Kenya County Climate Risk Profile: Samburu County

Highlights

- Livestock farming constitutes the bulk of the economy of Samburu County (Figure 1), with over 60% of the population practicing pastoralism and 30% practicing agro-pastoralism.
- The main climate risks in the lowlands of Samburu are heat stress and drought, which both affect crop and livestock productivity. At higher altitudes, flood risk is projected to be a key hazard in the future.
- Despite on- and off-farm efforts to increase resilience in the face of climate change, farmers' adaptive capacity is low and agricultural yields have decreased in recent years.
- To reduce food insecurity and poverty increased employment opportunities in agriculture and sustainable alternative livelihoods must be developed.
- The county has recently experienced climate changes with hazards such drought, heat stress, floods, and erosion. Overall climate change effects in Samburu include unreliable, erratic, and inadequate rainfall; recurring and prolonged droughts; high and increasing temperatures; and declining water levels.
- The successful implementation of climate adaptation strategies requires strengthening the institutional and financial capacities of stakeholders, delivering basic resources, and introducing agricultural incentives.

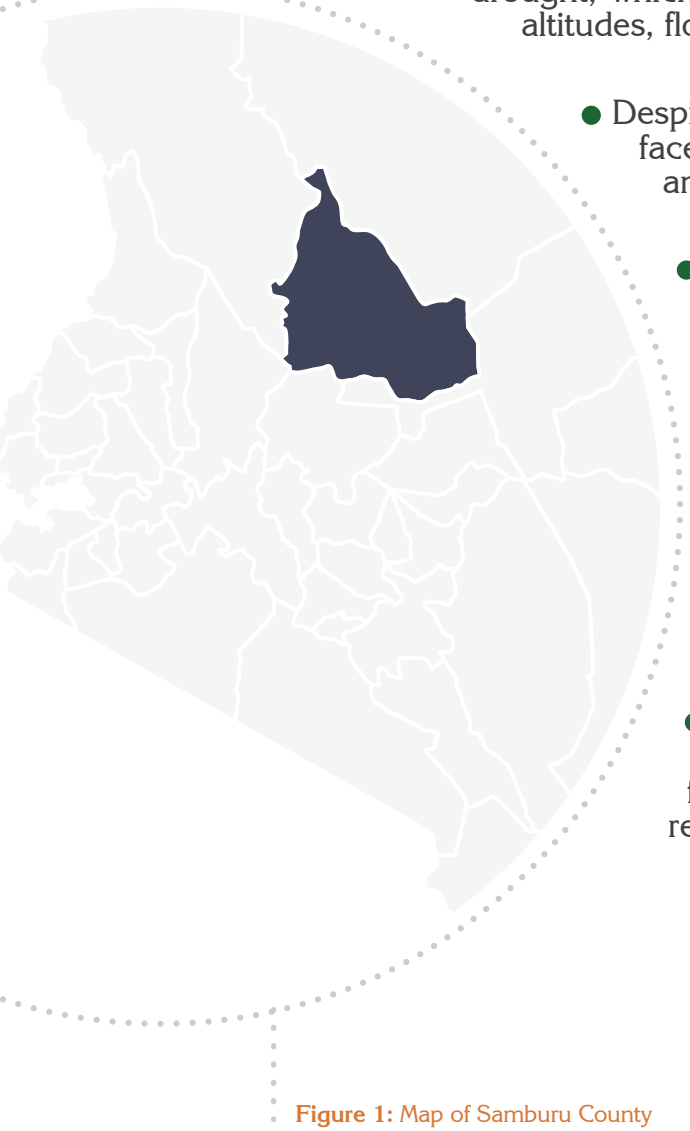

Figure 1: Map of Samburu County

Alliance
Bioversity International
CIAT
International Center for Tropical Agriculture
Republic of Kenya

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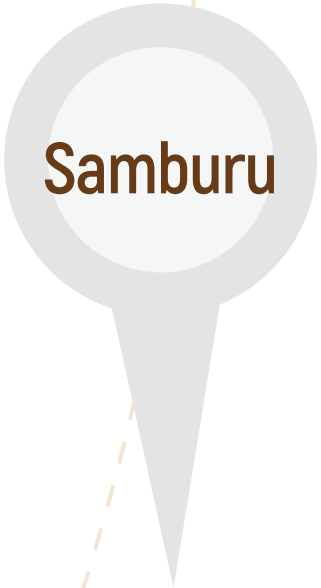
ACTED	Agency for Technical Cooperation and Development
AI	Artificial Insemination
CDD	Consecutive dry days
CIAT	International Centre for Tropical Agriculture
CIDP	County Integrated Development Plan
GoK	Government of Kenya
ICT	Information and Communications Technology
IPCC	Intergovernmental Panel on Climate Change
KALRO	Kenya Agricultural and Livestock Research Organization
KIPPRA	The Kenya Institute for Public Policy Research and Analysis
MOALFC	Ministry of Agriculture, Livestock, Fisheries, and Cooperatives
NARIGP	National Agricultural and Rural Inclusive Growth Project
NCCRS	National Climate Change Response Strategy
NDMA	The National Drought Management Authority
P5D	Maximum 5-day Running Average Precipitation
RPLRP	Regional Pastoral Livelihood Resilience Programme
VC(C)	Value Chain (Commodity)



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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Principal Secretary

State Department for Crops Development and Agricultural Research

1. Introduction

Climate change is becoming one of the most serious challenges to Kenya. The country is susceptible to climate-related events, and projections indicate that climate impacts will continue to affect the country in the future. In many areas, extreme and variable 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 rains. 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 blue print that seeks to transform Kenya into a newly middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment. Agriculture sector has been identified as one of the key sectors to contribute to the projected annual national economic growth. However, it has been constrained with inadequate access to quality inputs, marketing inefficiencies, non-conducive investment environment, declining soil fertility, low mechanization, land fragmentation and more significantly climate change.

In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS), which recognized the importance of climate change impacts on the country's development. This was followed in 2012 by the National Climate Change Action Plan (NCCAP), which provided a means for implementing the NCCRS and highlighted agricultural adaptation priorities. These initiatives are focused on the national level, climate change considerations still need to be mainstreamed in county-level policies, programs, and development plans. Locally relevant, integrated adaptation responses with active involvement of local stakeholders are necessary to achieve this goal.

Through the Ministry of Agriculture, the Government of Kenya (GOK) is implementing the National Agricultural and Rural Inclusive Growth Project (NARIGP) with support from the World Bank. The project development objective is to increase agricultural productivity and profitability of targeted rural communities in selected counties. To address the climate change risks and vulnerabilities that negatively impact agricultural production, the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) completed a climate risk assessment in 14 counties supported by NARIGP. The aims of the assessment are to provide information on current climate and possible future climate scenarios; to identify climate-related vulnerabilities and risks for major agricultural value chains and specific groups of people involved in agriculture; to identify adaptation options that address climate risks/vulnerabilities; and to assess the institutional capacity to deliver adaptation programs.

This climate risk profile seeks to inform county governments and stakeholders about climate change risks and opportunities for agriculture so they can integrate these perspectives into county development. This report will help county governments and stakeholders integrate climate change risks and opportunities for local agriculture into county development plans.

The Alliance undertook the assessment in a set of interrelated stages (Figure 1). It first initiated a desk review of the conceptual and analytical contexts of climate change risks at the national and county levels. It made efforts to involve a wide range of institutions that have worked on climate change at the national and regional levels. The team used globally available data sources like the Kenya Open Data Portal and county development plans, and collected information from relevant government departments, such as the Department of Resource Surveys and Remote Sensing, the Kenya Meteorological Department, and the Drought Monitoring Centre. The team also collected data through focus group discussions, key informant interviews with carefully selected experts, climate modeling, and three days of sub-national stakeholder workshops. The final reports were then presented and validated by national- and county-level stakeholders.

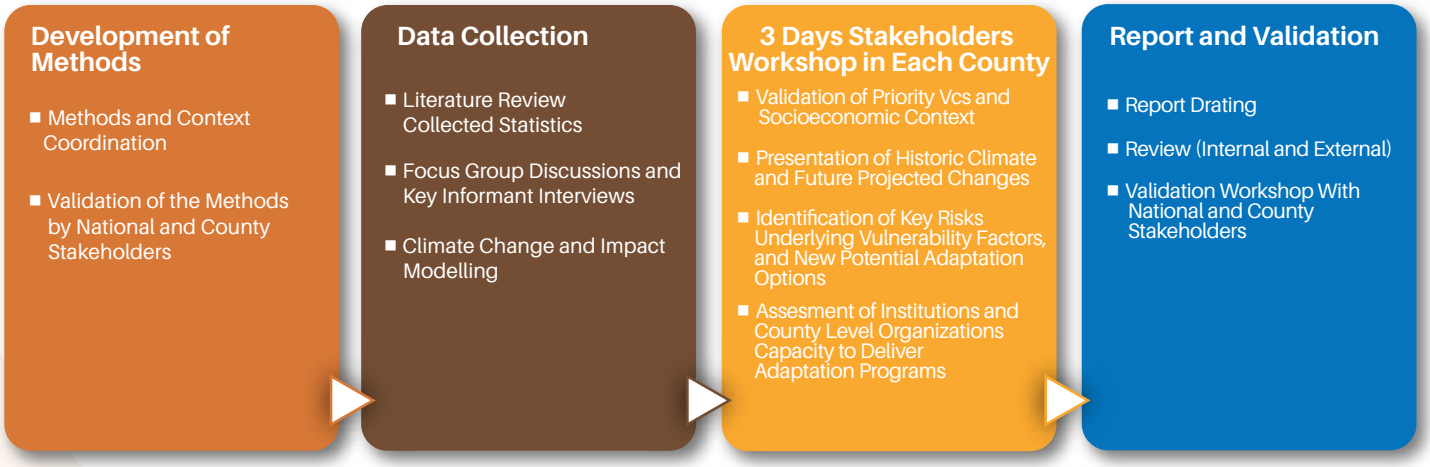

Figure 2: Climate Risk Profile (CRP) development process

This document presents the Climate Risk Profile for Samburu 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 document first offers an overview of the agricultural commodities key to food security and livelihoods in the county, and then lists major challenges to agricultural sector development in Samburu. 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 climactic hazards on 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 also 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

Samburu County is located within the northern parts of Great Rift Valley in Kenya. It lies within Kenya's arid and semi-arid lands, covering an area of 21,022 km2 and bordering Turkana to the northwest, Baringo to the southwest, Marsabit to the northeast, Isiolo to the east, and Laikipia to the south. Administratively, Samburu is divided into three sub-counties, 15 wards, and 108 villages. The largest sub-county is Samburu East (10,049.7 km^2) and smallest being Samburu West 3937.3 km^2). The County has seven divisions, the largest being Waso (5,378.9 km^2) and the smallest is Kirisia (1,237.7 km^2). A total of 139,892 ha, or (8%), of the land is arable; most of this land is concentrated in Samburu's central highland. Samburu County encompasses five agro ecological zones.

(Figure 3): Upper Highland (UH), Lower Highland (LH), Upper Midlands (UM), Lower Midland (LM), and Inner Lowland (IL). More than 75% of the land in Samburu County is classified as 'low-potential' rangeland that receives only 250-600 mm of rain annually. About 140,900 ha, or 7%, of the land is medium-to-high-potential land suitable for agricultural production, as it receives 600-900 mm of rain per year (Samburu County Government, 2018).

