate change. Farmers in the drought-prone lowlands are also vulnerable. Pastoralists are vulnerable because their agricultural activity is less diversified and they do not practice destocking activities. Furthermore, extension workers have difficulties keeping track of them as they move about in search of water and pasture.

In the local chicken value chain, lowland farmers are vulnerable to drought. Similarly, poor farmers, women, youth, and the disabled are vulnerable to climate change because they have little access to money or education in order to adapt to extreme weather events.

4.2 Adaption Options

4.2.1 Ongoing Practices

As dry spells in Narok County become prolonged and severe, rainfall has become intense and short-lived. If the water from these periods of heavy rainfall was to be harvested, it would be enough for all domestic, livestock, and irrigation purposes (Water Resource Authority, Narok 2020). Narok County farmers are therefore encouraged to practice flood-based farming and rainwater harvesting. This water serves as a safeguard against periods of drought and moisture stress.

Farmers have begun diversifying their livelihoods. Many farmers now rely on different sources of income. For example, many farmers have begun farming fish and chicken, in addition to livestock and crop farming. Farmers have also begun growing drought-resistant, early-maturing, and disease and pest-resistant varieties

of seeds. This ensures harvest even during short growing seasons.

The Dorper sheep and the Galla goat breed are drought-resistant, and farmers are embracing them. These breeds grow very fast and are not seriously affected by climate change. Farmers have also begun establishing, harvesting and e conserving pasture. Farmers plant pasture seeds during good conditions, then harvest and preserve the pasture in the form of silage and hay. This enables the farmers to feed their cattle during periods of extreme weather. The Narok County Government distributed 7 tons of grass seeds to support pasture development. The processes of seasonally restocking and destocking livestock are also gaining popularity, though growth is impeded by cultural factors. For example, Maasai and Kalenjin farmers strongly believe in keeping large herds of cattle.

To control the spread of local chicken diseases and parasites, farmers in Narok County now house their birds. They also vaccinate and feed them, as opposed to free-range systems. Narok County farmers have also begun introducing improved breeds of local chicken. These breeds grow fast and are resistant to diseases. In the dairy value chain, milk is processed into yoghurt, cheese, and milk powder to increase its marketability. This increases the famers' income and the product's shelf life.

Although it is rare, Narok County engages in some conservation agriculture practices such as minimum tillage in order to conserve nutrients and moisture within the soil. In contrast to conventional tillage, conservation tillage does not till the soil. This leaves a certain amount of crop residue on the soil's surface. However, most farmers do not have knowledge on the technology. Furthermore, the majority of the farming community in Narok County is skeptical of new techniques like conservation tillage.

Finally, the county government is developing dams to store water as a long-term adaptation measure. Dams control flooding and act as sources of water for domestic, farming, and irrigation purposes.

4.2.2 Potential Practices

The county can upscale its education efforts for improving crop production and managing livestock (Figure 10). The Ministry of Agriculture, Livestock, Fisheries and Cooperatives currently offer education services. However, climate change topics need to be integrated into education initiatives.

Rainwater harvesting is a potential adaptation that needs to be explored further. Conservation efforts must be upscaled in order to protect water catchment areas. Currently, the Water Resource Authority works hand in hand with the Water Resource Users Association to

The National Drought Management Authority (NDMA) develops monthly drought early warning bulletins. Among the intervention proposed by NDMA for the county include construction of water reservoirs, water and sanitation programmes, development of market infrastructure, enhanced livestock vaccination, crop and livestock surveillance, protection of water sources through catchment rehabilitation and de-silting, agroforestry, pasture establishment and conservation, promotion of agricultural advisories and range rehabilitation.

example, the lowlands are more prone to drought and the farmers who live there have different needs than farmers who live in the highlands. The Kenya Meteorological Department issues sub-county-specific weather and climate advisories to farmers. It also informs farmers of expected changes to the growing seasons and rainy seasons. It advises people to move from areas that are vulnerable to flooding. These early warning systems are very helpful to farmers and can be communicated through SMS, radio, and TV in local languages.

Farmers can also get agricultural information from media like television and radio. The information includes weather advisories, information on seeds varieties, information on fertilizers, and demonstrations. The “Shamba Shapeup” program, on Citizen TV, educates farmers on current farming techniques. Farmers can also receive advisories in the form of phone messages (SMS).



Adaptation strategies used in selected value chains in Narok County

Sheep (Mutton)



Provision of
Inputs



On-Farm
Production



Harvesting
Storage and
Processing



Product
Marketing



Extreme Rainfall
Consequences

Fewer sheep survive; input markets are inaccessible; more animal feeds grow, thus increased productivity, bloating and invasive species; vet services, extension services, and A.I services are inaccessible due to poor infrastructure and high cost of vaccines; increased levels of disease.

Inaccessible vaccines; increased incidence of diseases blue tongue, pneumonia, and foot rot; improved pasture and browsing conditions; improved productivity; less time spent trekking to water sources.

Poor road networks; low flow of trade; washed-out bridges; disruption of market activities; few strategic structures for processing.

High prices; inaccessible markets and slaughter houses; discouraged farmers; poor handling techniques; poor sanitation and hygiene in slaughter houses.

Magnitude of
Impact

Major-Moderate

Minor-Moderate

Major-Moderate

Moderate

Farmers' Current
Coping Strategies

Improving breeds; using early warning systems; promoting pasture production; water conservation e.g. excavating water pans and using water tanks; using advisories from both the livestock department and from private vets.

