Kenya County Climate Risk Profile: Kisii County

Highlights

- The agricultural sector plays a key role in the socioeconomic development of Kisii County (Figure 1). It contributes 60% of the county's gross domestic product (GDP) and provides a source of livelihood, including food and household income, to over 70% of its population.

- Despite the significance of agriculture in Kisii County, food insecurity is still rampant: 70% of households suffer from it, 71% of the population is undernourished, and 7% of children are wasted.

- Kisii County has recently experienced climate change, such as unpredictable rainfall patterns, untimely onset and cessation of seasonal rainfall, frequent and prolonged dry spells, increased daytime temperatures, extreme rainfall events, and the disappearance of natural water sources.

- Dry spells, extreme rainfall, moisture stress, and heat stress are the climatic hazards in Kisii County that most affect the key agricultural value chain commodities under consideration.

- Reliance on rain-fed agriculture increases the vulnerability of smallholder farming systems to the impacts of climate change, thus subjecting rural households to ongoing food insecurity, poverty, and malnutrition.

- In response to the changing climate, farmers have taken up adaptation strategies for both crop and livestock production. Several organizations support farmers through off-farm interventions and services.

- Impediments to effective climate change adaptation and mitigation in Kisii County include inadequate funding, a lack of policy and governance structures, insufficient human resource capacity, limited political will, and poor collaboration among relevant stakeholders.

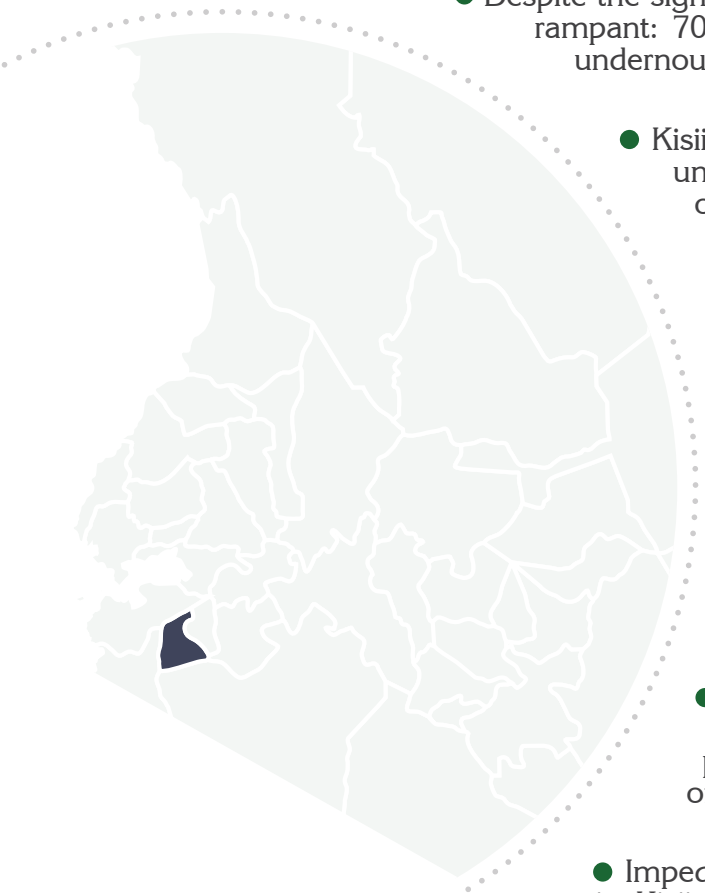

Figure 1: Map of Kisii County

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List of Acronyms

AEZs	Agroecological zones
AR5	Fifth Assessment Report
ASALs	Arid and Semi-Arid Lands
ASDS	Agriculture Sector Development Strategy
ASDSP	Agriculture Sector Development Support Program
CA	Conservation Agriculture
CCCF	County Climate Change Fund
CDD	Consecutive dry days
CIAT	International Centre for Tropical Agriculture
CIDP	County Integrated Development Plan
CIGs	Common Interest Groups
CMIP5	Fifth stage of the Coupled Model Intercomparison Project
CSA	Climate-smart agriculture
FYM	Farmyard manure
GAPs	Good agricultural practices
GDP	Gross domestic product
GoK	Government of Kenya
IPCC	Intergovernmental Panel on Climate Change
KALRO	Kenya Agricultural and Livestock Research Organization
KDB	Kenya Dairy Board
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
Ksh	Kenyan shillings
LGP	Length of the growing season
masl	Meters above sea level
NARIGP	National Agricultural and Rural Inclusive Growth Project
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy

Kisii

NT35	Total number of days with maximum temperatures greater than or equal to 35°C
P5D	Maximum 5-day running average precipitation
PRB	Population Reference Bureau
PSP	Participatory scenario planning
RCP	Representative Concentration Pathway
SACCO	Savings and Credit Cooperative Societies
USAID	United States Agency for International Development
VCCs	Value chain commodities

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.

Prof. Hamadi I. Boga, PhD, CBS

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 Kenya 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 socioeconomic activities of millions of households at risk.

The Kenya Vision 2030 is a national blueprint that seeks to transform Kenya by 2030 into a newly middle-income country that provides a high quality of life to all its citizens in a clean and secure environment. The agricultural sector is a key contributor to the projected annual national economic growth, but it has been constrained by inadequate access to quality inputs, marketing inefficiencies, a non-conducive investment environment, declining soil fertility, low mechanization, land fragmentation, and most 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. In 2012, the National Climate Change Action Plan (NCCAP) provided a means to implement the NCCRS and highlighted agricultural adaptation priorities. These initiatives are focused on the national level, and 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's objective is to increase the 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 about the current climate and possible future climate scenarios, to pinpoint 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 and 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.