The county experiences tropical climatic conditions. The driest months are January and February. The long rainy season falls in the months of March, April and May. The elevation and orientation of the major topographic features, such as the Matthew Range and Ndoto Hills, influence rainfall distribution. Except in the South Horr and Wamba areas, a second, short rainy

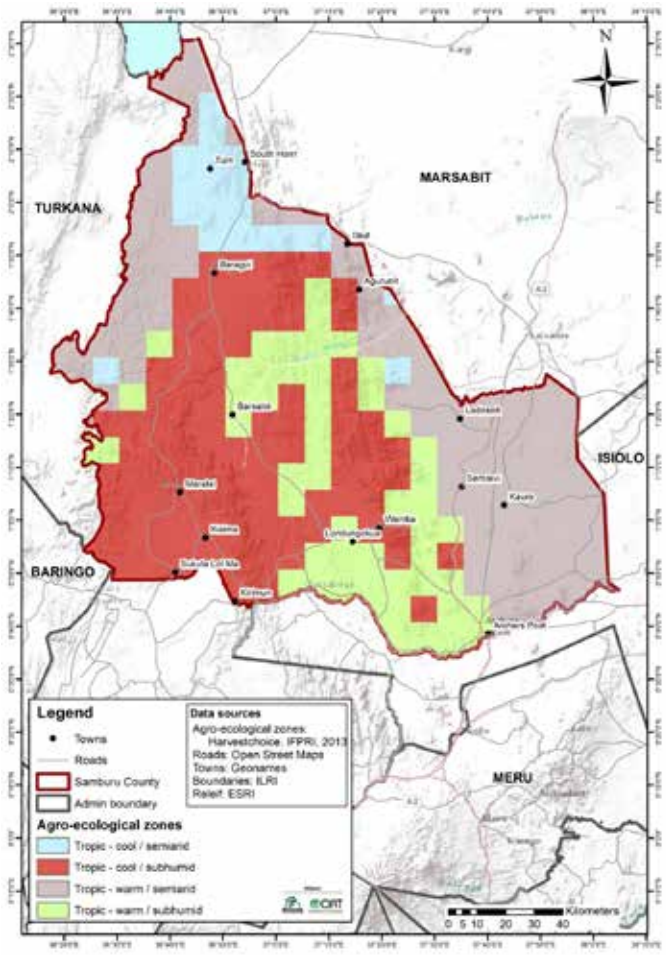

Figure 3: Map of Agro ecological zones in Samburu County

season occurs during the months of July and August, sometimes extending into September. At Wamba and South Horr, the short rainy season starts later in October and November and sometimes extends into December. The southwest plains and the Lorroki Plateau receive 500-700 mm of rainfall annually. The Nyiro and Ndoto Mountains and the Matthews Range receive the greatest amount of rainfall: 750-1250 mm annually. The central basin and the plains east of the Matthews Range are the driest parts; there annual rainfall is 250-500mm. The county has annual mean temperature of 29°C with a maximum of 33°C and minimum of 24°C. The central plains and the region east of the Matthews Range have the highest temperatures, while the highland belts in the North Eastern side of the Lorroki Plateau are cooler (Samburu County Government, 2018).

2.1. Economic Relevance of Farming

Agriculture forms the backbone of Samburu County's economy, contributing around 60% across three sub-sectors, namely, crop farming, livestock rearing, and fisheries. Around 85% of the population lives in rural areas. The agricultural sector is important for poverty reduction and the creation of employment

opportunities, either directly or through value-addition activities, such as milk processing. Overall, the contribution of the agricultural sector to household income in Samburu County is 66% from livestock related activities, 2.7% from crop farming, and 31% from off-farm activities. The livestock sub-sector is a significant contributor to the economy of Samburu County; its main products are milk and meat. Among pastoralists, livestock production contributes 85% of cash income; agro pastoralists derive 60% of their cash income from livestock and 20% from crop production. Production systems in Samburu are primarily traditional, focused on indigenous livestock breeds and local crop varieties and with very few external inputs (Samburu County Government, 2018).

The county had an average population of 169,000 heads of cattle; their estimated annual meat production is valued at Kenya Shillings (KSh) 168 million[1] and milk at KSh 235 million. The production of goats and sheep happens at a larger scale, with an average population of 850,000 goats and 430,000 sheep. The annual meat production for goats is valued at KSh 105 million and that of sheep at KSh 58.46 million. Local chicken populations are estimated at 300,000 with a value of KSh14 million for meat and KSh88 million for eggs. There are, in addition, 32,911 beehives with honey production of KSh 67 million and wax production of KSh11 million (MoALFC, 2019).

2.2. People and Livelihoods

Samburu County has a population of approximately 310,000, of which 50.5% are male and 49% female (Figure 4). The youth (aged 15 to 30 years) represent about 80% of the total population. The average household size in the county is 4.7, and the population growth rate is 4.45%, higher than the national growth rate of 2.3%. The County's average population density is 15 persons per km2. Around 85%, or 263,000 persons, live in rural areas while the urban population stands at 15%, or 47,000 (KNBS, 2019). The Samburu tribe represents 80% of the county's population while the Turkana, Somali, Rendille, Kikuyu and Meru comprise the remaining 20%. The topography, soil type, rock types, and vegetation cover influence population distribution and settlement patterns in the county (Samburu County Government, 2018). The main livelihood activities in the county are crop farming, livestock rearing, fishing, harvesting non-wood products and, to some extent, mining. The majority of households that are rural depend on the livestock sub-sector as their main source of household income. Nationally, the country is ranked 42nd in terms of contribution to poverty, with 71.4% of the population living below the poverty line (defined as living on USD 1.90/day).

2.3. Agricultural Activities

The primary land use practice in Samburu County is pastoralism, with secondary amount of crop, poultry, aquaculture and the upcoming beekeeping animal production systems. Around 92% of the county is rangeland suitable for livestock production. Within the county's pastoralism, grazing is normally communal. The main breeds of cattle kept are local, including Zebu, Boran, and their crossbreeds; goat breeds include the Small East African and Galla. The Dorper and the Red Maasai are common sheep breeds. Beekeeping is an emerging production system being practiced as an alternative livelihood. Crop farming is undertaken in favorable areas like Poro in Kirisia Division, Baragoi, South Horr and Tuum in Nyiro division (Samburu County Government, 2018).

Land ownership in the county falls into four categories: trust, communal, government, and private. Presently, the county has 43 group ranches with a registered membership of approximately 26,000. These ranches comprise 830,000 ha, which is approximately 40% of the county. The promotion of small-scale farming is inhibited by a lack of title deeds since farmers are unable to access credit facilities due to their lack of collateral. The average smallholder plot size is less than 0.4 ha; these plots are mostly found at Poro where crop farming and livestock activities are practiced. Large-scale farms are on average 20ha and are used mostly for livestock rearing and wheat farming (Samburu County Government, 2018).

2.4. Agricultural Value Chain Commodities

Among the diverse range of value chain development in Samburu County, several are prioritized by the County Integrated Development Plan (CIDP), development programs NARIGP and the Agricultural Sector Development Support Programme (ASDSP), and government institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO). For the development of this profile, a list of the major agriculture value chain commodities (VCCs) in the county was compiled using the following prioritization indicators: productivity characteristics, including harvested area, production, and production variations over the past five years; economic value; and nutrition characteristics, including dietary energy consumption (Kcal/capita/day), protein content, iron content, zinc content, and vitamin A content. This list was presented to stakeholders for in-depth analysis and selection during a 3-day-long workshop. The list was further honed using a set of criteria agreed upon by the stakeholders, including resilience to current and future climate change impacts (low to high), the percentage of population involved in the value chain

1Exchange rate: 1 KES = 0.00912897 USD (on 26 Nov 2020)

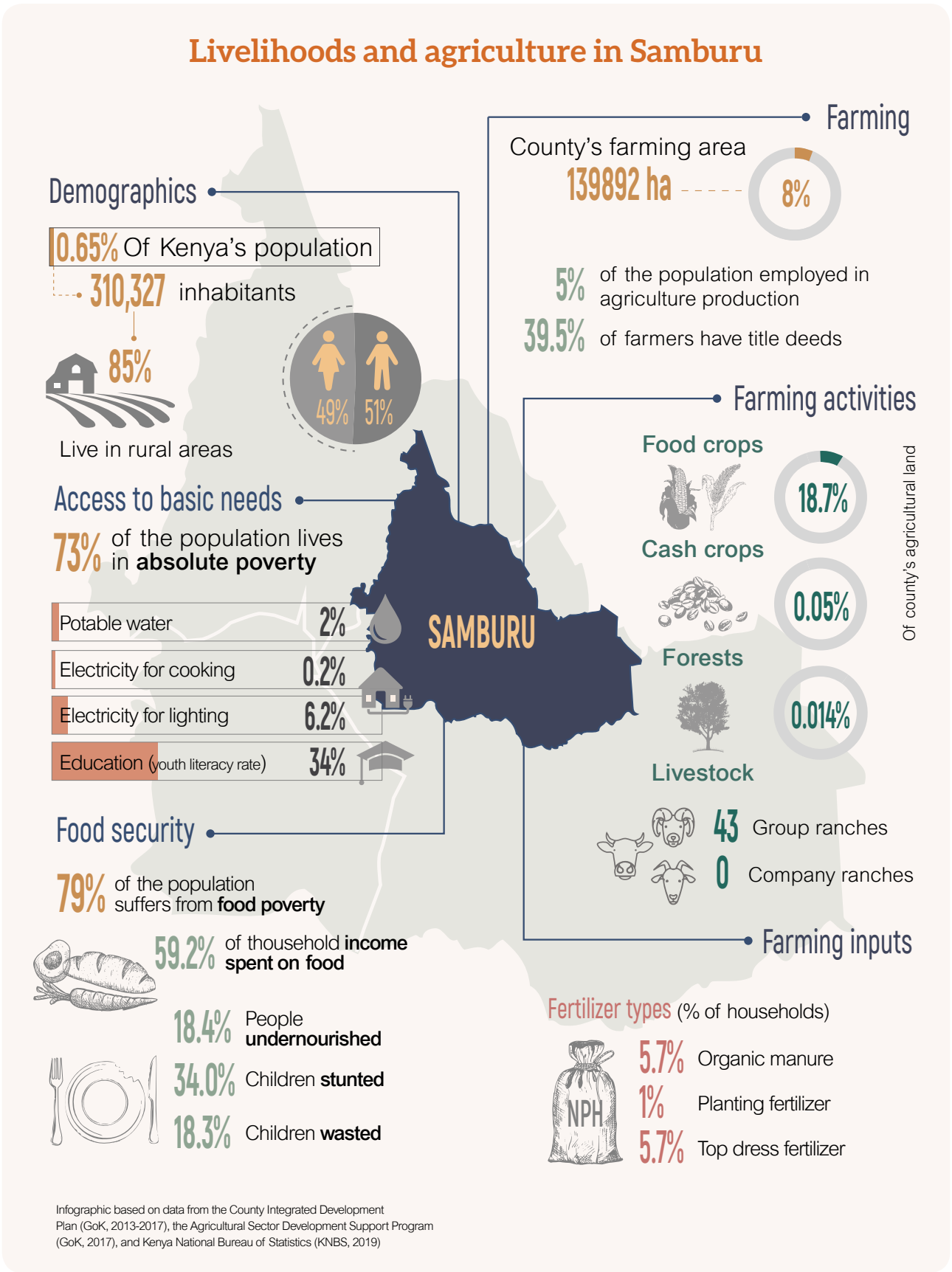

Figure 4: Agriculture and livelihoods in Samburu County

(%), and the involvement of economically and socially vulnerable groups (poor, women, and youth) in the VCC (low to high). Each value chain was assessed against all criteria, and the value chains with the highest percentage of the population involved—with special attention on women and the youth—were selected. The four VCCs chosen for this report are cattle (beef), local chicken, small ruminants (sheep and goats), and apiculture (Figure 4).

2.4.1. Cattle (Beef)

The livestock subsector contributes significantly to the economy of Samburu County since cattle meat is one of its main livestock products. Beef cattle contribute to household income and nutrition, as well as providing major opportunities for self-employment along the VC. Production has, however, remained low due to inadequate and low-quality feeds, low-quality breeds, poor husbandry practices, and high incidence of pests and diseases. More than 80% of the population in Samburu is engaged in the beef value chain. The participation of women and youth is low to medium scale, compared to the highly involved male population. Service providers and merchants supply inputs. The key activities in this stage are agrovet services, veterinary services, feed acquisition, and improving livestock breeds through artificial insemination (AI). At the on-farm production stage, farmers use acaricides for tick control, conduct vaccinations, feed their stock, and deworm the cattle. The actors at the post-harvest stage are farmers and the processors. Key activities are transporting live animals to the slaughterhouses, slaughtering, and meat processing. The marketing stage involves farmers, intermediaries, retailers, and wholesalers; its key activities are linking farmers to cattle buyers, selling, pricing, and promotion.

2.4.2. Local Chicken

Indigenous chickens are common in the rural areas of the county where they play a key role in enhancing household food security. They are primarily kept in traditional, free-range systems. Keeping local poultry is a low-cost activity that requires basic skills and small resources but in exchange provides eggs and meat. Local chicken can be profitable if managed well. Chicken production thus presents an alternative source of high-quality nutrition and of income, especially for women and youth. Eggs and meat contribute directly to household protein needs, alleviating malnutrition and offering food security. Women and youth own and manage most local poultry; they combine a free-range system with protection of chicks from predators and bad weather. Feeding indigenous chicken is necessary to increase their production of meat and eggs. Inadequate feed and water intake reduces resistance to disease and parasites and leads to chicken mortality. The cheapest way to supplement poultry diets is to use local resources like leftover maize grains, wheat, grass, insects, and vegetables.