Using private deworming services; empowering farmers on how to deworm at the household level; improving accessibility of affordable dewormers; integrating indigenous methods for deworming and new technology; producing pasture in dry areas; paddocking individually. Managing grazing fields communally through ranging /conservation; insurance uptake, using seasonal weather forecast.

Maintaining excess roads; using easily-issued permits; constructing crossing bridges; using livestock market yards, slaughter houses, and farm gates. Using ITK

Using the readily available market-Narok has a sheep market with a regulatory body in existence; the market can be available on set dates for trading and free market; there is however a negative cultural association with sheep meat in Narok County.

Potential
Adaption Options

Policy development on climate risk adaptation; enhancing capacity building; improving road networks; establishing research centers, and information hubs on climate change and agricultural sectors; intensifying pasture production and storage facilities; using new feeding methods; reseeding ranges; manufacturing feeds at the county level; intensifying extension services and improving mobility for extension services officers; employing more extension officers, and incorporating chief administrators at the ward level.

Teaching farmers how to deworm at home; improve accessibility and affordability of dewormers; integrating local and new technology; using ring vaccination and isolation and quarantine centers; training farmers on animal health; using routine/seasonal vaccination and improving monitoring; shading feeding areas; enforcing land use policies; using new, adaptable feeding methods; introducing new species.

Enhancing road maintenance; using railways as an alternative; regulating transport costs; increasing livestock market yards; discouraging farm gate sale; fumigating collection centers; avoiding middlemen; embracing modern slaughtering and packaging methods; exploring the use of by-product waste.

Promoting weighting before sale; exploring international markets; forming cooperative groups to control prices; using the internet; registering farmers for market access.

Underlying Factors

Nasosura and Masiro have poor roads, so they are more affected; most farmers do not have good storage for livestock feeds; flood-prone areas in the lowlands are likely to be more affected

Inadequate extension services due to low or no funding; some farmers are still using traditional methods; poor shading; political interference; conflict; infectious diseases from surrounding wild animals; human-wildlife conflicts.

Political instability; national market trends; middlemen who control market prices and interfere in markets; poor implementation of sales of good ACT.

National and international policies impede growth; little structure; lack of market exploration by relevant institutions; negative cultural beliefs - for example, the belief that goat meat is better than mutton.



Drought
Consequences

High capital required for maintenance and nursing emaciated animals; poor pasture conditions, less animal feed; increased migration leads to more human and wildlife conflict; expensive vet services, extension services, and A.I costs; limited vaccines.

Emaciated animals; inaccessible dewormers; little growth and development; emerging livestock diseases; limited supply of vaccines thus become expensive; low productivity; poor foliage and pasture conditions; expensive animal feeds.

Poor road accessibility; little rustling; trekking to search for pastures and water; increased accessibility to collection points; increase in transportation; low prices at farm gates; increased animal slaughtering; increased processing.

Low sheep prices; poor terms of trade; destocking; low prices and stronger market links; poor handling of meat/end products and poor hygiene.

Magnitude of
Impact

Major-Severe

Major-Severe

Minor- Major

Moderate-Severe

Farmers' Current
Coping Strategies

Adopting red Masai sheep; using available grazing land; opening of parks for grazing and using early-warning advisories; migrating from lowlands to highlands; using maize and wheat residues, and hay strolls; increasing livestock off-take rates; monitoring diseases.

Using ITK; using ring vaccination; conducting disease surveillance and control; issuing continuous advisories to farmers concerning animal health; conserving grazing land; using advisory services; migrating to other areas for pastures and water; destocking/off-take.

Trekking in search of pasture; transport weak animals by motorcycles; using market structures and sheep yards; using advisories to monitor off-take animal health; selling to the local community.

Using available markets on set days as per the existing regulatory bodies; cultural marketing.

Potential
Adaption Options

Developing shading for small scale farmers; introducing of drought-tolerant breeds; educating farmers on drought mitigation; introducing drought-tolerant feeds; subsidizing animal feeds; encouraging destocking; intensifying disease surveillance.

Ensuring that farmers have easy access to dewormers; intensifying disease surveillance and control; providing vaccines for farmers; controlling the movement of livestock from one region to another; enforcing land use policy; using adaptable feeding methods; providing pastures and water for farmers and livestock; destocking to discourage migration; using advisories.

Regulating transport costs; discouraging foot trekking; encouraging railway connectivity and improving road networks; increasing livestock market yards; discouraging farm gate sales; increasing number of modern slaughter houses; discouraging indigenous slaughtering methods; improving slaughter houses' sanitation; installing piped water/boreholes; enforcing slaughtering law.

Exploitation of international markets; formulation of cooperatives to control prices and pitch for more markets; using ICT for marketing; registration of farmers for market access; encourage development of SACCOs and associations

Underlying Factors

Lack of coordination, leading to conflicting activities; overgrazing; inaccurate advisories; lack of knowledge on drought emergencies.

Migrating to search for pasture without treating animals before migration; shortage of extension officers; lack of adequate funding to mitigate drought; insufficient coverage of water sources and low volumes of water.

Fluctuating market prices; no structured way of responding to drought emergencies; farmers not willing to reduce livestock during drought, leading to loss of livelihoods; emerging diseases, which could lead to market quarantine.