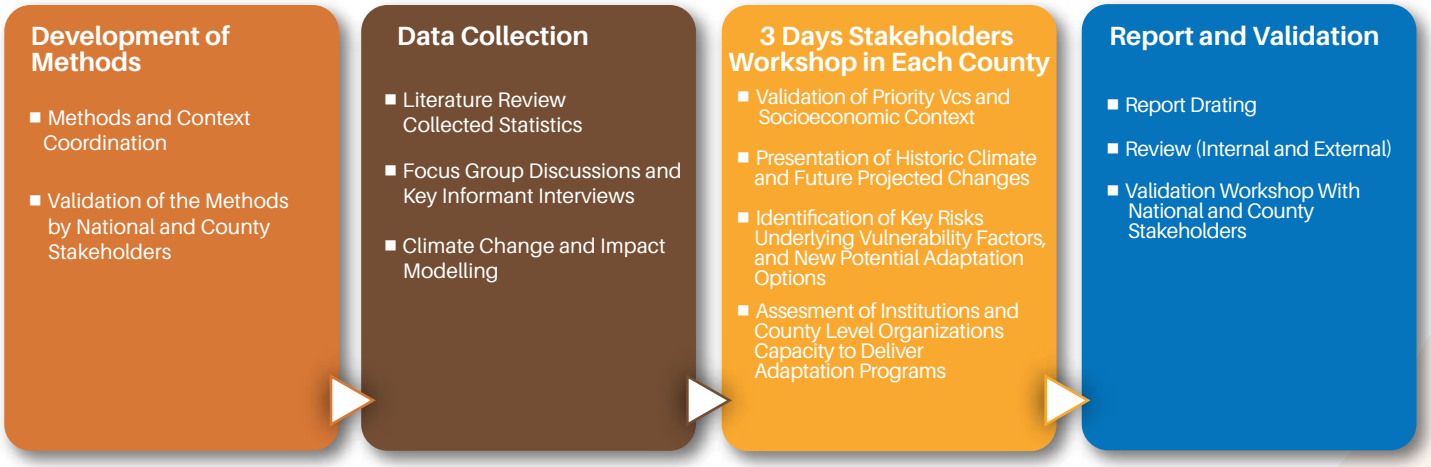

Figure 2: Stages in developing a climate risk profile

This document presents the climate risk profile for Kisii County. It is organized into six main sections, each reflecting an essential analytical step towards understanding current and potential adaptation options for important local agricultural value chain commodities. The document first offers an overview of the agricultural commodities key to food security and livelihoods in Kisii County, and then lists major challenges to agricultural sector development in Kisii. In the second section, it identifies major 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 Third, the report analyzes the vulnerabilities and risks these climactic hazards create within the identified value chains. Based on these vulnerabilities, the fourth section discusses current and potential on-farm adaptation options and off-farm services. In the fifth section, the report provides snapshots of the enabling policy, institutional, and governance contexts for the adoption of resilience-building strategies. Finally, the sixth section presents pathways for strengthening institutional capacity to address climate risks.

2. County Context

Kisii County is located southeast of Lake Victoria, and it borders Nyamira to the northeast, Narok to the south, and Homabay and Migori Counties to the west. It lies between the latitude 0o40' 38.4" South and the longitude 34° 34'46° 61" East. Kisii is endowed with a rich diversity of natural resources, including forest areas like Nyangweta, Ritumbe, Ntamocha, Sameta, and Mborogo; fertile agricultural soils; mineral deposits such as soapstone, granite, and ballast; and numerous permanent water sources including springs, waterfalls, and the rivers Gucha, Nyakomisaro, Riana, Mogusii, Mogonga, Chirichiro, and Lyabe.

The topography of the county is hilly, with several ridges and valleys. Kisii County encompasses three main topographical zones. The first zone—primarily located on the western boundary—covers areas lying below 1,500 meters above sea level (masl) and includes parts of Suneka, Marani, and Nyamarambe Divisions. The second zone covers areas lying between 1,500 -1,800 masl and is located in the western parts of Keumbu and Sameta Divisions, Eastern Marani, and the Gucha River basin. The third zone covers areas lying above 1,800 masl in parts of eastern and southern Keumbu, Masaba, and Mosocho Divisions.

2.1 Economic Relevance of Farming

Agriculture is crucial to the socioeconomic development of Kisii County (County Government of Kisii, 2018). The sector is key for realizing food and nutrition security, reducing poverty, and creating employment. Agriculture employs about 80% of the labor force and contributes 60% of Kisii County's gross domestic product (GDP). In 2019, the county received approximately Kenyan shillings (KSh) 4 billion in revenue from livestock and KSh 7 million from crop enterprises (GOK, 2020). The reason for the variability in incomes from crops and livestock could be due to the increasing inconsistency in rainfall patterns coupled with land fragmentation, infertile land and less use of agricultural inputs resulting to decreasing crop yield thus affecting household's crop incomes negatively and significantly. On the other hand, owing to the small land sizes, farmers are continually adopting intensive livestock production systems, which coupled with increasing demand for livestock products owing from increasing population especially in the urban areas has increased incomes from livestock products. In the livestock sector, the highest contribution came from dairy milk (51%), whereas in the crops sector, maize (54%), beans (30%), and bananas (16%) were responsible for major shares of the GDP.

The agriculture sector, particularly crop cultivation, plays a significant role in the provision of household income. On-farm income earns households an average of Kshs 39,511 per year with crop sources contributing 61%, livestock contributing 14%, and 25% from other sources (ASDSP, 2014). The on-farm activities contribute 38% of the income for male-headed households compared to 37% and 24% contribution for incomes for female-headed households and youth-headed households respectively.

2.2 People and Livelihoods

According to the most recent housing and population census, Kisii County has a population of 1,266,860 with male and female populations comprising 49% and 51% of the total, respectively. The population density is 958 people per km^2. The population is divided into 308,054 households with an average size of 4.1 persons (KNBS, 2019). The total rural population was estimated at 1,115,450 persons, or almost 90% of the total population (Figure 3).

The age dependency ratio compares economically productive individuals aged 15-64 to dependents under 15 or over 65 years of age. At about 85%, Kisii County's age dependency ratio is among the highest in Kenya, above the national average of approximately 82%. The absolute poverty rate in the county is estimated to be 45%, higher than the national absolute poverty rate of 32% (KNBS, 2016). Contrarily 51% of the population live below the poverty line (US$ 1.90 a day).

The percentage of households with access to electricity for lighting is about 30%, and only about 1% of households have electricity for cooking, while 21% have access to potable water (County Government of Kisii, 2018).

Most households in Kisii depend on agriculture as a direct or indirect source of income, food, and employment. The agricultural sector also enhances the development of agro-based industries through provision of raw materials. About 46% of adults are engaged in crop and/or livestock farming, compared to 21% who have formal salaried employment as public servants, private-sector employees, non-farming laborers, and domestic workers; 20% who are self-employed in business and trade in agriculture-related activities; 1% who work as farm laborers; 2% who depend on a pension scheme; and 10% who rely on other occupations (ASDSP, 2014). Most of the farmers in Kisii County practice subsistence farming due to small plot sizes.

Almost 45% of households in Kisii County suffer from food poverty, 71% of the population is undernourished, and 7% of children are wasted (KNBS, 2016; GOK, 2014) (Figure 3). The reason for a higher percentage of undernourished could be because food poverty is associated with inadequate food intake, reduced consumption of calories, and lower dietary quality and diversity (Siddiqui et al., 2020). Some of the indicators used to determine food and nutrition security include food production, post-harvest losses, household size, food availability in terms of the number of meals per day, and seasonality in the food supply (ASDSP, 2014). On average, individual members of the household, regardless of age or gender, eat three meals on a normal day during the peak food availability season. On the other hand, during periods of low food availability, only children get three meals, while other household members take only two meals per day. The overall proportion of households that do not have enough food to meet their dietary needs is 58%. At least 60% of adult male-headed households, 62% of adult female-headed households, and 54% of youth-headed households do not have enough food to meet their needs (ASDSP, 2014). Seasonality in food production also influences food and nutrition security. There is one distinct peak of food availability in Kisii County from March–June; 70% of households recorded food security in May. The food deficit months are August–December, during which the male-headed households were found to be fair in terms of food availability compared to other households.