The local chicken value chain engages 41-60% of the county's population, with a center in central Samburu. Suppliers and agro-vets are the main actors at the input supply stage. They supply feeds, veterinary medicine, chicken equipment (feeders, drinkers), breeding stock, and information. Their activities are important for overall production, the provision of technical advice, and the prevention of disease. At the on-farm production stage, farmers are the main actors, and they engage in feeding, cleaning, bulking, vaccination, feeds supply, and slaughtering activities. These are important for preventing diseases, promoting good hygiene, ensuring optimum chicken production, and providing manure as a by-product.

There are not large-scale poultry processors in the county, so small-scale actors engage in slaughtering, linking farmers to intermediaries, and transporting live birds and eggs. Transporters play an important role in moving poultry from various production points to the final consumers. Producers, brokers, and small-scale retailers transport birds from farms or intermediate markets to end markets. At the marketing stage, the main actors are wholesalers and retailers. Their activities include linking farmers to buyers, pricing, and selling. The activity is important in strengthening market information and selling. The commercial market in Samburu is characterized by a growing urban population and expanding food retail sector that includes fast-food outlets, supermarkets, and restaurants. A ready market exists for free-range eggs and chicken meat within the county.

2.4.3. Small Ruminants (Sheep and Goats)

Small livestock production provides income opportunities and promotes self-sufficiency, particularly for women and youth. Small ruminants are versatile and adaptable to extreme weather, have undemanding feeding habits, accept low-value feed, and possess high production value considering their size. Small ruminants are capable of enduring prolonged water deprivation and can withstand heat stress better than cattle. Small ruminants play an integral part in the welfare of many families and communities. In mixed systems, goats and sheep are multipurpose animals, producing offspring, milk, meat, hide and fleece. The goat and sheep meat sector significantly contributes to the economy of Samburu County.

Over 80% of the county's population is engaged in the small ruminant value chain. At the input supply stage, actors include service providers and suppliers. The key activities in this stage are agro-veterinary services for the provision of feeds, mineral supplements, and drugs; the provision of veterinary services; feed acquisition; and crossbreeding services. At the on-farm production stage, farmers and service providers are the main actors; they feed and fatten, spray, vaccinate, and de-worm. At the post-harvest stage, farmers and the processors engage in bulking and fattening of animals, transporting live animals to

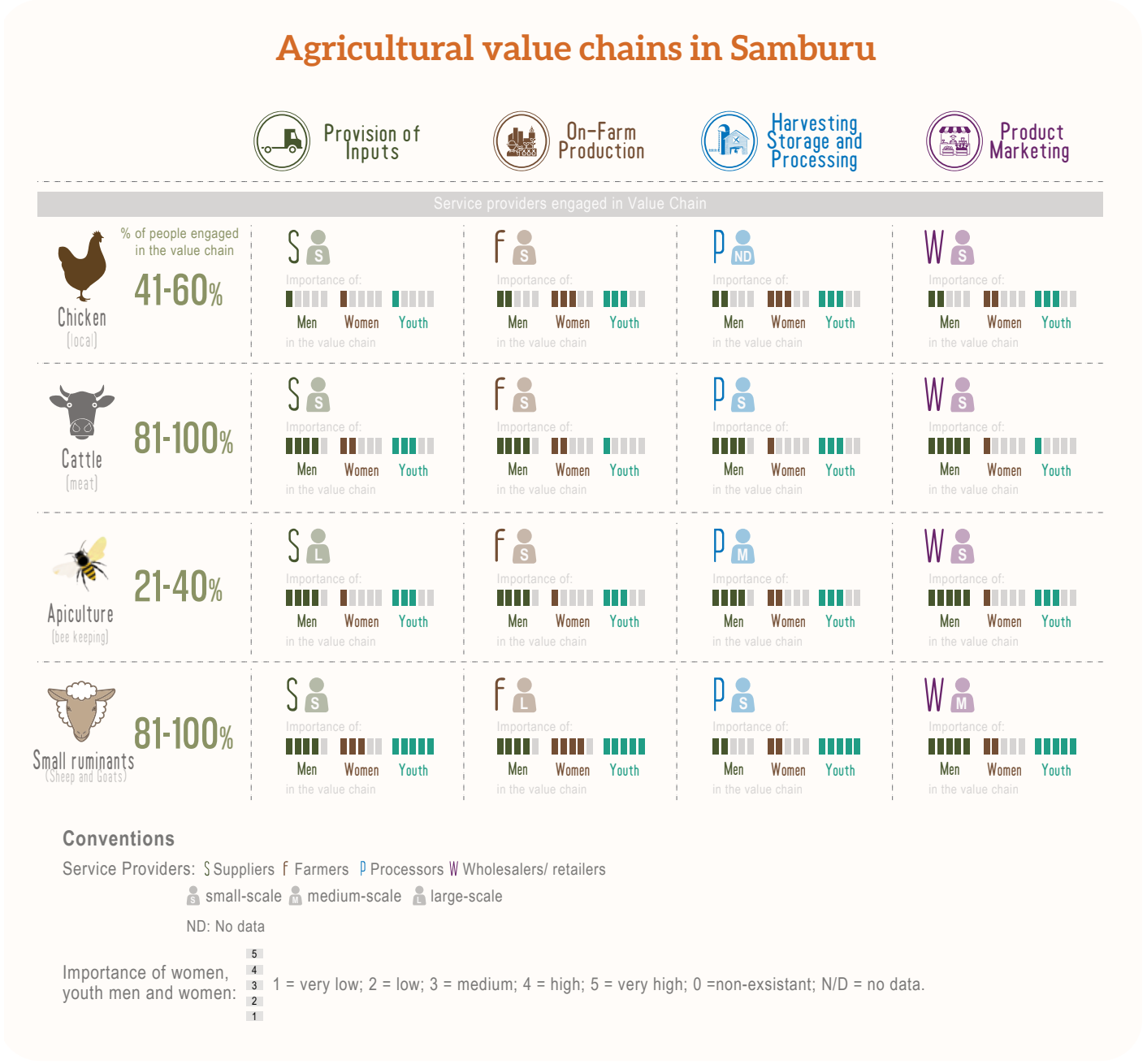

Figure 5: Characterization of the selected value chains in Samburu County

the market, and slaughtering. At the marketing stage, the main actors are farmers, intermediaries, service providers, wholesalers, and retailers. The key activities at this stage are linking farmers to buyers, selling of live animals, and provision of market information.

2.4.4. Apiculture (Beekeeping)

Beekeeping is a low-cost activity requiring only basic skills and small resources. Bees can be kept in temperate, semi-arid, and tropical conditions as long as there is abundant, flowering vegetation available for long periods throughout the year. Bees require access to water. Famers in Samburu mainly keep bees for honey, beeswax, royal jelly, propolis, and pollen production. Bee products are used as food and as a source of household income. In Samburu, bees are kept in both traditional and modern beehives, such as Langstroths or Kenya top bar hives.

Across the country, 20-40% of households participate in the beekeeping value chain. With the support of NARIGP, most farmer groups are now embracing the project. Men are the primary participants in the local beekeeping value chain. At the input supply stage, suppliers offer modern beehives and equipment, such as harvesting kits and processing materials, to support farmers. Most of the suppliers come from outside the

county and the county government. The key activities at this stage are sourcing beehive equipment, assessing beehive locations, and setting up and installing beehives. At the on-farm stage, farmers engage in hive inspection to monitor progress and assess timing for colony splitting. At the post-harvest stage, farmers and processors are engaged in collection of bee products, bulking, transporting, storage, and value addition (processing). Wholesalers, retailers, and farmers are engaged in the output market. Their key activities are promotion of bee products, marketing, and selling the products. Farmers have organized themselves into beekeeping groups across the three sub-counties and they sell their crude honey to Samburu Bee Keeping Cooperative for processing (Samburu County Government, 2018).

2.5. Agricultural Sector Challenges

Agricultural production in the Samburu County has not yet reached its potential. Changing and unpredictable rainfall patterns have greatly affected farmers' ability to plan their farming activities. Farmers continue to use outdated and ineffective farming technologies and efforts to increase agricultural productivity have been constrained by research extension farmer linkages that are inadequate. Crop production is constrained by limited access to agricultural farm inputs (fertilizer, seeds, chemicals, and machinery) and agricultural finance services (credit and insurance), high incidence crop pests and diseases, and inappropriate farming practices. Extension service is a critical agents of change necessary to transform subsistence farming into modern, sustainable agriculture that promotes household food security, improves income and reduces poverty. However, access to extension services is currently limited due to a shortage of agricultural extension services and officers. Poor rural road conditions have led to high transport costs for agricultural inputs and products. Livestock feed supplementation is limited due to their cost and the inaccessibility of input markets (Samburu County Government, 2018).

The main challenges to the livestock sub-sector include the prevalence of livestock disease outbreaks, inadequate grazing resources, a low level of value addition, insufficient early warning information, a lack of cooling facilities, disorganized markets, frequent droughts, conflicts over water and communal grazing areas, and cattle rustling. Most of grazing areas in the county are in gazetted forests, reducing pastoralists' access to pasture, especially during periods of extreme climatic conditions. The main barriers include poor governance of the rangelands—largely due to the absence of an appropriate legal framework for land tenure, a weak framework for disaster response, and inappropriate or inadequate social and financial service systems (Samburu County Government, 2018).

More specifically, the beef cattle and small ruminant value chains in Samburu County experience challenges including inadequate modern abattoirs and holding grounds; high breeding costs; weak and uncoordinated marketing; exploitation by intermediaries; market inefficiencies; and lack of market information. The county does not have adequate capacity, in terms of physical and human resource capital to manage all the livestock markets effectively and efficiently. The poultry sector is constrained by inadequate marketing information; the failure of producers to take full advantage of existing opportunities; inadequate technologies and facilities to process or extend product shelf life; poor product handling; lack of regulated pricing; high transportation costs; exploitation by intermediaries; poor road infrastructure and long distances to input and output markets; expensive power tariffs for processing and storage of chicken products and inputs; lack of certification for chicken input suppliers and products; and lack of timely access to inputs.

Apiculture is constrained by inadequate processing technologies that extend honey shelf-life and increase returns; a lack of product certification; poor market linkages; inadequate supply of beekeeping equipment; a lack of value-addition infrastructure; and the inability of farmers to meet the rigorous local and international market requirements. Limited access to quality beekeeping inputs and equipment is an important challenge to apiculture in the county.

3. Climate Change and Agriculture: Risks and Vulnerabilities

In generating this profile, we assessed past trends and future projections of precipitation and temperature, and computed several related hazards from these two variables. These hazards included 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 rain) is the 100-day wettest period from January to June, while the second season (short rain) is the 100-day wettest period from July to December (KMD, 2020).

We used Representative Concentration Pathway (RCP) 8.5, one of the four greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014. Future climate projections were generated based on an ensemble of multiple Coupled Model Intercomparison Project (CMIP5) models (Taylor et al., 2012), using RCP 8.5 for two future periods, 2030 and 2050.[2]

[2] For 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

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

For each season, heavy precipitation events were captured with the 5-day running average of rainfall, indicative of floods, and the 95th percentile of daily precipitation, indicative of extremely high rainfall over a short period of time, indicating flash flooding risk. 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 adequacy of rainfall and soil moisture to meet the potential water requirements for agriculture, indicators for drought stress were examined in terms of 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 certain level of stress.

3.1. Climate Change and Variability: Historic and Future Trends

Samburu County has historically seen monthly temperatures varying from 15-30°C (Figure 6). The county has two main rainy seasons. The first growing season (the long rainy season) runs from February to June; the second season (short rains) occurs between August and December. Dry seasons are experienced in two annual phases; the first phase occurs in January and February and the second phase usually falls between June and September (Figure 7).

The annual rainfall trends does not show any significant increase in the past but some variability. By 2040, rainfall will decrease slightly during the long rainy season while during the short rainy season, rainfall will significantly increase (Figure 8). The annual mean temperature trends showed an increase from 1985 which will continue towards 2060, in both season (Figure 9).