Poor market strategies for fast off-take; inefficient cultural practices; psychological stress; increased land demarcation, which reduces animal populations; poor-quality breeds.

Maize



Provision of
Inputs



On-Farm
Production



Harvesting
Storage and
Processing



Product
Marketing



Extreme Rainfall
Consequences

Low acquisition of land; limited land preparation; little acquisition of farm inputs like seeds.

High costs involved; low land preparation and planting activities; reduce crop husbandry activities e.g. weeding

Limited sun drying; difficulty in storing product; low-value addition activities like milling.

Limited packaging due to low production; little branding activity; less transportation.

Magnitude of
Impact

Moderate-Major

Major-Severe

Major

Farmers' Current
Coping Strategies

Long-term leasing; using herbicides, light machinery, and hand tools like jembes, pangas and waling tractors; diversifying inputs e.g. purchasing barley seeds.

Early preparation as guided by the market, though not wide-spread; early planting; using of climate-smart agricultural practices like selective herbicides.

Harvesting and drying in bits; drying in special stores/granaries; transporting products to dry areas for drying; owners improving their own stores; storing products in N.C.P.B storage; use of small posho mills for value addition; using millers in Narok town, Olerai Osirua.

Packaging in big outlets and supermarkets such as Naivas; packaging in small outlets like shops and posho mills; using domestic transport like donkeys, boda boda, walking tractors; grading roads to improve transportation.

Potential
Adaption Options

Upscaling long-term leasing; upscaling the use of meteorological information before input acquisition; upscaling the use of herbicides and light machinery; enhancing the diversification of inputs

Upscaling use of weather and meteorological information on early land preparation; embracing climate-smart agricultural practices like selective herbicides and pre-emerging herbicides.

Using diesel, electric, or solar cereal driers; enhancing warehouse receipting systems; developing zonal storage facilities with modern status and sufficient capacity; operationalizing ng'etia national cereals and storage board stores; promoting individual storage facilities; developing regional value-addition centers.

Developing regional branding companies and packaging facilities; developing producer organizations; improving road infrastructure.

Underlying Factors

Farmers located in lowlands and highlands areas such as Mosiro, Suswa are prone to water logging, soil erosion, and flooding; delivery of inputs impeded due to slippery roads; farmers from areas with poor roads like Olpeusimoru and Melili will suffer more.

Poor farmers are more likely to suffer than wealthier farmers, due to their lack of capital for risk mitigation; uneducated farmers are more affected; farmers who are located in areas with black cotton soil like Narok South and Transmara East are more likely to suffer.

Farmers in highland areas are most likely to be negatively affected due to inaccessibility; poor farmers and vulnerable groups are more likely to suffer due to lack of capital; farmers who are located in politically marginalized areas like Olpeusimoru and Sogoo are more likely to suffer.

Farmers located in areas with poor roads, like Olokurto, Olpeusimoru, Melili, and Oloropil, are more likely to be affected; small and medium-scale traders and packaging-industry players may suffer more due to low capital.



Drought
Consequences

Difficulty in acquiring suitable land for maize production; expensive leasing/land acquisition due to competing interests; expensive land preparation machines and services; expensive inputs like seeds and fertilizers.

Difficulty in land preparation due to hard pans; reduced planting; minimal crop husbandry activities like weeding.

Limits post-harvest activities e.g. drying, storage and milling.

Little packaging activity; little branding activity; little transportation activity.

Magnitude of
Impact

Moderate-Major

Major

Major

Moderate-Major

Farmers' Current
Coping Strategies

Long term leasing that is limited to some areas; farmer groups offer extension services on climate change; shifting from disc plough to chisel plough; using the government-subsidized fertilizer program; using extension services from MOALF on new seed varieties that are drought-resilient.

Using chisel plough instead of disc plough at Teeka, Olorai farm, Ndovu farm; using M.E.T information; planting drought-tolerant seed varieties like 513, DHO4, and DHO2; laborers seeking alternative jobs like boda boda.

Laborers seek alternative livelihoods like boda boda, and domestic chores; laborers adopt new activities to generate income, like Kazi mtaani, kazi kwa vijana, local chicken breeding, bee keeping.

Diversifying their farm practices; adopting dairy farming, chicken, sorghum, millet, sweet potatoes.

Potential
Adaption Options

Developing shading for small-scale farmers; introducing drought-tolerant breeds; educating farmers on drought mitigation; introducing drought-tolerant feeds; subsidizing animal feeds; providing animal feeds to farmers; encouraging destocking; providing water to farms; intensifying disease surveillance; sensitization

Ensuring that farmers have easy access to dewormers; intensifying disease surveillance and control; providing vaccines to farmers; controlling the movement of livestock from one region to another; enforcing land-use policy; using adaptable feeding methods; providing pastures to farmers; providing water to livestock; destocking, which discourages migration; using advisories.

Regulating transport costs; discouraging foot trekking; encouraging railway connectivity; and improving road networks; increasing livestock market yards; discouraging farm gate sales; increasing the number of modern slaughtering houses and their sanitation; discouraging indigenous slaughtering methods; installing piped water/boreholes; enforcing slaughtering laws.

Improving storage capacity for bumper harvest, branding, and packaging; enhancing diversification of goods to be transported, for example, transporting cattle and sheep with barley.

Underlying Factors

Poor farmers have less access to required inputs and are more prone to drought compared to wealthier farmers; farmers located in lowland areas of Narok are more prone to the effects of drought than farmers in the highlands; women and youth are vulnerable due to lack of capital.