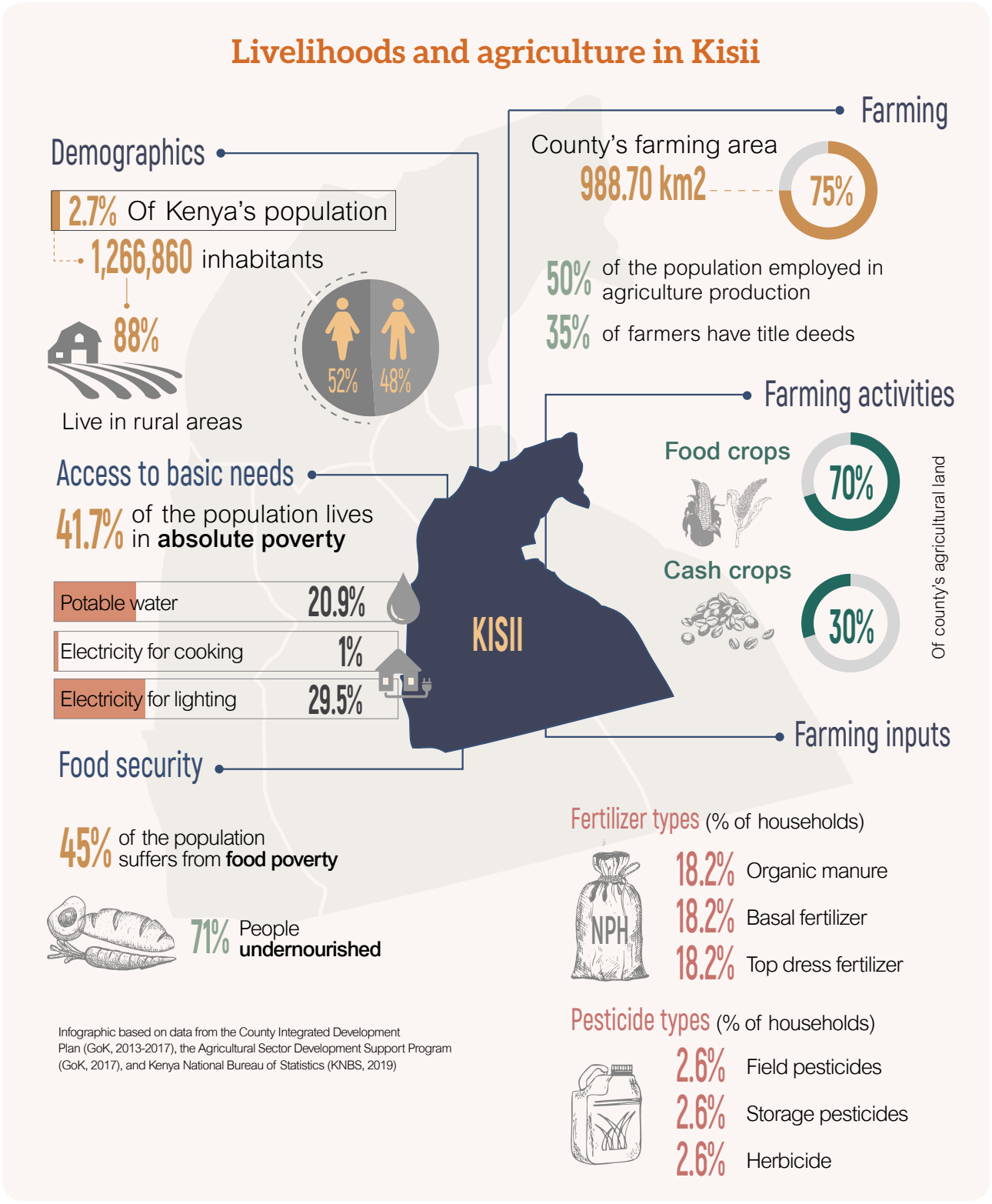

Figure 3: Agriculture and livelihoods in Kisii County

2.3 Agricultural Activities

As indicated above, the great majority of the people in Kisii County are dedicated to agriculture, dividing their activities between crop production, livestock rearing, and fishing. The county has a total land size of about 1,318 km^2, of which approximately 78% (989 km^2) is arable land, most of which is used for agriculture. Land that is not arable covers about 329 km^2; almost 19 km^2 are water mass, and 137 km^2 are urban area (GOK, 2013). The average farm size is 1.6 ha overall; disaggregated by head of household, there are disparities, with male-headed households averaging 1.9 ha, female-headed households averaging 1.5 ha, and youth-headed households averaging 0.9 ha (ASDSP, 2014). Approximately 17,800 ha are under cash crops, and the area under food crops is about 72,500 ha.

Kisii County is divided into three agroecological zones (AEZs) in terms of agricultural potential (Figure 4).

- The lower highland AEZ, the tea and pyrethrum zone, includes the lower highland humid (LH_1) and the lower highland sub-humid (LH_2) zones. The two zones encompass areas lying above 1800 masl. They constitute around 20% of the total land area and cover regions of eastern Nyaribari Masaba and southern Nyaribari Chache. Suitable agricultural enterprises in these regions include cultivating coffee, tea, bananas, cereals, Irish potatoes, and pyrethrum.

- The upper midland humid (UM_1) AEZ, referred as the coffee and tea zone, lies between 1500 masl and 1800masl. It is located in the western parts of Nyaribari Chache, Bonchari, Upper Bobasi, Bomachoge Borabu, Bomachoge Chache, Lower Bobasi, Kitutu Chache North, and South Mugirango. The zone is mainly suitable for growing coffee, tea, bananas, fruits, cereals, and Irish potatoes.

- The lower midland AEZ comprises the lower midland humid (LM_1) zone, also known as the sugarcane zone, and the lower midland sub-humid (LM_2) zone, or the marginal sugarcane zone. These zones lie between 1000 masl and 1,500 masl. They are located on the western boundary of Kisii County and include parts of Bonchari, Bomachoge Chache, Lower Bobasi, and South Mugirango. This zone is suitable for the production of bananas, fruits, cereals, and sugarcane.

Over 135,000 households in Kisii County have land holdings for mixed farming. Most farming households occupy land holdings that are less than 10 ha, generally ranging from 0.2 ha to 2.1 ha (ASDSP, 2014). The increasing population growth rate drives the rampant land fragmentation that leads to small-sized land holdings. These small plots are not economical and

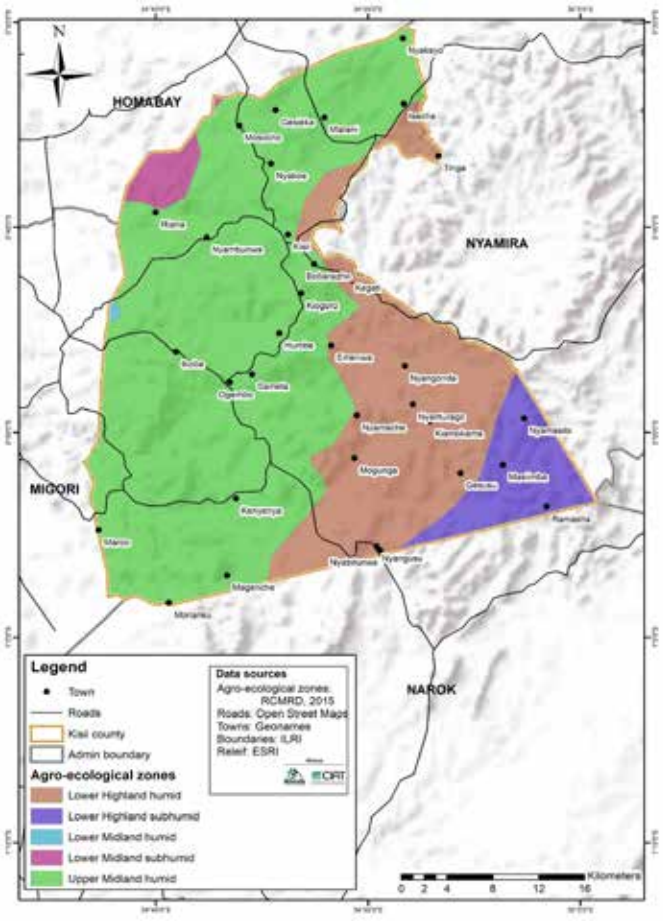

Figure 4: A map of agroecological zones in Kisii County

cannot sustain the use of modern farming technology. This situation has serious implications for food security in Kisii County; measures such as policies on land use and intensification could be implemented to mitigate this problem. Only about 35% of the farmers within the county have title deeds to land (County Government of Kisii, 2018). This fact severely constrains land planning and development, since only a small percentage of the population can access loans for development purposes. About 60% of households reside on ancestral lands without formal rights; cases of landlessness are limited due to strong family and community ties that regulate land-use rights (ASDSP, 2014).