Past trends and future projections of climate hazards identified drought, heat stress, floods, and erosion risk as the major hazards in the county. Risks in the county are modulated by topography: while temperature and precipitation risks are both expected to increase in the future, flood risk is a moderate hazard in the second season for higher elevations, while the risk of heat stress is more urgent at lower elevations. Overall, the second season is expected to become more suitable for crop growing.

Historically (defined as the period 1985-2015), the number of CDD in Samburu County was 50 or fewer in the first rainy season and less than 70 in the second. Our future projections (for the period 2021-2061), suggest that the county could experience an overall increase of up to 30 additional CDD in the first rainy season, suggesting a significant increase in the incidence of drought. In the second rainy season, projections indicate far lower incidence of CDD with an overall decrease of up to 35 CDD (Figure 10).

Historically, the P5D values indicated a low risk of flood risk throughout the county. Future climate projections indicate that P5D values may increase at higher elevations regions by 8 mm or more, suggesting increased flood risk in areas like Maralal, Porro, Kisima, Wamba, the Matthews Range, the Ndoto Mountains and Mount Nyiro. In the second rainy season, there could be an increase of around up to 15 mm precipitation over the future period (Figure 11). Future climate projections indicate that 95th percentile of daily precipitation (which is an indicator of heavy rainfall) will somewhat remain the same, with a variation between 7.5 mm on either side.

In the first season, historically the total number of days with a maximum temperature greater or equal to 35°C varied between 10 and 20. In the future, the total number of days will significantly increase in lower elevations, suggesting future extreme heat events.

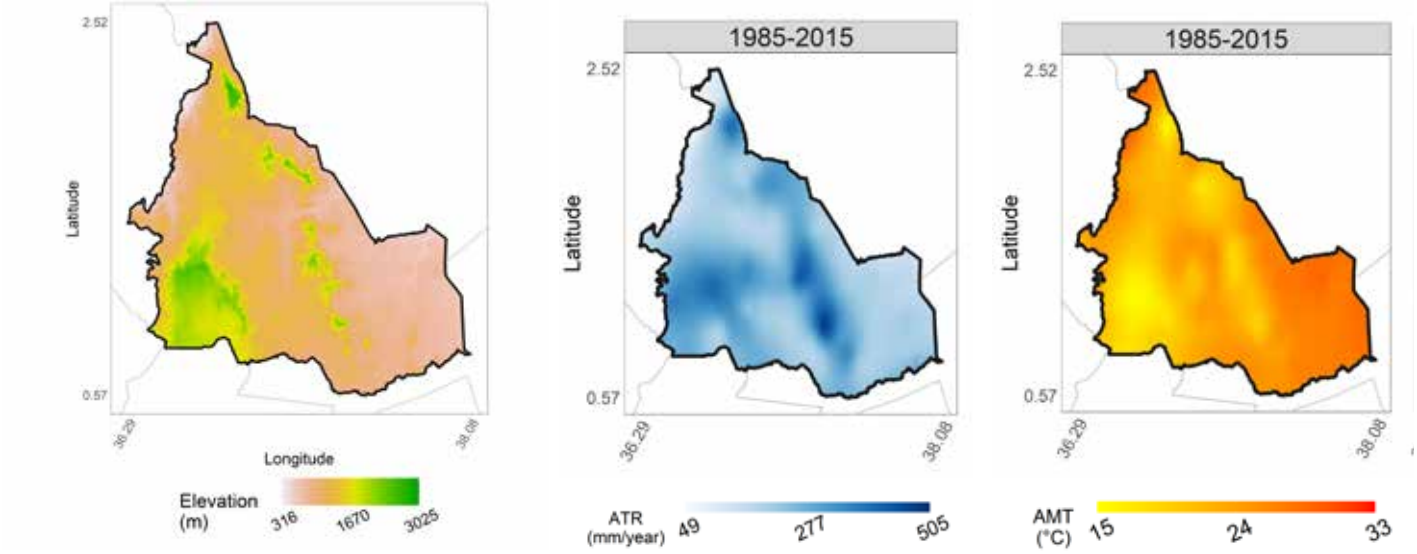

Figure 6: Elevation (left), historical (1985-2015) annual mean precipitation in mm (center), and historical (1985-2015) annual mean temperature in °C (right) for Samburu County for the long rainy season

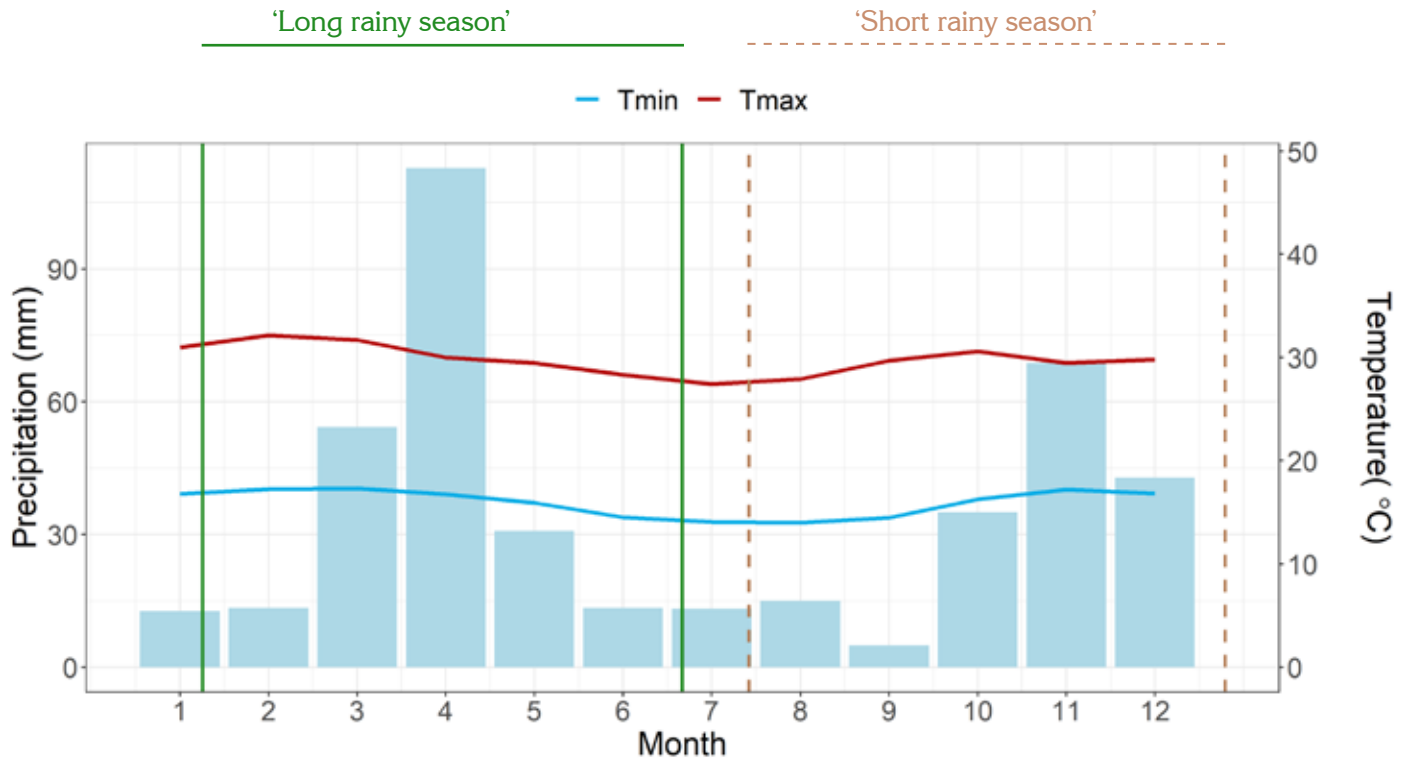

Figure 7: Historical monthly mean temperature and precipitation for Samburu County. The long rainy season is the 100-day wettest period from January to June, while the second, short rainy season is the 100-day wettest period from July to December. Bars represent total monthly precipitation and lines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

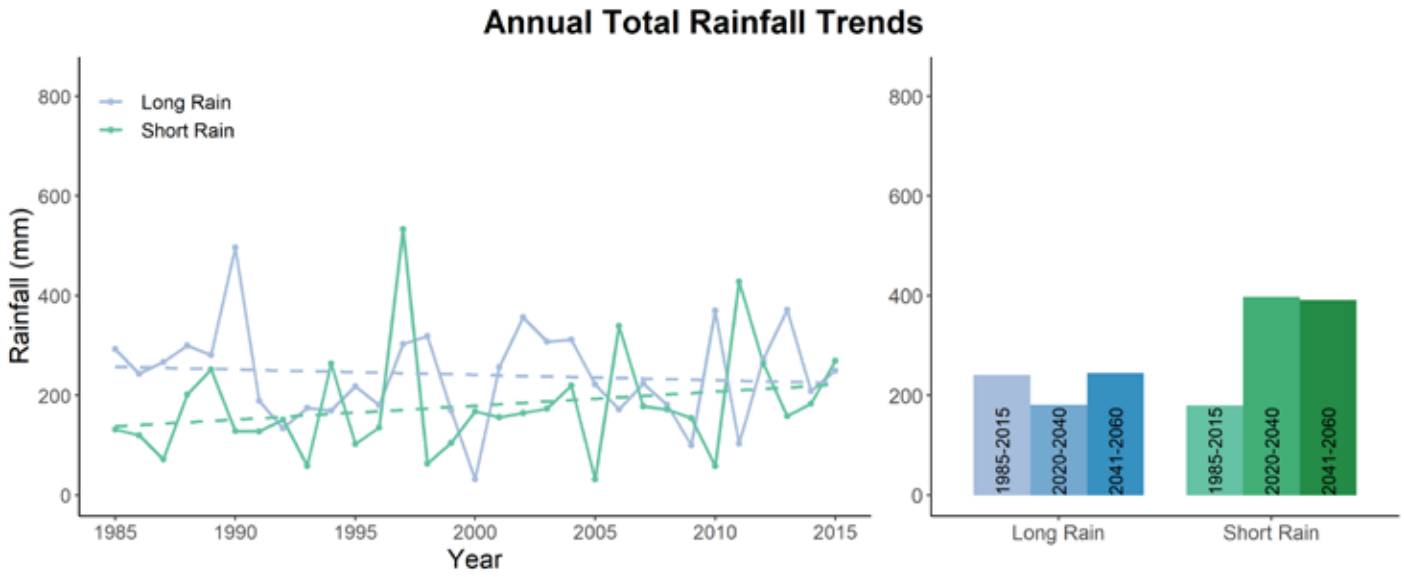

Figure 8: Annual total rainfall trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060

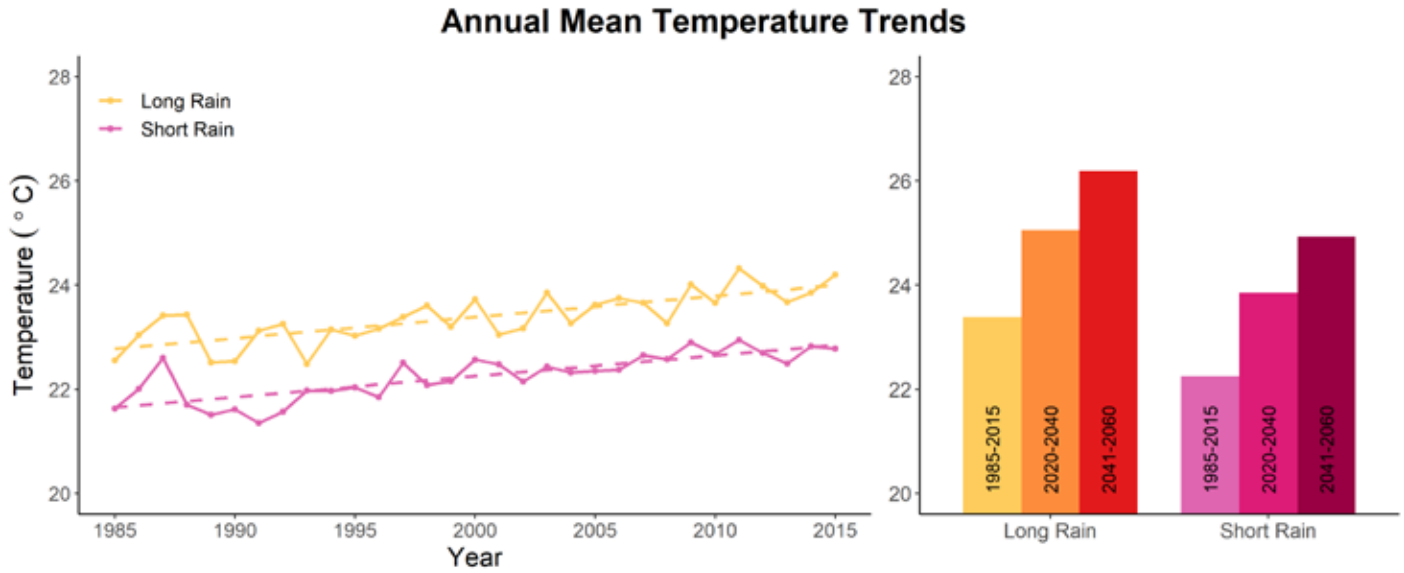

Figure 9: Annual mean temperature trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060)