Small-scale farmers cannot acquire appropriate machinery and equipment to carry out their on-farm production activities during drought; poor farmers cannot afford to lease appropriate machinery; lowland areas of Narok County are more affected by drought.

Vulnerable groups like youth and women are more prone to suffer post-harvest risks due to lack of capital; land-right practices do not favor vulnerable groups like youth, women, and PLWD; poor infrastructure in remote areas of Narok poses challenges to the locals.

Large scale traders and packing and branding companies are likely to be more affected by drought due to their heavy capital investment and low operation capacity.

Chicken (Local)



Provision of
Inputs



On-Farm
Production



Harvesting
Storage and
Processing



Product
Marketing



Extreme Rainfall
Consequences

Little sourcing of chicks due to impassable roads and extreme cold; fewer working hours due to heavy rains affects production of chicken feeds; feed and material delivery is difficult due to impassable earth roads; chicken housing wood decays.

Increased necessity of cleaning, leading to tedious labor; low supply of feed due to increased rainfall leads to reduced feeding, which lowers production; increased necessity of vaccination and treatment due to increased infections.

Poor distribution of chicken products due to impassable roads; reduced slaughtering hours due to bad weather conditions; damage to packaging materials like egg trays.

Farmers reduce market prices to minimize losses due to product spoilage; reduced interaction between farmers and buyers due to bad weather; reduced sales due to poor road conditions and bad weather.

Magnitude of
Impact

Severe

Major-Severe

Minor-Severe

Minor-Severe

Farmers' Current
Coping Strategies

Hatching their own chicks or sourcing from neighbors; using available poultry feeds like left overs, vegetables, and grains; using donkey carts to transport chicken and products to market; using locally-available materials.

Constructing poultry houses properly, using wire mesh that separates chicken droppings from the poultry; improvising feeding troughs to do in-house feeding; lighting jikos for warmth and hatching; using heater bulbs and steamed water.

Using local transport systems like donkeys, motorbikes, and human beings; using timber-improvised saw dust; selling live chicken and converting it into the product they desire; using buckets and cartons to carry eggs.

Farmers are producing manageable products so as to reduce the rate of spoilage; farmers are forming groups which increase links with buyers; farmers supply what they can manage to carry; farmers sell to neighboring markets.

Potential
Adaption Options

Improving infrastructure; for example, constructing all-weather roads; buying surplus chicken feed and storing for future use; constructing good poultry houses during the dry season.

Buying tanks for water harvesting and storage; drilling boreholes; improving poultry houses by raising them high and collecting droppings on a daily basis; including chicken in-house feeding areas in poultry houses; buying chicken brooders; vaccinating early against new castle, coccidiosis, etc.

Improving infrastructure like roads and electricity; purchasing four-wheel drive; forming groups; farmers built a chicken slaughter house in one center by forming a cooperative; using synthetic egg trays to transport eggs; forming egg cooperative societies for easy service and accessibility.

Looking for readymade markets to sell produce; forming cooperatives to collect and sell products from farmers; forming SACCOs to avoid fluctuation and uncontrolled prices; improving feeder roads and pathways so as to reach market easily; online advertisements and sales.

Underlying Factors

Farmers will be affected by poor roads in rainy seasons; chicks are exposed to bad weather and can die; when the supply of feed is low, the price rises.

Increased vulnerability to chicken infections and pests increases the necessity and cost of vaccinations; during the rainy season, the predator population increases.

Impassable roads lead to poor distribution of farm products; due to damaged packaging materials, the farmer incurs losses; losses incurred in chicken slaughtering as well.

Reduced prices, set in order to dispose of products, reduce farmers' profits; bad weather reduces buyer-farmer interaction and diminishes market.



Drought
Consequences

Chicks are few and expensive due to unavailability of feeds; feeds become expensive; increased prices for construction materials like timber.

Due to water scarcity, cleaning occurs less frequently; scarce, expensive, and poor-quality feeds reduce feeding frequencies

Ease of transportation, as most roads are earth; low costs of transportation; the rate of chicken-slaughtering reduces; eggs spoil.

Low supply of chicken, eggs, and by-products; increased demand and prices; fewer links between farmers and buyers, due to a reduction in chicken production caused by lack of feed.

Magnitude of
Impact

Moderate-Severe

Minor-Severe

Minor- Major

Moderate-Major

Farmers' Current
Coping Strategies

Adapting from local chicken to improve breeds; hatching their own eggs at the household level rather than purchasing the chicks; using advisory services from the ASDSP; practicing free-range poultry rearing; giving chicken available feeds; using alternative, less expensive construction materials that are less, like iron sheets and wire mesh; consulting extension services.

Constructing poultry houses properly, using wire mesh to separate chicken droppings; feeding the chicken with available poultry feeds and freeing them to feed themselves; restricting poultry's movements to avoid them mingling with infected chicken.

County government is improving the roads' condition, which make transportation easier for farmers; sourcing more chickens from nearby farm gates, so as to increase product supply; in order to reduce egg spoilage, the farmer should look for a ready market.

Sourcing from neighboring farms and advertising through sign posts; outsourcing eggs from farm gates, so as to ensure there is a continued supply to traders.

Potential
Adaption Options

Using incubators; purchasing chicken feeds during the harvesting season and storing for future use in dry season

Practicing water harvesting during the rainy season; farmers should stock feed when there is surplus, for future use; improving farm structures to limit chickens' movements.