The main food crops in Kisii County include maize, beans, bananas, sweet potatoes, sorghum, finger millet, avocadoes, passion fruits, cabbage, kale, groundnuts, and indigenous vegetables. Coffee, tea, pyrethrum, and sugarcane are grown as cash crops. The primary livestock are dairy and beef cattle, indigenous chickens, and goats; tilapia and catfish are also reared.

The agricultural system in Kisii County is predominantly intensive, small-scale, mixed agriculture with very little mechanization (Kiprop et al., 2015). Ploughs are the most widely used equipment by 43% of farmers; draft power animals and ox and donkey carts are also common at 29% each (ASDSP, 2014). Farmers

depend on inputs such as fertilizer for improved productivity, yet utilization of inputs such as fertilizer, certified seed, and pesticides is still quite low (Kiprop et al.,2015). The three major inputs used are basal fertilizer by 56% of farmers, top-dress fertilizer by 33%, and organic manure by 18%. Pesticides are used less with field pesticides at 2.6%, storage pesticides at about 15%, and herbicides at 2.9%; irrigation farming is only practiced by 0.8% of the farmers in Kisii County (ASDSP, 2014).

2.4 Agricultural Value Chain Commodities

Among the diversity of commodities grown in Kisii County, several are prioritized by the County Integrated Development Plan (CIDP), development programs such as the NARIGP, 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 agricultural value chain commodities (VCCs) in Kisii County was compiled using the following prioritization indicators: productivity characteristics, including harvested area, production, and production variations in the past five years; economic value (K Sh); and nutrition characteristics like dietary energy consumption (Kcal/capita/day) and protein, iron, zinc, and vitamin A content. The team presented this list to stakeholders during a three-day workshop for in-depth analysis and selection. We further honed the selection using a set of criteria which were first determined with the stakeholders. The criteria were resilience to current and future climate change impacts, on a scale from low to high; the percentage of population involved in the value chain (%); and involvement in the value chain of economically and socially vulnerable groups such as poor people, women, and youths, again measured on a scale from low to high. First, we assessed each value chain against each criterion. Then, we selected the value chains that involved the highest percentage of the population and engaged poor people, women, and youths. The four VCCs chosen for this report are dairy cows, indigenous chickens, bananas, and indigenous vegetables.

2.4.1 Dairy

Dairy is an important value chain in Kisii County, engaging 41-60% of the population. Small land size and high investment costs limit the involvement of more households in the value chain. In the production and input supply stages, the dairy value chain is composed of small-, medium-, and large-scale actors, but the post-harvest and marketing stages are comprised of only small-scale actors. The dairy cattle kept include local cows such as Zebu; exotic cattle such as Friesian, Ayrshire, and Guernsey; and crossbred cows. Most exotic cattle are owned by male-headed households, while female-headed households primarily own local breeds (ASDSP, 2014). The number of dairy cattle in the county in 2018 was 54,300 and in 2019, 55,416. Exotic heifers produce an average of 9.3 L of milk per cow per day during the dry season and 10.2 L/cow/day during the wet season. On the other hand, local heifers produce 4.0 L/cow/day in the dry season and 4.5 L/cow/day in the wet season, while crossbred heifers produce 5.8L/cow/day during the dry season and 5.9L/cow/day in the wet season (ASDSP, 2014).

Women, who are highly involved in the input supply, post-production, and marketing stages, dominate the value chain. Conversely, men are most involved in the input supply stage. Youths are moderately involved at all stages of the value chain. Exotic cattle have the highest milk production generally, and exotic cattle from male-headed households have the highest production of all (ASDSP, 2014). This could be because men have better access to extension, veterinary, and credit services as well as higher utilization rates for livestock inputs like artificial insemination services, dipping, and climate data (ASDSP, 2014). Policy changes could help alleviate production constraints and augment access to services for women and youths.

Land scarcity is a major challenge for the dairy value chain in Kisii County; this fact underscores the need to promote intensive, modern methods of livestock production like zero grazing, which requires smaller plots. Zero grazing supports resource use efficiency by using feeds and fodder to increase milk productivity and balance the competing needs of crop and livestock production. Land scarcity further limits farmers whose small holdings prevent them from growing their own fodder, forcing them to purchase fodder instead. Limited financial resources and feed shortages also hinder effective dairy farming in Kisii County. Conversely, increased demand for zero grazing units creates business opportunities for commercial feed and fodder production among individual farmers, farmers' groups, and investors. Farmers could be empowered for fodder production and management and shown how to carry out better post-harvest management to reduce losses. Subsidies for certified fodder seed and other costly inputs could help make them affordable for farmers. The low quality of some inputs, such as acaricides to control blue ticks, calls for proper regulation and quality assurance from the county government.

2.4.2 Indigenous Chickens

Another important value chain in Kisii County, a major source of livelihoods, centers on indigenous chickens. Approximately 81-100% of the population is involved, with nearly every household engaging in the enterprise. Indigenous chickens are preferred, since they can tolerate harsh climatic conditions and have lower production costs compared to exotic breeds. Chickens are kept for meat and eggs, most of which are bound for the local market. In 2017, there were 1,406,630 indigenous chickens in Kisii County

(County Government of Kisii, 2018), which produced 652,153 eggs valued atKSh 4.53 million (GOK, 2013). Input suppliers are small-scale actors, while farmers, processors, wholesalers, and retailers are involved at the medium scale. Most farmers practice production at a small scale due to inadequate financial resources and constrained market access. Processors' involvement is also small-scale due to inadequate skills and a lack of capacity building, storage, and processing facilities. Processors' low rate of involvement translates to low value addition, which is limited to de-feathering, differentiation of parts, and boiling (ASDSP, 2014).

Women, who are highly involved in the on-farm production, post-production, and marketing stages, dominate the value chain. Adult females predominantly make production decisions about chicken (ASDSP, 2014). On the other hand, men are highly engaged in the input supply stage, with medium involvement at the on-farm production, post-production, and marketing stages. The involvement of youths is high during the on-farm production stage, medium at the post-production and marketing stages, and low at the input supply stage. The high involvement of youths in the on-farm production stage also corroborates findings by the government which showed that in 2013, youth-headed households registered the highest number of eggs sold at 2,846, compared to sales from both male and female-headed households at 735 and 64, respectively (ASDSP, 2014). Despite women's significant involvement in the value chain, their underrepresentation in selling eggs may be due to utilizing their eggs for other purposes such as household consumption and brooding. Male-headed households are more likely to own improved indigenous chicken breeds due to their increased financial capacity to buy them (ASDSP, 2014).

2.4.3 Bananas

The banana (Musa species) value chain is vital in Kisii County, engaging 81-100% of the population. Bananas are produced both for subsistence and for commercial purposes. They grow well in hot and humid areas from 0-1800 masl. Bananas require rainfall of at least 1000 mm per year, and to achieve good yields they should receive 200-220 mm of water per month. The optimum temperature for growth is 28°-38°C. Below 13°C, plant growth is retarded, and chilling injuries occur. The plants tolerate a soil pH of 4.5-7.5, although their optimum pH is between 6 and 7.5 (Mbwana et al., 1998). Good climatic conditions favor production of bananas in Kisii County.