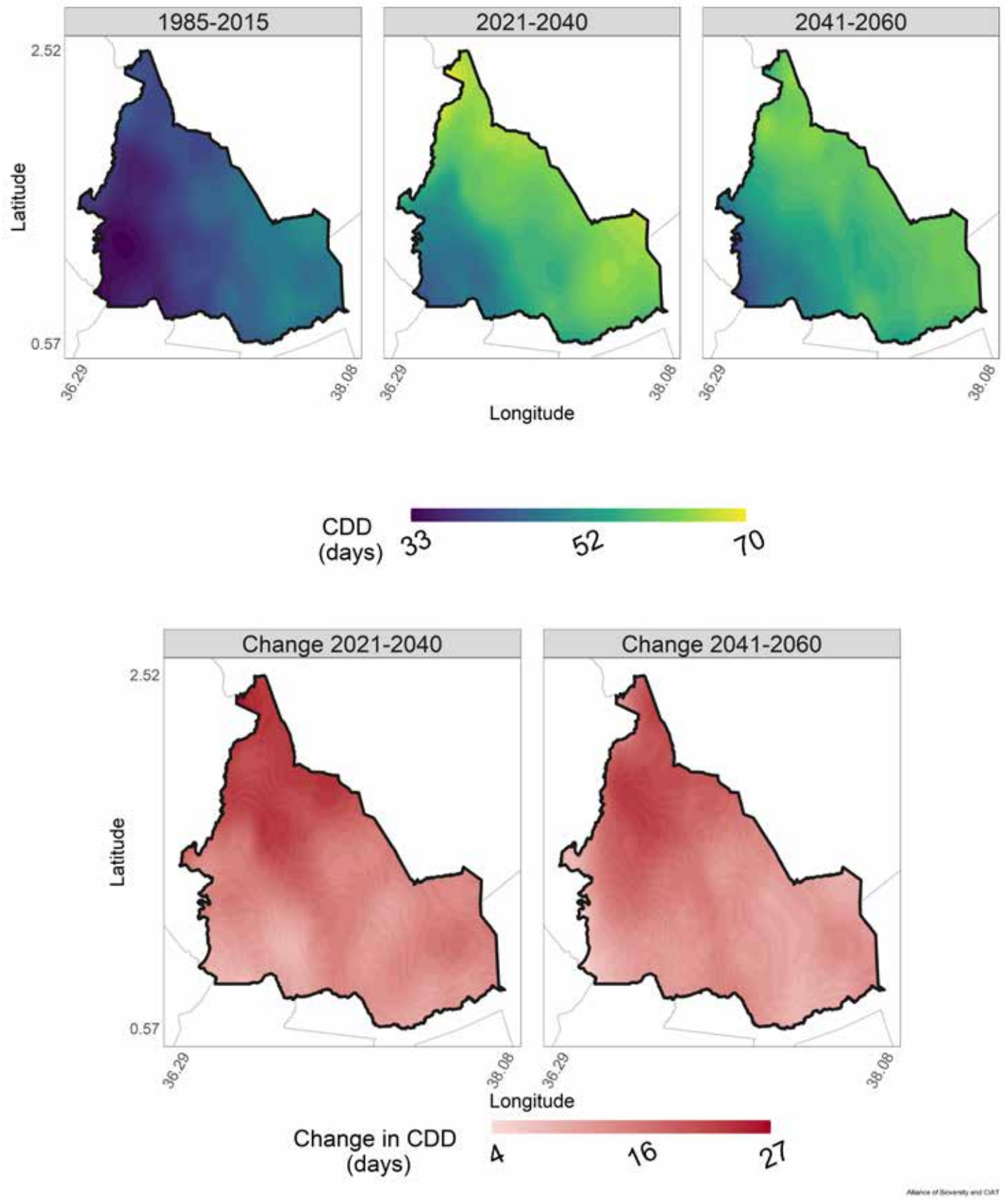

Figure 10: Historical (left), future projected (center), and projected change (right) for the number of CDD for the long rainy season

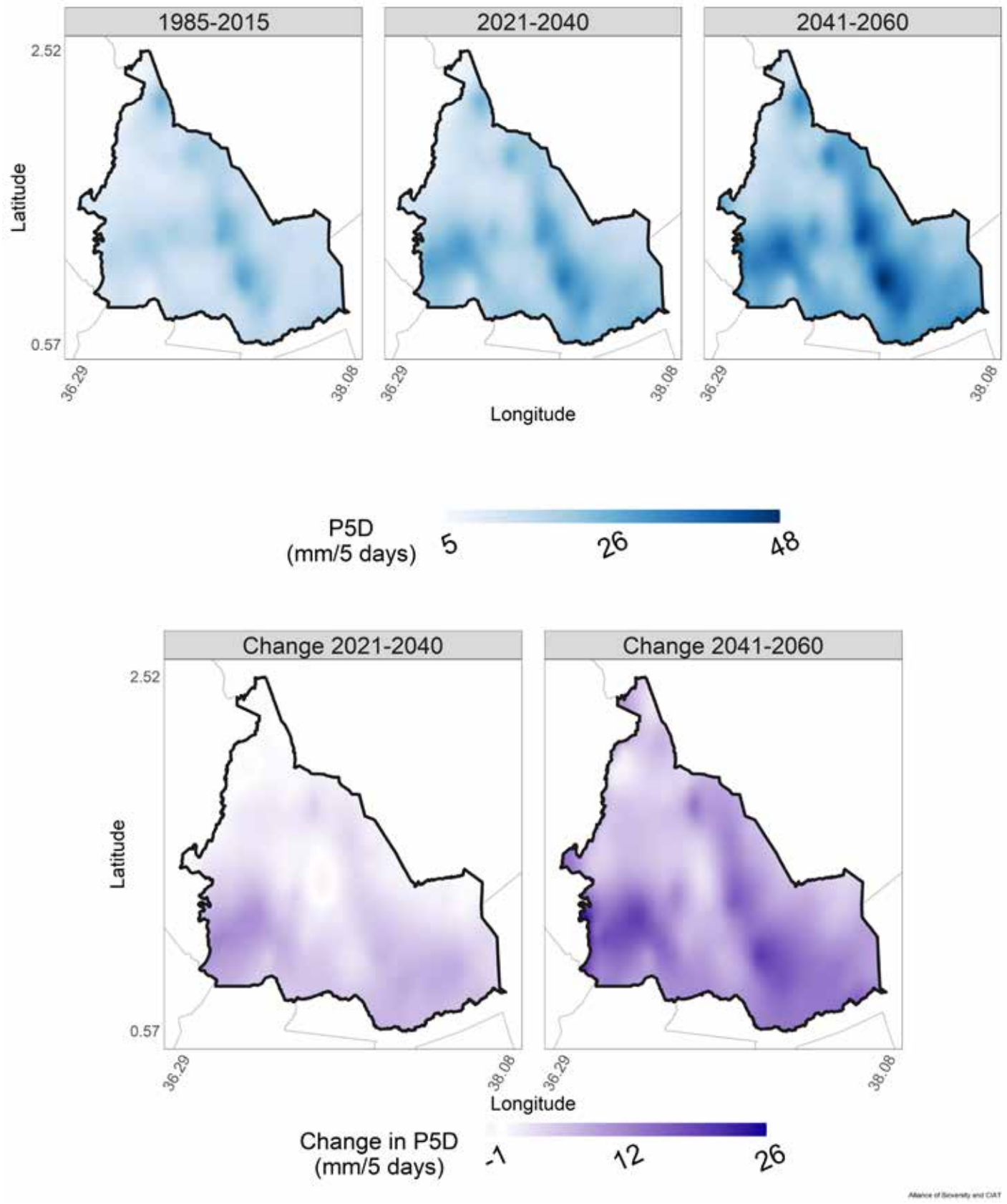

Figure 11: Historical (left), future projected (center), and projected change (right) for maximum 5 days running average precipitation for the short rainy season

3.2. The Climate from Farmers´ Perspectives

Climate change has greatly affected the environment, livelihoods, and food security in Samburu County. Farmers here have experienced climate variability that has affected their agricultural activities. The county has erratic rainfall, which varies significantly in amount and distribution across the county. Temperatures likewise vary. Currently, mornings and evenings are cold, especially in the highlands, when they used to be more moderate. Farmers believe that human activities such as deforestation and environmental degradation are the cause of climate change in the county. Climate change has greatly affected crop farming and livestock rearing and contributes to the current poverty levels in the county. Climatic variability further reduces the land's capacity to support livelihoods, accelerating environmental degradation. This is made apparent by significant reductions in vegetation cover and pasture size, soil erosion, and increasing resource-based conflicts.

The most common changes reported by farmers include rising temperatures; recurrent droughts; erratic rainfall patterns; increased rainfall; flash flooding incidence; and longer cold seasons. They report effects including crop failure; increased incidences of pests and disease; increased water scarcity; acute food shortages; reduced pasture production; soil degradation; and declines in food security and livelihood opportunities. These effects all exacerbate stress and inter-tribal conflicts over natural resources like water and pasture. Frequent crop failures due to drought or high temperatures increase people's susceptibility to food insecurity and poverty. High temperatures lead to high evaporation rates in some parts of the county that necessitate supplemental irrigation for food crops and pasture. Heat stress reduces feed intake among animals, resulting in poor growth and low production of milk and meat. Excessive flooding, especially at higher elevations, occasionally leads to soil degradation and increased incidence of pests and disease. Variability in rainfall due to climate change patterns can adversely affect Value Chain Development.

3.3. Climate Vulnerabilities across Agricultural VCCs.

Expected future climate variation and change pose serious threats to the agricultural value chain commodities selected for analysis in this study. Based on the historic and future climate scenarios for the indicators presented in the Samburu workshop[2], participants identified drought and floods as the most important hazards to all four selected value chains. To assess climate vulnerabilities across the selected value chains in Samburu further discussions were carried out with relevant actors in the 3-day stakeholder workshop. In separate value chain commodity groups they identified two most important climate hazards for their value chains and assessed key risks across the value chain stages i.e. input supply, on farm production, post-harvest/production and product marketing. The results are presented in the next sections.

In addition to the aforementioned climate hazards that affect Samburu County, the locust invasion has also hit the county in the recent past. Billions of insects have devoured crops and grazing lands (browse and pasture), threatening the food security and livelihoods of a population in a region already weakened by extreme-climate events and conflicts. In particular, the cattle (beef) value chains and the small ruminants (goats and sheep) value chains have been most affected (Reach Initiative, 2021; FAO, 2020).

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

3.3.1. Cattle (Beef)

The most notable climatic hazards identified within the beef value chain in Samburu County are drought and floods. The consequences of drought at the input supply stage are a significant increase in demand for inputs such as feeds and drugs; disease outbreaks due to lack of veterinary support services; insufficient financial resources to mitigate drought's effects; low breeding; and high cattle mortality rates. The severity of these effects ranges from moderate to severe. At the on-farm stage, activities including feeding, vaccination, deworming, and spraying are affected. This is because of the scarcity or high price of feeds; increases in parasites; inadequate water supplies; and the high costs of acaricides and spraying equipment. The severity at this stage ranges from moderate to severe. At the post-harvest stage, risks include destocking unsupportable animals at low prices; increased transportation costs due to long distances and extreme temperatures; and reductions in slaughtering due to low animal body weight. The severity at this stage is moderate. Market stage effects include reductions in linkages between farmers and buyers; price fluctuations due to long distances to markets; low prices due to low body weight; and unregulated prices from buyers and traders. The severity at this stage is moderate to severe. Along the value chains all genders are impacted.