KERA participants import infrastructure; county government renovating feeder roads; farmers forming groups for education on poultry rearing; buying durable trays to store eggs; ventilating egg-storage areas; forming SACCOs to help build storage facilities and reduce egg spoilage.

Sourcing markets online through social media platforms; diversifying local chicken with improved kienyeji, which lays eggs that never hatch; interbreeding to get F1 and F2 breeds.

Underlying Factors

People in drought-prone areas will be more affected; these areas include Mosior, Suswa, Ntulele in Narok East, and Ongata Enterit in Narok South; high prices for construction materials affect poor farmers and people who live in remote areas; impassable roads affect input supply.

The farmer without access to any source of water may experience cleaning problems; high feed prices; no water availability in some remote places.

Farmers are affected by poor roads; limited innovation and technological development, especially in egg and product storage; the COVID-19 pandemic reduced the accessibility of markets.

The Maasai community do not value chicken as source of food; reduced chicken product leads to reduced income; during the COVID-19 pandemic there was reduction of exercise duty (TAX/VAT), and reduced demand.

Dairy (Cow)

Provision of Inputs



On-Farm Production



Harvesting Storage and Processing



Product Marketing



Flash Floods Consequences

Destruction of pasture fields affects seed sourcing; roads and bridges are destroyed; the animals' heat periods are affected; reduced accessibility to service providers; increased cost of services.

Destruction of infrastructure like stores, roads, and pasture fields; increased cost of the raw materials of feed formulation; reduced access to veterinary services, due to destruction of infrastructure like roads, bridges; destruction of cattle dips, which affects strategic deworming regimes; outbreak of respiratory diseases such as pneumonia, CBPP, and lungworm infestations.

Increased post-harvest losses due to delayed milk delivery; contamination of clean water sources; poor transportation and handling leads to delayed milk delivery and an increase post-harvest losses; poor feed storage leads to mold which compromises feed quality; destruction of feed storage infrastructure.

The destruction of advertising billboards; reduced market access due to poor roads; low sales; milk prices drop for farmers, due to poor market access; prices increase for consumers due to high cost of production; inability to meet contract agreements, high post-harvest losses

Magnitude of Impact

Moderate-Severe

Moderate-Major

Moderate-Major

Moderate

Farmers' Current Coping Strategies

Timely planting; developing early flooding warning systems; enhancing drainage systems on pasture fields; constructing farm ponds to store excess water; innovating of technologies to ensure that A.I services are not hampered by floods/weather changes; formulating policy; involvement of stakeholders in veterinary services.

Training in feed formulation; taking technical advice from relevant institutions; using innovation plans and A.I services from extension officers; learning about A.I services and vaccines; quarantining livestock.

Constructing of safe/flood free milking pens/houses; constructing passable roads with proper drainage systems to allow ease in transportation; training farmers in hygienic milk handling; implementing cooler use; establishing milk collection centers; educating farmers on TMR; securing grants for feed storage facilities.

Strengthening cooperatives to enhance product promotion; training in promotion and value addition for milk and its products; implementing regulations on branding and pricing milk and its products; forming laws and policies to protect milk brands and prices; conducting research and advertisement through social media.

Potential Adaption Options

Constructing dykes and other drainage systems on lowlands; enhancing agroforestry by use of fodder trees, soil, and water conservation measures along slopes; providing A.I equipment at the village level for easy access; training farmers in A.I techniques, subdivided A.I services, and information dissemination; intensify cooperatives.

Bulk sourcing of raw feed formulation materials for cheaper feed production; training farmers on feed formulation; producing quality feeds; constructing modern animal feed stores; training more farmers on heat detection methods; using improved, flood-resistant breeds; intensifying production systems of dairy cattle; enforcing disease control and management; using more effective vaccines; introducing cold drains on the wards level; creating links with the stakeholders like kevevapi, importers, and drug and vaccine sellers.

Enhancing surveillance to ensure that milk-handling regulations are fully implemented; building more processing plants and coolers to reduce time involved in milk handling; train farmers to improve hygienic standards at farm level; diversifying dairy products by acquiring processing machinery; writing proposals for funds and international grants; educating farmers on locally available materials for simple storage facility construction; giving grants to farmers to construct storage facilities; training farmers on feed preparation and storage.

Creating better policies and regulations to access more lucrative markets; creating more attractive platforms for milk-product promotion; investing in branding equipment; creating better regulations and policies to protect milk brands from counterfeiters; putting measures in place to localize branding; cooperatives introducing incentives to farmers; encouraging saving culture in farmers through cooperatives; providing access to credit; training farmers on lobbying for resources.

Underlying Factors

Poor roads and other infrastructure make farm inputs inaccessible to farmers in remote areas; poor policy implementation; poor systems for emergency interventions; poor information dissemination systems that do not allow farmers in remote areas to access information in real time.

Poor farmers-to-extension staff ratio, which hinders information dissemination to farmers in rural areas; poor access to information on rain patterns hinder farmers in making key decisions; poor drainage and water storage structures lead to flash floods that affect low-lying agricultural areas; poor crop cover leads to land degradation.

Poor drainage and infrastructure hampers efficient transport to processors and marketers; lack of storage facilities like hay barns, strategic feed stores, milk coolers; lack of processing plants; little conservation/agroforestry practice; enhanced soil and water conservation structures and measures.