Input supply, production, and marketing occur at all scales, but processing only takes place at a small scale. Men are significantly involved in all the stages of the value chain with a higher rate in the production and marketing stages. Women are also involved in all stages of the value chain, particularly at the post-harvest stage. Youths are highly engaged at the post-harvest stage as well, while their involvement was rated as medium at all the other stages. Despite the involvement of women and youths in the banana value chain, men remain the key decision-makers, possibly due to expected returns and sociocultural factors including their control of land use (ASDSP, 2014). Even though youth-headed households have the lowest preference for banana as their priority crop, their productivity was higher at 486 kg/ha than male- and female-headed households at 532 and 633 kg/acre, respectively (ASDSP, 2014).

There are small-, medium-, and large-scale input suppliers. Tissue culture plantlet suppliers include Bokimonge nursery suppliers at the small scale, Aberdare Technologies Limited at the medium scale, and Agro Plant Technology nursery, a large-scale supplier. To reduce post-harvest losses and fetch higher market prices, value addition through agro-processing is gaining popularity. In Kisii County, processed banana products include crisps and wine marketed by Nyangorora Banana Processors, flour marketed by Kenyuni women's group, and jam marketed by Famco Agencies Ltd.

The marketing system for bananas and associated products is suboptimal, however, due to a lack of policy and weak market linkages. Middlemen have been able to exploit farmers by offering very low prices for bananas. Poor infrastructure, including unimproved roads and insufficient collection sheds and storage facilities, greatly reduces the quality of produce, leading to post-harvest losses and spoilage. Smallholder farmers could be sensitized to the importance of producer marketing associations and collective marketing. The county government could put policies in place to increase the provision of agricultural extension and business development services and enhance access to information for transparency in banana marketing. The linkages between farmer groups and micro-finance institutions could be strengthened, and improving the terms of credit could make credit facilities affordable.

2.4.4 Indigenous Vegetables: African Nightshade and Spider Plant

Indigenous vegetables have recently gained popularity in Kisii County as crops that provide food and nutritional security and household incomes. This value chain engages 81-100% of the population; almost every household grows at least some local vegetables for their own consumption (Figure 4). The most popular local vegetables are African nightshade (*Solanum nigrum*) and spider plant (*Cleome gynandra*). Land size limits the level of production: small-scale farming happens across the county on farms of 10 m2 to ¼ acre with harvests of up to ten sacks; medium-scale farming occurs in Marani and Itumbe on ¼-½ acre farms that yield 10-25 sacks; and large-scale farming takes place in the Marani and Magena areas, on farms ½-1 acre in size, producing 25-60 sacks. Each sack has a capacity of 50Kg and sells for Kshs 600.

Proper selection and use of manure and fertilizer—a process that occupies farmers, agricultural extension officers, and researchers—were reported to be a key determinant of production level and quality.

Women are deeply involved across the value chain stages, while youth involvement is very high at the on-farm production, post-harvest, and marketing stages, and medium during input supply. Male engagement at the input supply stage was rated as low for seeds but high for fertilizers and pesticides; their involvement in the other stages was rated low.

Input suppliers in this value chain are both small- and medium-scale: agrovets such as Josemo, Enochem, and the Kenya Farmers Association are involved in seed and fertilizer supply at the medium scale; local market traders are involved in seed supply at the small scale; and farmers take part in local, small-scale, on-farm seed multiplication. Processing happens at a small scale. Processors like Sunshine in Itumbe engage in solar drying of vegetables. Hawkers and retail traders market produce at the small scale, while large-scale marketing takes place through brokers, individuals, and cooperatives like Kitutu Chache North Local Vegetables Cooperative.

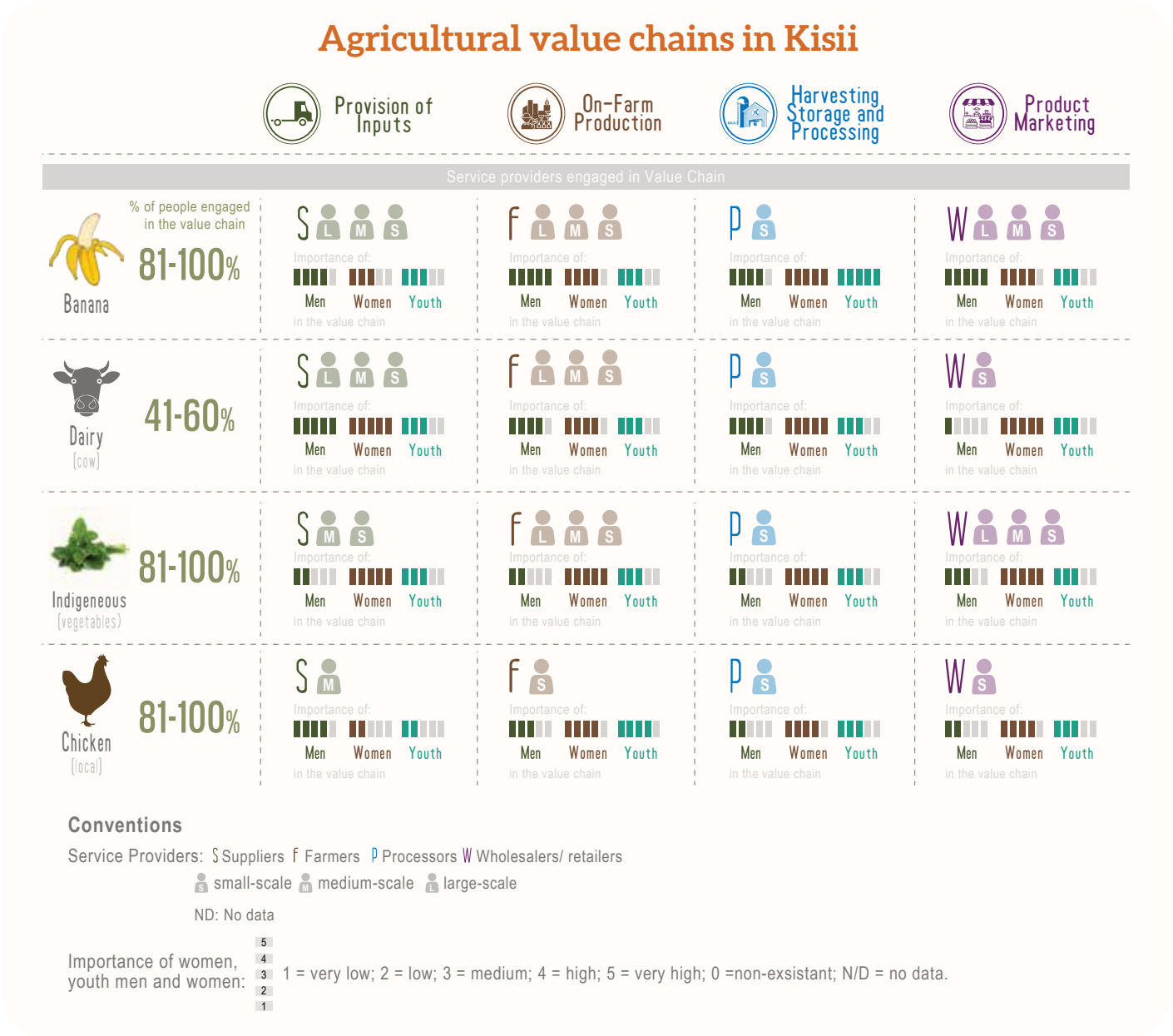

Figure 5: Characterization of the selected agricultural value chains in Kisii County

2.5 Agricultural Sector Challenges

Despite its key role in Kisii County's economy, the agricultural sector is dogged by many challenges such as high population levels, climate change, poor infrastructure, limited financial and human resource capital and low usage of right farm inputs. High population density has led to increased pressure on land and land fragmentation; small plot sizes are not economically viable and cannot sustain the use of modern and improved agricultural practices, ultimately leading to reduced productivity. The ongoing division of agricultural land reduces its capacity for food production and cash crop farming. This situation has serious implications for Kisii County's food security, income sources, and wealth creation, and has exacerbated poverty levels. Policies on land use could ameliorate the effects of fragmentation, and farmers could be trained in intensification and modern farming methods, like zero grazing, that have lower land requirements (County Government of Kisii, 2018; Kiprop et al., 2015).