Floods at the input supply stage reduce veterinary services due to compromised road networks; increase disease outbreaks due to floods; however, fodder availability can improve breeding quality and improve the body weight of cattle. The severity flooding consequences at this stage is moderate. At the on-farm stage, increased availability of feeds and low prices result in high productivity, but floods and equally cause disease outbreaks (e.g., Hoof and Mouth Disease); decrease disease surveillance due to impacted road networks; and the high cost of acaricides for spraying ticks. The severity at this stage is minor to moderate.

[3]Samburu Stakeholder Workshop: Kenya Climate Risk County Profiles – Phase III

At the post-harvest stage, flooding leads to a low number of animals to be collected at high prices and high transport costs due poor road networks as result of flood damage. The severity at this stage is moderate. The market stage sees selling and pricing affected positively by flooding, which causes higher demand than supply. The severity at this stage is moderate to severe. Along the value chains all genders are impacted.

3.3.2. Local Chicken

Local chicken production in Samburu County is most severely affected by drought and floods. The most affected by the risks are youth and women. A notable consequence of drought at the input supply stage is feed scarcity; reduced supply and high cost of raw materials and fluctuations in feed quality reduce the production of local chicken. Periods of drought also reduce farmers' access to veterinary services due to low supply and result in insufficient capital for equipment (feeders, drinkers). The severity at this stage ranges from minor to high. At the on-farm production stage, drought adversely affects production activities. Feeding is reduced due to feed costs, leading to health deterioration; vaccination activities decline, leading to high mortality rates. The severity of these consequences is minor to major. At the post-harvest stage, the consequences are increased costs of transportation. The bulking of chicken by processors becomes a problem due to high demand and the low prices of by-products. The severity is moderate to major at this stage, with women and the youth heavily impacted. The market stage is affected by low supply of live chickens and eggs, which sell at low prices. The severity is moderate to major at this stage.

At the input supply stage, floods affect local chicken by delaying feeds supplies and the provision of equipment and veterinary services due to compromised infrastructure. At the on-farm stage, crop destruction also reduces feed availability. During flooding, disease outbreaks increase, and the cost of vaccination and treatment is higher. The severity is major. At the post-harvest stage, poor roads delay the supply of live chickens and eggs. Similarly, market demand for chicken declines due to insufficient supply reducing slaughtering activities. Floods also increase operational costs in the collection and bulking of chicken. The severity is major at this stage, with heavy impacts on women and the youth. Similarly, marketing activities are affected by low supply levels for local poultry. The severity is major.

3.3.3. Small Ruminants (Goats and Sheep)

Drought and extreme rainfall events most affect the small ruminant value chain in Samburu County and impact all genders. The consequences of drought at the input supply stage are feed shortages, which in turn lead to low meat production, increased conflict over resources, limited veterinary services, low breading rates, and high mortality rates. The severities of drought consequences at the input production stage are severe. At the on-farm production stage, the impacts of drought on production due to limited spraying, deworming, and vaccination activities, all of which lead to increased incidence of disease and mortality. Drought also results in low production of meat and milk. The severity is moderate to severe at this stage. At the post-harvest stage, bulking and fattening, transportation, and slaughtering are all affected by drought. Bulking and fattening are reduced due to feeds of inadequate quality and high cost; low supply; and increases in the operational costs for collecting and transporting animals to market. The consequences are severe at this stage. At the output market stage, drought leads to reduced market linkages and provision of market information, both due to low supply and demand. The severity is severe at this stage.

The consequences of extreme rainfall at the input supply stage affect the small ruminant value chain positively, as the rainfall increases feeds, water, the quality of breeding. Extreme rainfall also carries risks, however, such as the limited provision of veterinary services, higher disease incidence, and increased animal mortality. Impact severity is moderate to severe at this stage. Extreme rainfall increases incidence of tick and worm infestations, thus increasing demand for acaricides. Because extreme rainfall damages road networks, inputs (vaccines and drugs) become more expensive or even unavailable. The severity is moderate at this stage. At the post-harvest stage, the impacts of extreme rainfall on production are generally positive, with increases in bulking, fattening, and slaughtering activities due to availability of high-quality feeds, high market prices, and high supply and demand. However, negative effects at the marketing stage include poor roads, high operational costs, and high mortality rates due to transportation delays. The severity is moderate at this stage. At the market stage, selling and the provision of market information are reduced. The severity is moderate at this stage with all genders and traders impacted.

3.3.4. Apiculture (Beekeeping)

The notable climate hazards affecting beekeeping are drought and extreme rainfall. The effect of drought on beekeeping at the input supply stage is severe, as it reduces time for siting suitable beehive locations. Men are most impacted at this stage, due to their involvement in this activity. At the on-farm stage, beehive inspection, colony separation, and harvesting are limited due to the shortage of bee swarms and deforestation that has cleared forests and depleted naturally available bee plants that reduce production of honey products. Effects are severe at this stage, with primary impacts on men and the youth. At the post-harvest stage, farmers suffer severe impacts from drought, which affects storage, transportation, and processing activities due to reduced honey yields.

Men and youth are impacted at this stage. Promotion, selling, and marketing at the market stage are also affected by the effect of drought due to low yields and reduced supply of honey products. The severity is severe at this stage with men impacted.

The consequences of extreme rainfall at the input supply stage impact beekeeping by reducing suitable land for the establishment of apiaries due to floods and poor road infrastructure. Floods can also render hives inaccessible or destroy them. The severity is moderate with men mostly impacted. At the on-farm production stage, extreme rainfall has moderately negative impacts on beehive inspection, colony separation, and harvesting; this leads to delayed on-farm activities and reduced honey production. The severity is moderate at this stage, with men impacted. The post-harvest stage is affected when low honey yields curtail activities such as transporting, storage, and processing. Damage to transport infrastructure can also hinder access to storage facilities, processing infrastructure, and markets. The severity is moderate at this stage and men are most strongly affected. At the market stage, promotion, selling, and marketing are affected by low or inadequate supply and production of honey. The severity is moderate and all genders impacted.

4. Adaptation to Climate Change and Variability

4.1. Factors Determining Future Vulnerability and Impacts of climate change

Climate change and variability affect weather patterns, cause shifts in seasons, and therefore have serious implications for food production and productivity. To mitigate the negative impacts of climate change and variability, farming communities are adopting different strategies. Adaptation is, however, hindered by inadequate technology advancement; limitations on extension support due to current policy frameworks and a lack of political goodwill; insufficient guidelines for livestock polices and regulations, especially concerning disease outbreaks and drug prices; the high cost of quality feeds and drugs; limited access to veterinary services; poor road networks; high transportation costs; inter-ethnic conflicts over resources such as pasture and water; and weak and uncoordinated market structures and linkages.

4.2 Climate Change Adaptation Options

4.2.1 On-going Adaptation options

Farmers in Samburu County currently employ a wide range of adaptation measures to increase the resilience of their production systems and livelihoods in the face of a changing and unpredictable climate (Figure 9). Some of adaptation strategies are specific to certain value chains, while others are cross-cutting. On-going adaptation measures by farmers in the livestock value chains include: controlled grazing patterns; fodder production, harvest, and storage; disease control; using AI; increasing slaughterhouse numbers in all markets; bulk-feed purchasing; digging cut-off drains; training farmers on vaccine handling; routine deworming; using herbal medicines; routine spraying; providing feeding supplements; mass vaccination; disease surveillance; fodder conservation; and using drugs and vaccines.

Apiculture adaptation strategies include bulk collection and storage of honey; utilizing queen rearing to trigger reproduction colony splitting; constructing modern beehives; making beehives outer cover that provides weather protection; promoting flow hive technology; using settling tanks to separate honey and wax; planting bee-friendly trees in the apiary sites; and providing syrup in the apiaries.

To deal with the locust invasion in their communities, most of the residents in the area have resorted to chasing and shouting at them while some other actors that include the government, non-government and community actors have resorted to aerial and ground spraying to control their sizes of the devouring pests. Moreover, they have also implemented desert locust surveillances, reseeding of range lands and cash assistance to the affected households.

4.2.2 Potential Adaptation options

Potential adaptation practices include trainings and on-farm demonstrations on sustainable land management practices; livelihood diversification (e.g. beekeeping); livestock marketing and rangeland management; promotion of the leather craft and dairy industries; building awareness about the importance of destocking; and fodder production and conservation. Other initiatives include enhancing agricultural mechanization; increasing access to agricultural insurance services; and promoting horticulture and increasing crop productivity through the provision of subsidized farm inputs. Investment in basic public services such as the provision of potable water, improved road infrastructure, expanded electric networks, and education could help reduce poverty among farmers. Reduced poverty would enable farmers to invest in activities that secure their livelihoods and help them to adequately use agricultural inputs for the increase of productivity and incomes.

Farmers' current practices will be enhanced through increased access to information, technology, and improved inputs. Print and electronic media, Information, and Communication Technologies (ICT) can improve access to market, climate, and production information in the county. A comprehensive meteorological communications system is necessary for the county. This could be developed into an effective early warning system that can be coupled with information about coping strategies. Adopting

electronic extension (e-extension) to cater to the diverse needs of stakeholders; modern communication technologies like radio, mobile phones, websites; e-marketing; and e-technology for disease surveillance and tracking will enhance Samburu's climate change adaptation response.

Farmers would benefit from enhanced insurance cover for livestock. It is also important to boost entrepreneurship, diversify investment across sectors, increase employment opportunities for the growing numbers of youth, and invest in high-value crop varieties and livestock breeds. For the apiary subsector, adaptation strategies should include building capacity for honey producers at value chain stages involving honey processing, packaging, transportation, stocking, and marketing and providing other services such as hive crafting. Efficient extension services for cattle rearing, management, and marketing will be required to cope with and adapt to changes in climate and the resulting impacts. The county requires more trainings on adaptation to climate change, greater access to agricultural insurance services, and improved access to socially inclusive financial services.

To control and contain the locusts, it is important to strengthen early warning systems for locust invasion, to bolster the surveillance capacity as well as have the necessary equipment and staff for aerial and ground spraying of chemicals.

Adaptation strategies used in selected value chains in Samburu County

Cattle (Beef)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Drought Consequences	Increase of input prices; outbreak of diseases associated with drought; reduced breeding; high mortality rates; frequent abortion	Low productivity; scarcity of feed grains; high feed prices; increase in drought-associated parasites; increase in disease surveillance; insufficient water	Low prices for livestock carcasses; high transport costs; low livestock body weight	Low prices due to emaciated animals
Magnitude of Impact	Moderate-Severe	Moderate-Severe	Moderate	Severe
Farmers' Current Coping Strategies	Planting of drought-resistant and early-maturing forage crops; animal tracking; training of para-vets; introducing improved breeds; controlled breeding	Animal migration (pastoralism); hay purchasing; feeding survival pellets; supplementing with vitamins; increasing water pans; sinking boreholes for ease of spraying	Working through strategic marketing points; building abattoirs in each market point; livestock off-take	Networking; formation of cooperatives, establishing county policies
Potential Adaption Options	Capacity building on pasture production, preservation, and storage; purchasing of seeds and equipment; equipping vet-laboratory for fast disease testing; introducing e-technology in disease surveillance and tracking; capacity building on good quality breeds	Training on feed formulation and establishment of feed lots; establishment of strategic stores; establishment of vaccine distribution centers in every sub-county; deworming and vaccination; capacity building on the importance of cattle dips management committees	Training on the importance of animal holding grounds for marketing; building of modern abattoir; capacity building on value addition	Building awareness on marketing/ auction days; introducing apps for marketing; introducing liveweight scale/ price tagging; holding virtual training days for farmers
Underlying Factors	Financial stability enables livestock feed purchase / livestock transport to places where feeds and water available	Economic factors: high feed costs; high input prices	Infrastructure: inadequate auction yards & abattoirs; poor road network	Political factors; weak agricultural policies; structures and regulatory frameworks
Flood Consequences	Moderate demand for inputs; impassable roads constrain input supply	High productivity; availability of seeds, low feed prices ; increase in wet weather associated diseases- e.g. foot & mouth disease; increase in disease surveillance costs; high risk of waterborne diseases, high acaricide cost	High transportation costs;, high livestock prices; high body weight	Delayed transportation because of poor roads/floods; demand is higher than supply (few animals in the market)
Magnitude of Impact	Moderate	Minor-Moderate	Moderate	Moderate-Severe
Farmers' Current Coping Strategies	Fodder conservation; planting/bulking of fodder; centralized vaccination: training of para-vets	Controlled grazing/ grazing plans; fodder conservation; provision of vaccines; water harvesting, disease control	Improvement of infrastructure; increased number of abattoirs in all market points	Formation of cooperatives; networking; establishing policy and regulatory frameworks
Potential Adaption Options	Equipping veterinary laboratory; introducing e-technology on disease surveillance and tracking; introducing / building genebank in existing livestock improvement center; establishing A.I facility; establishing model feed lots; farmers' capacity building for feed formulation; establishing strategic stores	Establishing vaccine centers at sub-county level; establishing more spray races/dips; establishing cattle dips management committees; establishing animals holding grounds en route to market	Purchasing trucks to transport livestock to abattoir; constructing modern abattoirs at sub-county level; value addition of slaughter by-products	Introducing sales apps; introducing live weighing scales and price tagging animals; holding organized auction days; developing and using digital tools for data collection of buyers & sellers;
Underlying Factors	Economic factors: high input costs; high breeding & veterinary service costs	Economic factors: high cost of feeding, spraying & vaccination or deworming	Infrastructure: inadequate auction yards/collection yards, and abattoirs; poor road network	Political factors: weak agricultural policies, structures and regulatory frameworks