Poor awareness mechanism leads to ineffective interventions; poor access leads to exploitation of farmers; limited farmer-buyer links; cartels and brokers taking over for farmers and buyers; weak or absent cooperative societies.



Drought Consequences

Lack of moisture for feed growth, germination, and development; threats to the animals' health; increasing calving intervals; low income farmers do not have money to seek veterinary services, leading to poor production.

Leads to low supply of raw materials for feed formulation and pasture development; leads to delayed heats, poor conception rate and a lack of resources for insemination services; leads to weak animals, an outbreak of tick borne diseases, and expensive services.

Reduced hygiene due to limited clean water; leads to low volumes of milk, higher processing costs, job loss, low supply of feeds for storage, and underutilization of feed storage facilities; animals can experience feed poisoning, as less feed is available.

Leads to low supply of milk, price hiking, poor-quality milk, youth unemployment; also leads to fake and diluted milk in the market, high branding and production costs; leads to low production, which affects contracts.

Magnitude of Impact

Moderate-Severe

Moderate-Severe

Major-Severe

Moderate-Major

Farmers' Current Coping Strategies

Providing pasture seed, training, and information on climate and weather changes; harvesting and storing animal feed for dry days; providing A.I and veterinary services and training.

Timely planting of pasture; training farmers in feed formulation and pasture development; holistic on-range management and rehabilitation; efficient utilization of feed; training farmers in heat detection; linking farmers to machines; training farmers in TMR (total mix ration) for making feed; educating farmers on proper animal husbandry; forming policy on subsidized inputs; engaging and involving stakeholders.

Training on hygienic handling of milk, from milking sheds to the consumer; using clear jerricans in milk handling and transporting; using coolers to preserve and store milk in bulk; engaging in small-scale value addition; engaging in major milk processing out of the county; constructing hay and barns; using silage-making technology; creating strategic feed reserves at the cooperative level.

Training farmers on proper product marketing options; certifying and registering brands; training farmers on branding and pricing analysis and market trends; developing farmer-buyer links through stakeholders; forming cooperatives for better links; comparing to other traders and processors.

Potential Adaption Options

Developing research extension linkages for more resilient varieties, establishing pasture and fodder under irrigation; destocking livestock; intensifying pasture systems; monitoring and controlling disease and pests; upscaling and subsidizing A.I services to reach all; providing effective veterinary services; educating farmers on emerging diseases.

Growing of protein-rich feeds to supplement grass; growing drought-resistant varieties of pasture; diversifying sources of animal feed; training farmers on heat detection; training A.I technicians to reach more farmers; constructing and rehabilitating cattle dips; providing more effective acaricides; controlling agrovet products to avoid counterfeiters.

Promoting the use of aluminum milk containers and maxi-cans from the farm level to processors; imposing milk-handling and safety measures; providing subsidized modern milk-handling equipment, avail milk testing reagents, and kits at the farm level; upscaling strategic feed stores; mechanizing feed storage to enhance efficiency; training farmers on TMR; establishing feeding structures to minimize losses.

Enhancing production across regional markets; producing daily premium products; strengthening cooperatives to enhance product promotion; trainings farmers in marketing and pricing; enforcing dairy development policy; strengthening cooperatives to enhance links; comparing to new markets; enforcing a school feeding program using locally sourced milk.

Underlying Factors

Lack of ability to acquire and use modern technology, making women and youth more vulnerable; lack of water storage/harvesting structures; this affects mainly women and youth, who are tasked with watering animals and thus spend more time sourcing water; policies in place that do not support access to subsidized farm inputs like A.I services.

Lack of adequate information on good animal husbandry; this affects mostly women and youth, who are the most involved in the on-farm production; culture promotes the use of bulls instead of A.I services; locals lack the financial capacity to produce A.I, access to veterinary services, and construct water storage facilities.

No food/feed reserves for the dry seasons; a shortage of processing plants to combat post-harvest losses; lack of insurance services to help farmers with harvest losses.

Lack of supportive measures to sustain productivity; lack of policies to protect farmers and processors from the unfair competition of cheap milk imports and counterfeit milk products.

Figure 12: Climate Change Adaption Strategies across Selected Value Chains in Narok County

5. Policies and strategies on Climate Change

Several policies have been developed and implemented in Narok County in response to climate change (Table 1).

Table 1: National policies and strategies targeting climate change adaptation and mitigation