Increased settlement and the rising demand for agricultural land have led to deforestation, the loss of biodiversity, and soil degradation. These impacts, compounded with poor farming methods, low usage of proper farm inputs, and improper use of inputs, especially of inorganic fertilizers, have depleted soil fertility and reduced crop productivity (County Government of Kisii, 2018). Agricultural input use may be low for a variety of reasons, such as high prices and insufficient financial capacity, distance from input markets, inaccessibility to inputs at the right time, and adulteration of inputs (ASDSP, 2014).

In the recent years, Kisii County has experienced changing weather patterns. Erratic and unpredictable rains have made it difficult to plan for agricultural production. Some of the visible changes associated with climate variability and change include moisture stress, extreme temperatures, limited rainfall, and increased frequency of extreme events such as floods and droughts (ASDSP, 2014). Climatic changes increase the vulnerability of rain-fed agriculture and make it difficult to maintain adequate production.

Few irrigation schemes exist in Kisii County, despite the potential offered by the many permanent rivers that traverse the county and the amount of rainfall that could be harvested for irrigation purposes. Instead, Kisii County depends mainly on rain-fed agriculture, and poor crop yields result in the importation of produce like kale, tomatoes, onions, and potatoes from counties that have embraced irrigation, like Nakuru, Narok, Bomet, and Nyandarua (County Government of Kisii, 2018). Poor farming methods, such as continuous cultivation and the planting of eucalyptus trees along all the rivers in Kisii County, has led to soil erosion, declining water tables, the drying of springs, wells, and rivers, and reduced water volumes. Declining water volumes lessen the potential for irrigation farming and water availability for domestic use (County Government of Kisii, 2018).

Poor rural infrastructure impedes the transportation of highly perishable agricultural produce to destined markets. This issue, combined with inadequate markets and marketing infrastructure and poorly organized and institutionalized marketing strategies, hinders the agricultural sector's growth in Kisii County. Poor organization among farmers also deprives them of bargaining power that could facilitate efficient marketing. As a result, farmers sell their produce individually and are thus exposed to exploitation by middlemen. Encouraging farmers to organize and form groups may facilitate their access to agricultural services and enable them to better market their produce.

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 like flash floods, droughts, moisture stress, heat stress, and the start and length of the growing seasons, in order to assess climate change and variability in Kisii County. The growing season was defined as follows: the first, 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 (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.[1]

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

[1]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 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 using the 5-day running average rainfall, indicative of floods, and the 95th percentile of daily precipitation, indicative of extremely high rainfall over a short period of time that can lead to events like flash floods. We calculated the 95th percentile of daily precipitation distribution, based on the 100 wettest days per season per year, for each pixel.

To assess the adequacy of rainfall and soil moisture to meet potential water requirements for agriculture, we focused on drought stress, represented by the number of consecutive days in each season when the ratio of actual to potential evapotranspiration falls below 0.5. We computed this number for each pixel per season per year by evaluating the soil's water capacity and evapotranspiration in order to define the number of days that met the requirements for drought stress.

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.[1]

3.1 Climate Change and Variability: Historic and Future Trends

Kisii County has historically seen monthly temperatures varying from 15-30°C with annual average temperature between 19°C and 25°C. The county has two growing seasons: a long rainy season from February to June and short rainy season between August and December. The long rainy season is usually wetter than the short rainy season. Kisii County experiences relative dry spells, defined as periods with less than 100 mm of rainfall, between the two rainy seasons, in January and February and in July. April and May receive the highest rainfall with more than 200 mm per month. The annual average precipitation in Kisii County is 1400-2000 mm. Its central region receives around 2000 mm annually (Figure 6 and 7).

The annual total rainfall trends did not show significant changes for the period 1985-2015 for the long rainy season. Annual total rainfall is however expected to decrease by 2040. The trends for the short rainy season show an increase of rainfall for the future (Figure 8). The annual mean temperature trends show an increase in the past which will continue in the future (Figure 9).

In the future, Kisii County will experience an overall increase in CDDs of 3 to 7 days, suggesting that drought incidence will become more common. Future climate projections indicate that in the first season, P5D will increase significantly across the county by 3 to 9 mm, with the northern and central regions experiencing more extreme rainfall events than the southern regions (Figure 7). Flooding and flash-flooding risks will remain lower, but still tend to rise considerably in future scenarios. Future climate projections indicate that NT35 will jump drastically in the western regions, suggesting extreme heat events in the first season (Figure 9). Thus, heat stress is projected to become an important hazard in the future, with up to 30 days of extremely hot temperatures in some years. A comparison of historical and future trends indicates that moisture stress is expected to increase in the first season by up to 10 days; conversely, the second season will see a slight increase in 95th percentile of daily precipitation of 4-7 mm implying the reduction of moisture stress days, mainly in the southeastern regions. Future climate projections suggest that the LGP of the first season will shrink, and the season will start earlier, while the short rainy season will see a delay of up to 2 months in the northern regions (Figure 8). Climate advisory services will become critical to inform farmers about the optimum planting windows and avoiding crop losses. Future climate projections indicate that the LGP of the long rainy season will drastically reduce throughout Kisii County, and the LGP of the short rainy season will also decline, especially in northern regions. A shortened LGP will have serious implications for farming, because the current crop varieties will not have sufficient time to meet plant growth requirements. As a result, production will drop precipitously. Shorter-duration varieties may help farmers adapt to these changes to some extent. Climate advisory services will also play an indispensable role in informing farmers about their earliest planting window.