Apiculture (Bee keeping)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Extreme Rainfall Consequences	Poor roads; difficulties in setting up an apiary; rain destroys installed beehives/welting	Beehive inspection: daily bee activities are low making it impossible to inspect; colony separation- is not possible (reproduction is low)	Inadequate honey for processing; transportation- poor road networks	Selling affected by low production of honey; low yields hence no promotion
Magnitude of Impact	Moderate	Moderate	Moderate	Moderate
Farmers' Current Coping Strategies	Constructing roofed/modern hive; using waterproof, quality materials	Introducing green feeding to trigger reproduction; introducing flow hive technology	Bulk collection, storage and aggregation points at respective zones	Establish platforms for promotion e.g. websites, local radio, TV, Facebook; door-to-door deliveries
Potential Adaption Options	Introducing bee-friendly plants in every homestead e.g. bottle brush, sunflower, hyacinth, marigolds, blackberries, pumpkins, strawberries, raspberries; capacity building on hive construction and beekeeping accessories; pre-qualification of local merchants to source hives	Using centrifugal machine to avoid comb damage; introducing complete processing system with settling tanks, wax processors, honey press; enhancing collection centers in every zone	Grading honey according to the nectar e.g. croton, acacia	Regional and national exhibitions; e-marketing platform; web-adverts; forming a collateral union; signing formal contracts with buyers
Underlying Factors	Industrialization: inadequate industries/manufacture of bee keeping equipment and lack of artisans in the county	Biophysical factors: adverse environmental factors affect honey production	Institutional: inadequate collateral and strong cooperative movement to perform value addition of honey	Infrastructural factors: poor road network across the county constrains marketing
Drought Consequences	Reduced suitability of locations to apiaries	Small, dormant swarms and colony separation is not possible; inadequate foliage leads to reduced honey production	Processing: low yields which affects processing	Low honey produced hence low promotion and sales
Magnitude of Impact	Severe	Severe	Severe	Severe
Farmers' Current Coping Strategies	Cooperatives and unions to link farmers & groups to suppliers; planting bee-friendly trees in apiary sites; providing syrup in the apiaries; training on construction of bee equipment	Development of farmer field school to improve bee management and colony inspection; establishing modern beekeeping to improve splitting large colonies; using clearer boards when harvesting to avoid killing bees during drought periods	Using centrifuge machines to draw honey without breaking the combs; using settling tanks to separate honey and wax; establishing and enhancing honey collection centers to improve transport logistics	Establishing cooperatives to add value, package; label and grade; creating awareness through local radio FM, TV, exhibition, SMS and digital media; diversifying honey products- bee syrup, wax, pollen and honey grading
Potential Adaption Options	Introducing bee-friendly trees; pre-qualification of local merchants to source the beehives, training local artisans	Installing surveillance cameras in the hive- a tracker in every queen; introducing double suppers in the langstroth to create space for the swarm; placing queen excluders to separate honey and pollen/broods; placing comb sheets/comb starters with plastic cells	Using centrifugal machines to avoid comb damage; introducing a complete processing system with settling tanks, wax processor and honey press; enhancing collection centers in every honey zone	Grading honey; regional and national exhibition; e-marketing platforms, web adverts, forming a collateral union; signing formal contracts with buyers
Underlying Factors	Educational status: to adopt bee technologies; levels of industrialization: not yet exploited and structured; human resource: limited workmanship and human capital; shortage of raw materials for constructing hives; sourcing of equipment: there is inadequate capital to buy beehives	Inadequate extension support hindered by lack of policy framework and political goodwill	Inadequate facilities exacerbating poor supply logistics in honey collection	Economic- inadequate capital to purchase bulk/large volumes of honey to market during drought period; Social factors- the enterprise is associated with cultural issues

Economic- inadequate capital to purchase bulk/large volumes of honey to market during drought period; social factors: the enterprise is associated with cultural influences

Chicken (Local)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Drought Consequences	Feed shortage; low demand for equipment	Feed shortage; low demand for equipment; disease outbreaks as a result of dust particles; farmers will resort to using traditional ways of treating chickens because of low income	Increase of white meat in hotels/ eateries; increasing supply of chicken and b-products leading to low prices	Promotion-: market information will be strengthened as a result of easy access to buyers; the sales of chicken and by products will be high but at low prices
Magnitude of Impact	Minor-Moderate	Minor-Major	Moderate-Major	Moderate-Major
Farmers' Current Coping Strategies	Training on how to make feeds; storing feeds in bulk; training farmers on equipment making and handling ; training farmers on how to handle vaccines	Farmers' training on proper chicken feeding; training on proper poultry house cleaning; forming groups & cooperatives to enhance cold-chain storage	Purchasing in bulk at eateries/restaurants; establishing a good storage facility for bulking products to enhance quality	Establishing a good storage facility by groups of farmers for bulking products & byproducts; using individual farmers/groups to promote chicken products & by-products, training groups on utilizing chicken products
Potential Adaption Options	Bulk feed purchasing; training farmers on how to make their own feeds; training farmers, youth and women on making their own equipment; training farmers on best poultry inputs	Storing feeds in bulk for use in droughts, encourage production of cereals and other chicken feed; training farmers on hygiene and proper poultry house cleaning methods ; forming groups & cooperatives to enhance on cold chain storage; training farmers on vaccines handling	Establishing a good storage facility for bulking products or by-products to enhance quality; ferrying products / by-products in bulk to reduce individual transport costs	Establishing good farmer-group storage facilities for bulking products/ by products; training groups on utilizing chicken product; using individual farmers/groups to promote chicken products/by products
Underlying Factors	Access of veterinary services and inputs is affected by low income	Low income farmers lack funds to access vaccines and use traditional ways of treating their poultry	Restaurants and farmers sell their products at lower prices	Economic factors: due to easy access to markets, some farmers sell their products at low prices
Flood Consequences	Feed supplies will be delayed due to infrastructure destruction; equipment supply will be delayed; high equipment cost of due to high demand/ low supply; inaccessibility to veterinary services by local farmers	Difficult to clean poultry houses resulting in disease outbreaks; high vaccine costs resulting in use of traditional poultry treatments	Reduction of white meat in eateries/restaurants; transmission of diseases leading to death and losses to farmers/traders; delayed transportation of products (eggs and chicken) to market	Due to infrastructure destruction and disease outbreaks income reduced for farmers and brokers/ there will be low availability of products and by-products
Magnitude of Impact	Moderate-Major	Major	Major	Major
Farmers' Current Coping Strategies	Bulk feed purchasing; training farmers on how to make their own feeds; training individual farmers/ groups on making artisan (Jua Kali) products; training farmers on poultry practices and husbandry	Using locally-available materials; training farmers on chicken feed consumption; digging cut-off drains to channel water away from poultry house; forming groups/ cooperatives to enhance cold-chain storage at local level by use of renewable energy, training farmers on vaccine handling	Purchasing in bulk at eateries/restaurants, establishing good storage facility for bulking products/by-products to enhance quantity; ferrying products by farmers in bulk to reduce individual transport costs	Using individual farmers/groups to promote chicken products, training groups on utilizing chicken products
Potential Adaption Options	Training farmers to make feeds using locally-available materials; forming groups with common interest to purchase feeds in bulk; training champion farmers on disease prevention, control and vaccination; constructing improved housing with isolation rooms; training youth/women to make equipment in polytechnics within the country	Training farmers on chicken feeds consumption; construction of poultry houses with a gentle slope on the floor for easy cleaning	Establishing a good storage facility for bulking of products/by products to enhance the quality; purchasing in bulk at eateries and restaurants; establishing group storage facilities & using renewable energy; bulk transportation	Training groups on the utilization of chicken products, use of individual farmers/groups to promote chicken products/by-products
Underlying Factors	Infrastructure- most roads in Samburu county are inaccessible especially during rainy seasons; farmers may not be able to access veterinary services due to low income	Economic factor: some people in the county earn low income and are unable to access vaccines	Social factor: this activity is undertaken by women & youth hence they face disproportionate consequences	Economic factor: floods contribute to transmission of diseases and pests; this affects some low-income earners where they will incur high disease-treatment costs and more deaths; they will be forced to sell their products and by-products at a low income hence incurring losses