Policy	Year	Policy Objective(s)	Interventions	Challenges
Kenya Climate Smart Agriculture Strategy	2017-2026	Fortifying agricultural systems against climate change	Introducing and promoting livestock breeds that can withstand extreme weather conditions Promoting early-maturing and drought-resistant crop varieties	Lack of organization
National Climate Change Action Plan	2018-2022	Increasing forest cover	Protecting the Mau Forest Reducing deforestation	Inadequate staffing and funding
National Climate Finance Policy	2016	Providing a framework for funding climate-change response efforts	Establishing a climate change office Addressing poor coordination in climate change-related policy	Poor policy implementation
Climate Change Act	2016	Provides a framework for funding climate-change adaption actions at the national and the county level.	The national government has had several meetings with the Narok County Government to implement this act. Establishment of a Climate Change Office in the Department of Environment to spearhead climate change issues within the county.	Farmers are unaware of policies
National Climate Chang Policy	2013	Promoting the sustainable management of natural resources	Afforestation and reforestation efforts Raising awareness in the community	Policies are not well-integrated into development activities
National Livestock Policy	2013	Creating employment, improving livelihoods, enhancing food security, and contributing to Kenya's Gross Domestic Production through livestock farming	Creating public and private partnerships Establishing the Kenya Animal Genetics Resource Centre, the Kenya Leather Development Council, and the Kenya Tsetse and Trypanosomiasis Eradication Council Establishing medium-term and long-term emergency plans	Contradictory policies, due to limited stakeholder consultation
National Dairy Development Policy	2013	Supporting and developing the dairy value chain	Conducting breeding activities Promoting pasture establishment and development Offering veterinary services	
Environmental Management and Coordination Act	2015	Protect the environment	Protect riverbeds from encroachment Promotes the conservation of river and wetland soil Protect indigenous forests	
ASDSP	2013-2021	Enhance farm productivity while conserving natural resources	Promotion of dairy cattle, sheep, goat, and maize value chains Focuses on enhancing commercial and economic opportunities for the county's youth	
Agricultural (Farm Forestry) Act	2009	Preserve and conserve the environment	Kenya Forest Service and Narok County have tried to protect the Mau Forest and other smaller forest areas from settlement and encroachment	

Policy	Year	Policy Objective(s)	Interventions	Challenges
Forest Act	2005	Establishment of the Kenya Forest Service, which is a state corporation mandated to develop, manage, and conserve Kenya's forests	Advocates for sustainable tree harvesting Large-scale harvesting must be conducted under a harvesting plan	
Agriculture, Fisheries, and Food Authority Act	2013	Attempts to consolidate laws related to the regulation and promotion of agriculture	Established the Agriculture, Fisheries and Food Authority of Narok County Outlined the roles of the national and county governments in relation to agriculture Repealed the Agriculture Act, the Grass Fires Act, and the Suppression of Noxious Weeds Act.	
Fertilizer cost-reduction strategy		To ensure that the poor farmers can access and benefit from inputs	To make fertilizer increasingly available to farmers in the whole county To ensure fertilizer is well-priced The Narok County Government, through the Department of Agriculture, has also supported farmers by providing subsidized fertilizer More than 50,000 mt of fertilizer has been distributed, with more to come	

6. Institutional capacity on Climate Change

In Narok County, there are many institutions (government, private, non-government organizations, and community-based organizations) that work on issues related to climate change, agriculture, water, or food security. Most of these governmental entities provide agricultural advisory services, extension, inputs, and support to Narok County's farmers. For example, the staff from the Department of Agriculture support farmers through field visits, demonstrations, and inputs. They also decipher weather and

climate information from the Kenya Meteorological Department and release it to farmers in context with other agricultural information. Research institutions within the county are working on climate change and variability. For example, the Kenya Forestry Research Institute and Maasai Mara University conduct research on natural resource management. They are also involved in training and education activities. Here is a sample of institutions that are currently supporting agricultural activities in Narok (Table 2).

Table 2: Institutions that are Currently Supporting Agriculture in Narok County

Off-farm Services	Institutions	Interventions	Challenges
Agriculture Research and extension Services	Department of Agriculture	Providing crop extension and advisory services Promoting crop development Supporting farmers through field visits, demonstrations, and inputs	Limited training in climate change-related issues
	Department of Water	Drilling boreholes Constructing water pans Investing in water infrastructure	Allocated resources are inadequate
	Livestock Department	Provides livestock extension services Promoting different livestock value chains	
	Fisheries Department	Promoting and supporting fish value chain activities. Establishing fishponds Training farmers on and raising awareness about fish farming	Relevant expertise in various departments is inadequate
	Department of Environment	Protecting the environment and Narok County’s natural resources through proper policing	Climate change is a relatively new issue, and has yet to be integrated into the county’s developmental activities
	Energy Department	Providing renewable energy options	
	Department of Lands	Distributing title deeds and governing land use	
	Kenya Forestry Service	Protecting forest resources Promoting forest preservation and restoration Providing farmers with tree seedlings	At the county level, there are no specific funds allocated to climate-change adaptation efforts
	Kenya Forestry Research Institute	Conducting research on natural resource management. Conducting training and education activities.	
	Water Resource Authority	Regulating water resources	
	National Environment Management Authority	Regulating and coordinating projects with environmental impact	Financial and human resources are inadequate
	Maasai Mara University	Conducting research aimed at improving various value chains Creating tree-planting activities and awareness campaigns	Poor coordination among county departments and organizations
	Climate Information Services and Agro Weather Advisories	Kenya Meteorological Department (KMD)	
Early Warning Systems and Participatory Scenario Planning	Department of Agriculture	Analyzing weather and climate information from the KMD and releasing it to farmers	
	Kenya Meteorological Department	Issuing weather and climate advisories Issuing warnings for disasters like floods and droughts	
Non-financial Subsidies	National Drought Management Authority	Working to reduce the effects of droughts Providing early-warning drought-risk information to the public	
	Department of Agriculture	Distributing subsidized fertilizer and seeds	
Financial Services	Livestock Department	Providing artificial insemination services	
	Banks like Equity Bank	Providing financial support to farmers	
Market Services	SACCOs and Mobile Banking Services like Safaricom	Helping farmers save their money and access credit	
	Cooperative societies	Helping farmers to access markets Ensuring proper pricing, so that farmers are not exploited	

7. Synthesis and Outlook

Agriculture is the mainstay of Narok County. The dairy cow, sheep, local chicken, and maize value chains involve large areas of the county and vulnerable populations. The value chains that do so are more resilient to climate change than the county's other value chains.