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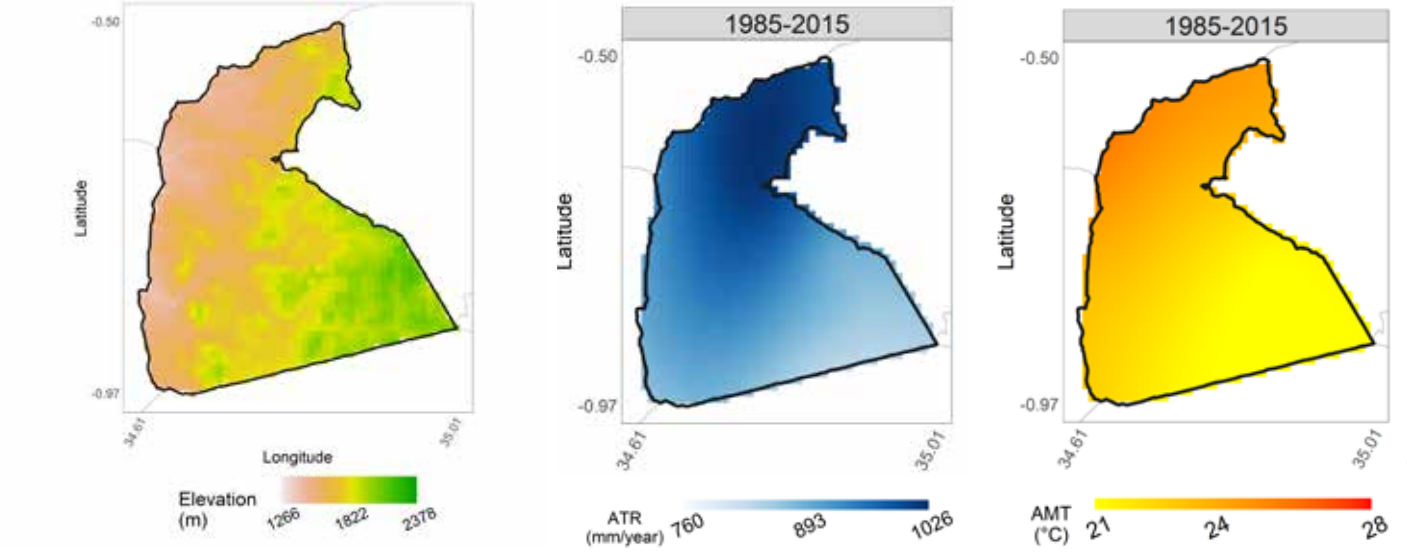

Figure 6: Elevation (left), historical annual mean precipitation in mm (center), and historical annual mean temperature in °C (right) for Kisii County for the long rainy season

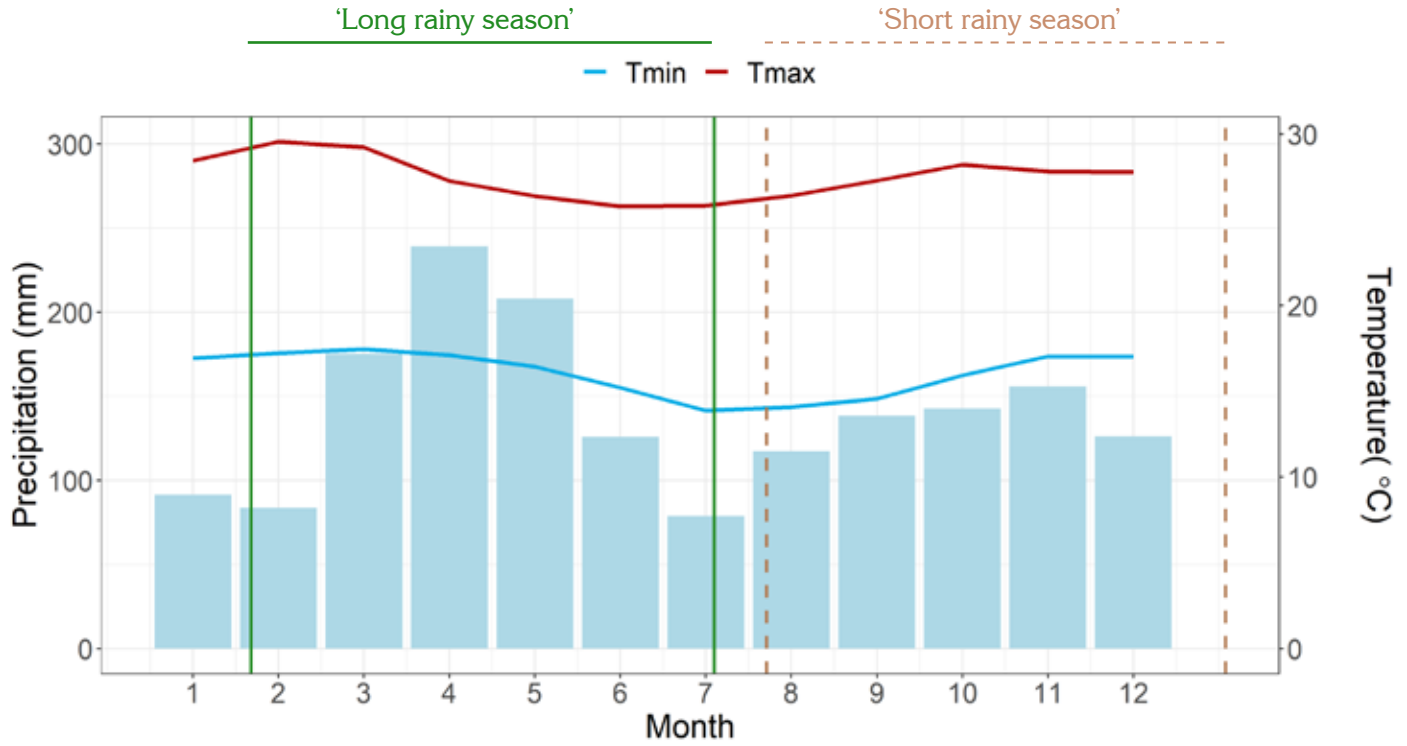

Figure 7: Average historical monthly mean temperatures and precipitation over the last 30 years for Kisii County. . The first long rainy season is the 100-day wettest period from January to June, while the second, the short rainy season is the 100-day wettest period from July to December. Bars represent total monthly precipitation, whereas the red and blue lines represent maximum and minimum monthly mean temperatures, respectively

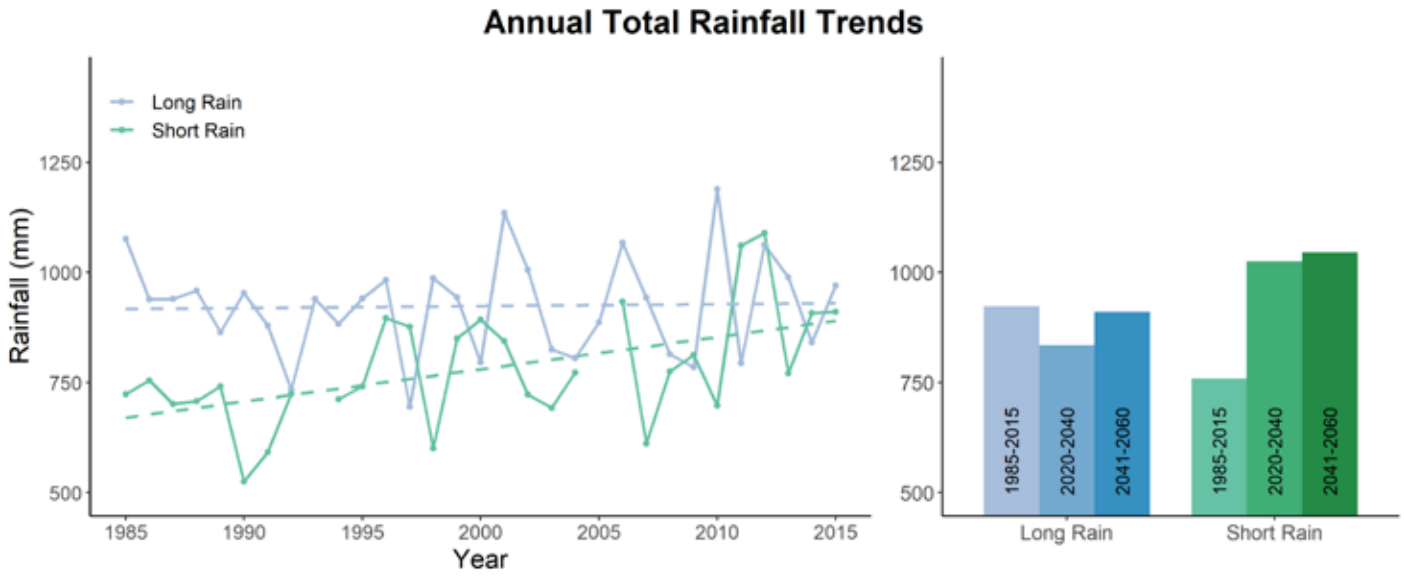

Figure 8: Annual total rainfall trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060)