Small ruminants (Sheep and Goats)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Heavy Rainfall Consequences	Adequate feed and water; increase in foot rot incidence and pneumonia; high demand for veterinary services,- sheep/goat deaths; high breeding, high conception rates, good quality breeds	High tick infestation; high demand for acaricides; high worm infestation	Availability of quality feeds; high market prices; high bulking and fattening; poor road networks/infrastructure; losses due to prolonged hours of transporting animals	High linkages; access to the market
Magnitude of Impact	Moderate-Severe	Moderate	Moderate-Severe	Moderate
Farmers' Current Coping Strategies	Storage for future use; controlled grazing; capacity building; forming grazing management committees; mass vaccination; disease surveillance; supportive treatment; regulation of agro-dealers; use of traditional medicine; upgrading indigenous breeds; maintaining pure breeds; control inbreeding	Planting pasture seeds; providing feed supplements; routine deworming; using herbal medicine; proper feeding; mass vaccination; ring vaccination; capacity building of community diseases reporters; disease surveillance and reporting	Tracking animals to markets; using tracks; improving infrastructure; developing abattoirs at Nomotia	Developing markets for livestock (infrastructure); strengthening livestock marketing association; strengthening market linkages; creating LMAs; champion farmers' capacity building; linking farmers to SACCOs & registration of groups
Potential Adaption Options	Constructing communal hay stores; upscaling pasture production; reseeding communal range lands; sensitization on disease outbreaks; introduction of mobile vet labs; routine vaccinations; use of A.I services; introducing improved breeds to farmers; capacity building farmers on breeding; controlled grazing	Introducing communal spray bases at village level; establishing agro-vets & vet labs at community level, controlled grazing; routine deworming; capacity building farmers on deworming & drug handling; mass vaccination, equipping labs, strengthening disease surveillance & reporting	Linking farmers to abattoirs, improving infrastructure (roads, communication); reviving the holding grounds and weighing scales; operationalizing the county headquarters' abattoirs and establishing abattoirs at county level	Strengthening LMAs; forming marketing cooperatives and SACCOs, constructing modern markets; establishing effective market linkages with LMAs; recruiting market monitors to disseminate market information; using local radio stations to disseminate information; establishing market information platforms, social media, SMS platforms
Underlying Factors	Biophysical: adequate water and feed, breeding; access to vet services	Policy: regulating prices and vet drugs; social-cultural - deworming, tick control	Economic: high supply of shoats to the market, high prices, availability of quality feeds; infrastructure- poor road networks, insecurities, and weak policies	Economic: high demand of sheep and goats, high prices and supply of shoats; Infrastructure:- poor road network; insecurity
Drought Consequences	Lack of water; conflicts; low production; limited access to vet services; high cost of vet drugs; disease outbreaks ; unscrupulous dealers who sell fake drugs to farmers; low breeding; low conception rates; high mortality rates	Limited access to acaricides; high supply of fake drugs; high resistance to acaricides; disease outbreaks (ECF); low production (meat & milk); high worm infestations ; high drug costs; low productivity and high mortality; vaccination schedules compromised; limited access to vet drugs; low surveillance; high vaccines and drugs costs; low immunity reduces effectiveness of vaccines	Less bulking and fattening; low supply to markets; high transport costs; road banditry increases; high meat costs; low quality milk supplies; outbreak of human diseases because of feeding on sick shoats; loss of jobs; increased theft cases	Low supply to markets; low prices; low household income leading to malnutrition; no linkages of farmers to markets, high exploitation of farmers by middlemen
Magnitude of Impact	Severe	Moderate-Severe	Severe	Severe
Farmers' Current Coping Strategies	Pasture production, harvesting and storage; controlled grazing; providing feed supplements; vaccinations; supportive treatments; surveillance missions; regulation of agro-dealers; use of traditional medicine; capacity building; using improved breeds; maintaining pure breeds of red Maasai sheep (more resistant to drought); controlled in-breeding	Routine/regular spraying using appropriate acaricides; controlled grazing patterns; regular deworming using recommended drugs, using herbal medicines, proper feeding (quality feeds and water); mass vaccination, ring vaccination, disease surveillance and reporting, capacity building of community disease reporters	Planting pasture seeds; provision of feed supplements/ multi-vitamins; control of worms;; use of trucks; improving road networks; developing abattoir at Nomotio; awareness creation on importance of slaughtering animals in abattoirs	Develop marketing policy; developing market infrastructure/creating new markets; strengthening livestock marketing associations; creating LMAs at local level; strengthening market linkages; formation and strengthening of market monitors; disseminating market information through local radio station
Potential Adaption Options	Upscaling pasture production and management through seeding of community range lands; capacity building and research on pasture seeds and seedlings, and on-farm feeds processing establishment of vet and livestock departments at ward level; establishment and equipping vet. labs at the sub county levels; facilitation of agriculture; livestock and vet personnel for delivery of services to farmers; controlled breeding (breeds; timing; capacity building on importance); use of breed resistant to drought and adopted to the area; use of A.I	Controlled grazing; farmers' capacity building on tick control and drugs handling; increase accessibility of drugs/establishment of agrovets and vet labs; controlled grazing; farmers' capacity building on deworming schedules; de-wormers; establishment of agrovets at village level; mass vaccination/ supportive treatment; strengthen disease surveillance and reporting; facilitation of vet officers in service delivery	Establishing feed lots; seeding community-managed range lands; linking farmers to abattoirs; improving infrastructure (roads; communication); reviving the holding grounds and weighing scales; operationalizing the county headquarters abattoir and establishing sub-county abattoirs; operationalize/reviving hide and skin tanning training community meat inspectors	Strengthening LMAs (Livestock market association); forming marketing cooperatives and SACCOs; construction of modern markets; establishing effective linkages with LMAs; recruiting market monitors; dissemination of market information through local FMs; establishing market information platforms, social media, SMS platforms
Underlying Factors	Social cultural conflicts; biophysical: unavailability of resources such as water; shortage of feeds; policy- delays/ regulation of vet drugs by the government; infrastructure: no access to vet services and livestock services	Policy: limited access to vet services and high supply of fake drugs; economic: high cost of drugs, low productivity	Economic status: high cost of quality feeds; high transportation cost, social cultural: road banditry	Lack of market information; low prices of shoats, low supply

Figure 12: Climate variabilities and adaptation options across selected value chains in Samburu County

5. Policies and strategies on Climate Change

Climate changes in Samburu County are causing decreases of agricultural productivity. The County supports the formulation of policies and acts to support the implementation of appropriate climate change programs. In response to climate variability and change, the county has developed and implemented several policies and programs with a focus on adaptation and mitigation (Table 1).

Table 1: National policies targeting climate change adaptation and mitigation in Samburu County

Policy	Year	Policy Objective(s) at the County Level	Climate Change Adaptation and Mitigation Interventions	Challenges and Policy Gaps
The Disaster Risk Management Policy	2015	Strengthens disaster risk governance Advocates for investments to increase resilience and disaster preparedness Emphasizes effective response, and a "build-back-better" mentality in recovery, rehabilitation, and reconstruction	Strengthening early warning information, preparedness and response Investing in affordable and quality early warning equipment Broadening early warning channels	A lack of legislation identifying enforcement officers and policies for climate change adaptation Reduced coordination and collaboration of development planning in sectors Weak coordination and collaboration between public (state) and private actors
The Samburu County Agricultural Machinery Services Act	2015	Provides a legal and regulatory framework for the development and regulation of agricultural machinery services	Enhances farmers' productivity and income through strategies including access to certified seeds, and agricultural mechanization	
The Samburu County Livestock Sales Yard Act	2018	Establishes livestock sale yards Promotes livestock marketing Provides for livestock sale yard administration Promotes effective and efficient operation of livestock markets	Provide for the establishment and control of livestock sales yards and other connected purposes.	
The National Agricultural and Rural Inclusive Growth Project	2017	*Increases the agricultural productivity and profitability of targeted rural communities*	Responding to disasters affecting the agricultural sector in selected counties	
The Agricultural Sector Development Support Programme Phase II	2019	Transforms crop, livestock, and fishery production into commercially oriented enterprises	Application of green growth and Climate Smart Agriculture approaches to value chain development Environmental resilience for value chain actors promoted	

6. Institutional Capacity on Climate Change

Institutional resources and capacity shape resources use actions and outcomes for increasing farmers' adaptive capacity and climate change resilience. In Samburu County, governmental, private, non-governmental, and community-based organizations are all working on issues related to climate change, agriculture, water, and food security. Their interventions include research and extension, early warning systems, capacity building, technology provision and transfer, enhancing market linkages, offering financial and credit services, the provision of inputs, and disease surveillance. Here is a sample of key institutions that are currently supporting and implementing agricultural interventions in Samburu (Table 2).

Table 2: Institutions that are currently supporting and implementing agricultural interventions in Samburu County

Off-Farm services	Institutions	Specific interventions	Challenges
Agriculture Research and Extension Services	Ministry of Agriculture, Livestock, Fisheries, and Cooperatives	Provides extension services and inputs	Poor coordination among the organizations that leads to duplication and overlapping roles and efforts
	Kenya Agricultural Livestock Research Organization	Develops and disseminates technologies, innovations and Management Practices (TIMPs).	
	The Drought Resilience and Sustainable Livelihoods Project	Enhancing water infrastructure for humans, agriculture and livestock Encouraging regional water basin cooperation and coordination Improving livestock infrastructure and management Offering project management and capacity building	
	The National Drought Management Authority	Restocking Capacity building on conservation Providing information on drought Disaster risk reduction Afforestation	
	Samburu County Government in partnership with The Swedish International Development Cooperation Agency European Union	Providing inputs and capacity building for the beekeeping value chain	
	European Union State Department of Planning and Devolution	Construction of one mini-modern abattoir for meat processing at Nomotio LIC.	
	International Livestock Research Institute	Livestock research	
Water Conservation Strategies	Ministry of Water and Irrigation	Administrates water technologies (e.g. irrigation infrastructure and schemes)	
Forest Research and Extension	Kenya Forest Research Institute	Promotes conservation of forest resources	
	Kenya Forestry Service	Afforestation programming	
Research and Extension Services	Department of Environment, Natural Resources, and Disaster Management	Natural resource conservation Disaster early warning bulletins Disaster response programs	
Climate Information Services and Agro-Weather Advisories	Kenya Meteorological Department	Provides weekly weather bulletins and seasonal weather forecasts in the local language	

Off-Farm services	Institutions	Specific interventions	Challenges
Early Warning Systems and Participatory Scenario Planning	Kenya Meteorological Department	Issues early warning warnings on disasters like flooding	Inadequate training and technological support to cope with current agricultural practices
Non-Financial Subsidies	Agency for Technical Cooperation and Development	Improves access to food, sustainable livelihoods, water, livestock, and agriculture technology	
	Caritas	Provides seeds, livelihood programs, and nutrition programs	
	World Vision	Supports livelihood programs	
Financial Subsidies and Extension Services	Synovus Financial Corporation (SNV)	Builds the capacity of focal groups Provides financial supportto improve the functionality and climate resilience of rural water systems	

These institutions and groups are critical to promoting cross-sectoral cooperation, sharing experiences, and developing policies that facilitate integrated management strategies, all of which are important components of capacity building.

Non-governmental organizations, faith-based organizations, and international organizations all play a key role in the socio-economic development of the county. Many have operations in Samburu county. They provide extension; provide inputs such as fertilizers, farm tools, high-yielding seeds, and irrigation equipment; develop market infrastructure; provide training and technology transfer; and link farmers to markets by encouraging them to organize themselves into groups that strengthen their bargaining power.

7. Synthesis and Outlook

Samburu County's agricultural sector has not been able to sustain the food production necessary to support its grown population due in part to the changing climate. The increased frequency and severity of climatic shocks such as drought, floods, and extreme rainfall has negative impacts on agriculture and food security. Concerted efforts at the farm, community, and county levels are necessary to deploy solutions, interventions, and instruments that address the impacts of climate change on agriculture. It is still necessary to enhance the capacity of farmers to cope with these new conditions. This should involve both short- and long-term adaptation measures that target production systems and value chains key to food security and livelihoods.

Necessary adaptation interventions include market-based mechanisms and policy-driven economic incentives to encourage the uptake of adaptation best practices. Implementation may also require policy dialogue aimed at the institutional reforms and new governance structures that are necessary to achieve climate adaptation and sustainability. There is an urgent need to implement adaptation measures that can help farmers reduce their vulnerability and cope with the adverse consequences of climate change in the short- and long-term future. More sophisticated management of the public and private funds aimed at agricultural development would facilitate the functioning established institutions, which currently lack the resources to effectively deliver services.

To complement on-farm adaptation services, off-farm activities such as early warning and extension services should be enhanced. Other initiatives include enhancing agricultural mechanization, increasing access to agricultural insurance services, promoting horticulture, increasing crop productivity with subsidized farm inputs, and insurance schemes. Investments in basic public services such as providing potable water, improving road infrastructure, extending electric grids, and providing education can help reduce poverty among farmers. Reduced poverty can allow farmers to invest in activities that secure their livelihoods and give them the means to adequately use agricultural inputs (fertilisers, seeds, vaccines, irrigation equipment, etc.) to increase productivity and incomes. Extension services on modern technology, innovation, and management practices; value addition; and formal markets should be made available to enhance production and improve livelihoods.

Adaptation programs will require the involvement of multiple stakeholders, including policymakers, extension agents, non-governmental organizations, researchers, merchants, financial institutions, and farmers. Extension services are critical for disseminating and sharing knowledge among farmers to promote household food security and income. Currently, a limited number of motor vehicles, poor road networks, curtails the provision of adequate extension services and insufficient staffing. Commercialized agriculture with greater value addition remains a key objective; improving agricultural productivity and value addition is an effective way to enhance food security, employment creation, and income generation. The county should provide adequate support to the livestock sector by helping livestock keepers form cooperative groups to strengthen their participation in the market. Establishing farmers' associations, marketing groups, and cooperatives to pool resources will enable farmers to set their own prices, sustainably manage their production levels, and improve on transportation systems.

The county needs to build the capacity of producer organizations to use good management practices; it also must improve the handling of products, targeting different market segments achieve premium value for. Producers also need to become more profit- and business-oriented, with stronger negotiating capacity to improve their access to farming inputs, technologies, agricultural services (including extension and finance), and markets. This will improve their ability to plan, implement, manage, and monitor community-level micro-projects.

A review of existing legislation is essential for the creation of an enabling environment for climate resilience. This review will reflect the current challenges and opportunities identified at local level. Potential benefits will accrue vertically through shared information and horizontally by facilitating long-term mechanisms for capacity building and knowledge sharing among key stakeholders and policy makers. Creating a policy, regulatory, and institutional framework that will improve technical and technological interventions in the pastoral meat trade subsector and market is essential. Attention should be paid to improving natural resource governance; enhancing access to markets (through infrastructure, providing appropriate credit facilities, livestock insurance, and cash-or asset-based assistance); and provision of basic services like education.

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10. Annexes

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 circumstances 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).

Drought: a prolonged period of abnormally low rainfall leading to a potentially disastrous shortages of water.

Dry spell: a short period of low rainfall, usually not more than a month.

Heat Stress: physiological stress experienced as a result of excessive heat.

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)

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