Some climate hazards pose a threat to Narok County's agriculture. These hazards are drought, extreme rainfall, and flash floods. The people of Narok County have adopted early maturing and drought-tolerant crop varieties, tolerant breeds of livestock, and the practice of rainwater harvesting to deal with these climate hazards. However, some adaption strategies are expensive and labor-intensive. For example, farmers need the government's help and financial support to build irrigation infrastructure. Narok County is in dire need of financial support. The county also needs to ensure that extension is given to farmers. In doing so, the county must consider the needs of the poor, the old, the disabled, and the illiterate.

To promote climate change adaptation within the agriculture sector, the county government must establish an appropriate framework that can effectively address social, economic, and environmental needs. The economic development of the agriculture sector should be streamlined and separate the efficient from the unsustainable. This framework must incorporate institutions, governments, and markets. Narok County is already home to several institutions whose activities play an important role in climate change adaptation.

They provide training, education, and advisory services to farmers through field days, demonstrations, and extension work. They also educate farmers on adaptive varieties of crops and trees and preserve and manage forests. However, most of these institutions lack human and financial capital. The county government must therefore invest further resources in these institutions. The county government must also train the staffs of these institutions to promote better policy implementation.

Gaps in policy and institutional limitations hinder Narok County's response to climate change. The government's existing policies conflict and contradict each other. There is no interdepartmental consultation. Mandates are vague and often lead to confusion. Therefore, law and policy development must begin to involve all parties including farmers. The county government must allocate more resources to deal with climate change.

Going forward, the county government and its partners must seek to improve agricultural production and extension, manage post-production losses, and provide inputs to vulnerable farmers. The county should also focus on controlling diseases and pests, developing feeds and pasture, conserving and developing livestock, and supporting poultry development. This could include building slaughterhouses, investing in milk coolers, and encouraging investors to invest in industries such as hide, skin, and canned meat.

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9. Acknowledgements

This study is the product of the Ministry of Agriculture, Livestock, Fisheries and Co-operatives of Kenya (MoALFC), with assistance from the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) and the Consultative Group on International Research (CGIAR) Research Programme on Climate Change, Agriculture, and Food Security (CCAFS), as part of the National Agricultural and Rural Inclusive Growth Project (NARIGP), supported by the World Bank (WB).

The document has been developed under the coordination of Evan Girvetz (Alliance of Bioversity-CIAT) and John Kimani (National Project Coordinator, NARIGP), under the technical leadership of Stephanie Jaquet and Caroline Mwongera with contributions from (in alphabetical order): Harold A.E. Achicanoy, Mildred Ada, Alejandra Esquivel, Aniruddha Ghosh, Dorcas Jalang'o, Stella Kasura, Ivy Kinyua, Victor Mugo, Jessica Mukiri, Wilson Nguru, Fridah Nyakundi, Ruth Odhiambo, Julian Ramirez-Villegas

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We acknowledge the contribution of the NARIGP team: Mary Maingi, Judy Amadiva, Meriki Joseph, and the county government of Narok. We also express gratitude to the following institutions in for providing information to this study: Kenya Meteorological Department (KMD), Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MoALFC), Water Department, National Environmental Management Authority (NEMA), National Drought Management Authority (NDMA), Water Resource Authority (WRA), Kenya Forestry Service (KFS), Environment Department, Agricultural Sector Development Support Programme (ASDSP), Engare Gusur Farmers Group, Ilaramatak Ilmashariani Farmers Group, Nashipae Ilmashariani Farmers Group, Osotua Poultry Farmers Group and Lanyuak Famers Cooperative Society.

This document should be cited as: MoALFC. 2021. Climate Risk Profile for Narok County. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Livestock, Fisheries and Co-operatives (MoALFC), Nairobi, Kenya.

10.1 Glossary

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2018).

Climate risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (IPCC, 2018).

Climate hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2018).

Climate variability: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2018).

Absolute poverty: a lack of basic human needs, mainly food, shelter, clothing, water, education, and health care.

Food Poverty: Not having the means to acquire enough food to live a normal healthy life. When a population cannot consistently afford the minimum amount of recommended nutritional food, it suffers from food poverty.

Wasted: weak or emaciated because of poor nutrition.

Stunted growth: when the “height for age” value is less than two standard deviations of the WHO Child Growth Standards median. Poor growth and development in children that experience poor nutrition, inadequate psychosocial stimulation, and repeated infection.

The Representative Concentration Pathways (RCPs): Four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report (AR5). The four RCPs, RCP2.6, RCP4.5, RCP6.0, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 (of 2.6, 4.5, 6.0, and 8.5 W/m², respectively).

Green House Gases: Atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Less prevalent but very powerful greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).

Mixed farming: a farming system where there is growing of crops as well as rearing of livestock.

Pastoralism: the rearing of animals which also involves moving around with their herds in search of pasture and water.

Ranching: the rearing and breeding of cattle for business purposes on a ranch.

Marginal mixed farming: a farming system where there is growing of crops as well as rearing of livestock on marginal (arid, saline, acidic) areas.

Agro-pastoralism: a system that is highly dependent on livestock and movement in search of pasture and water, and where possible is combined with crop cultivation.

Prepared by

Alliance