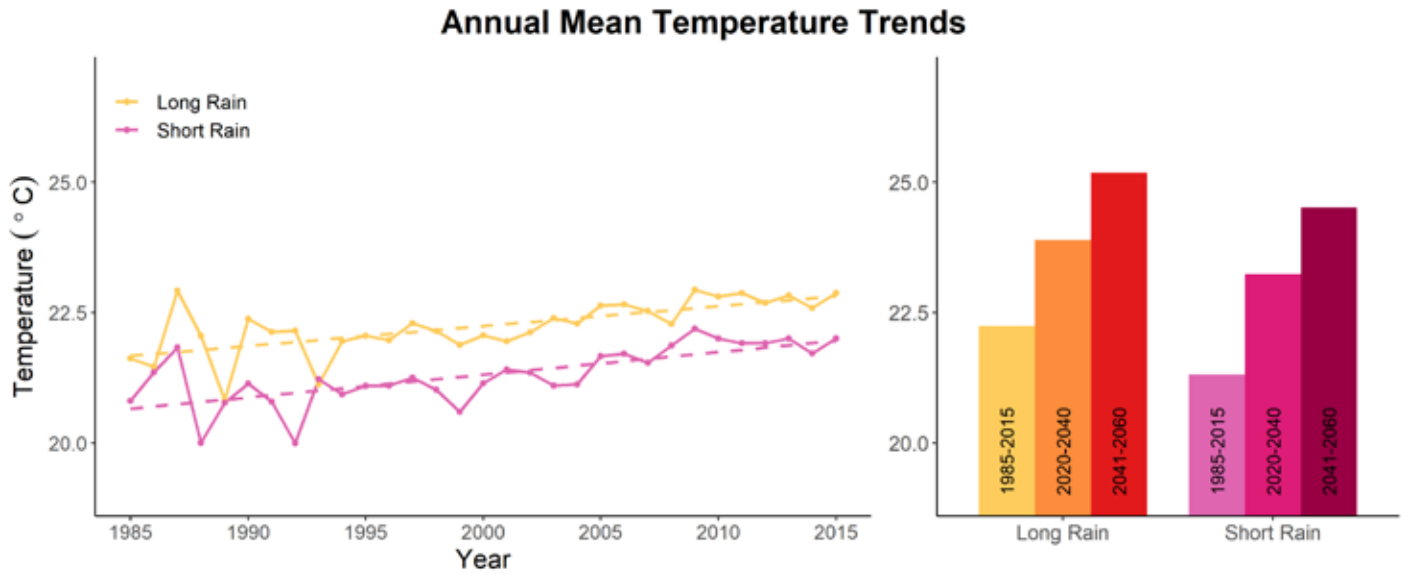

Figure 9: Annual mean temperature trends for the long rainy and short rainy seasons in the past (1985-2015) and in the future (2020-2040 and 2041-2060)

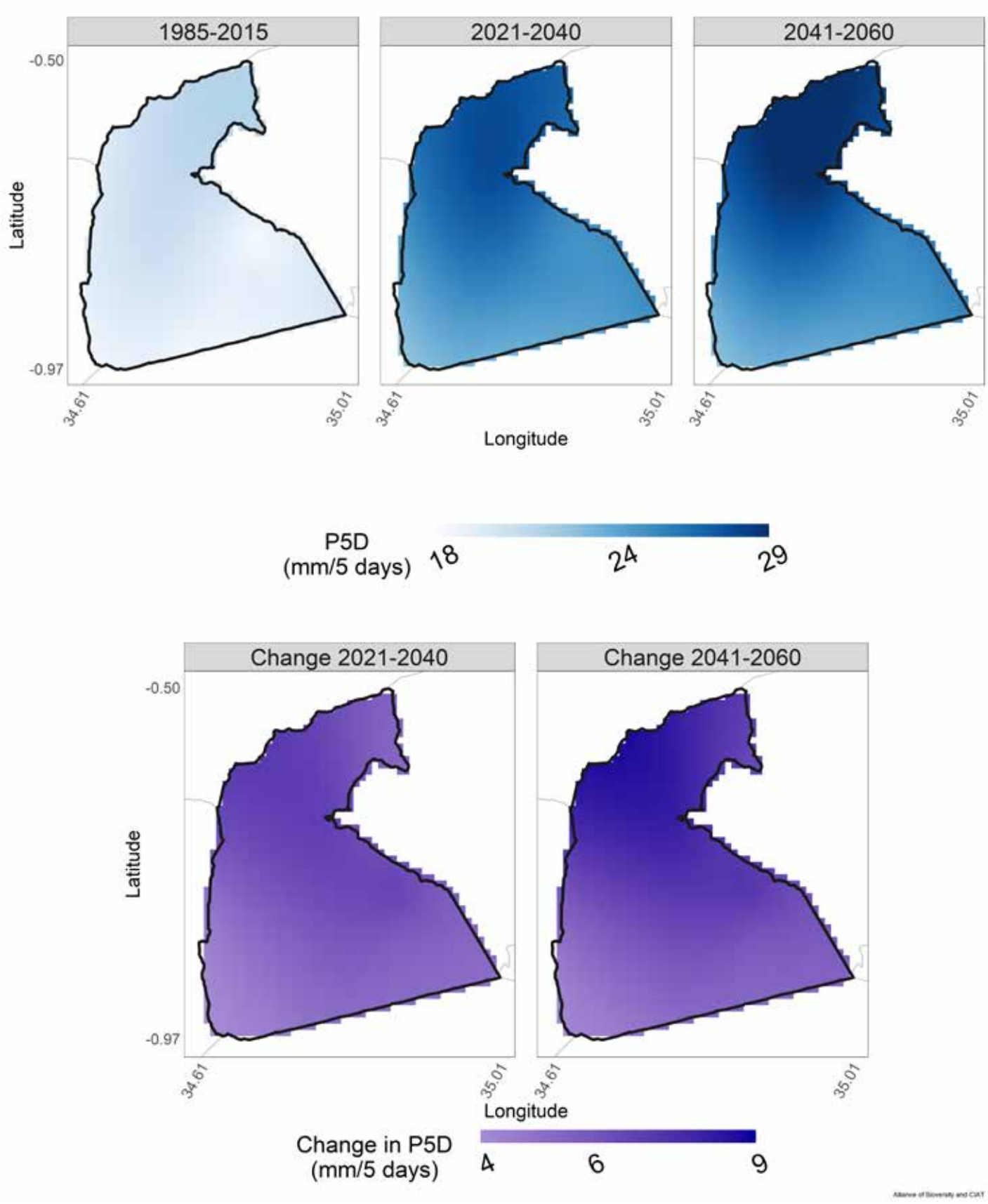

Figure 10: Maximum 5-day running average precipitation in mm for the long rainy season: historical values (left), future projected values (center), and projected change in values (right)

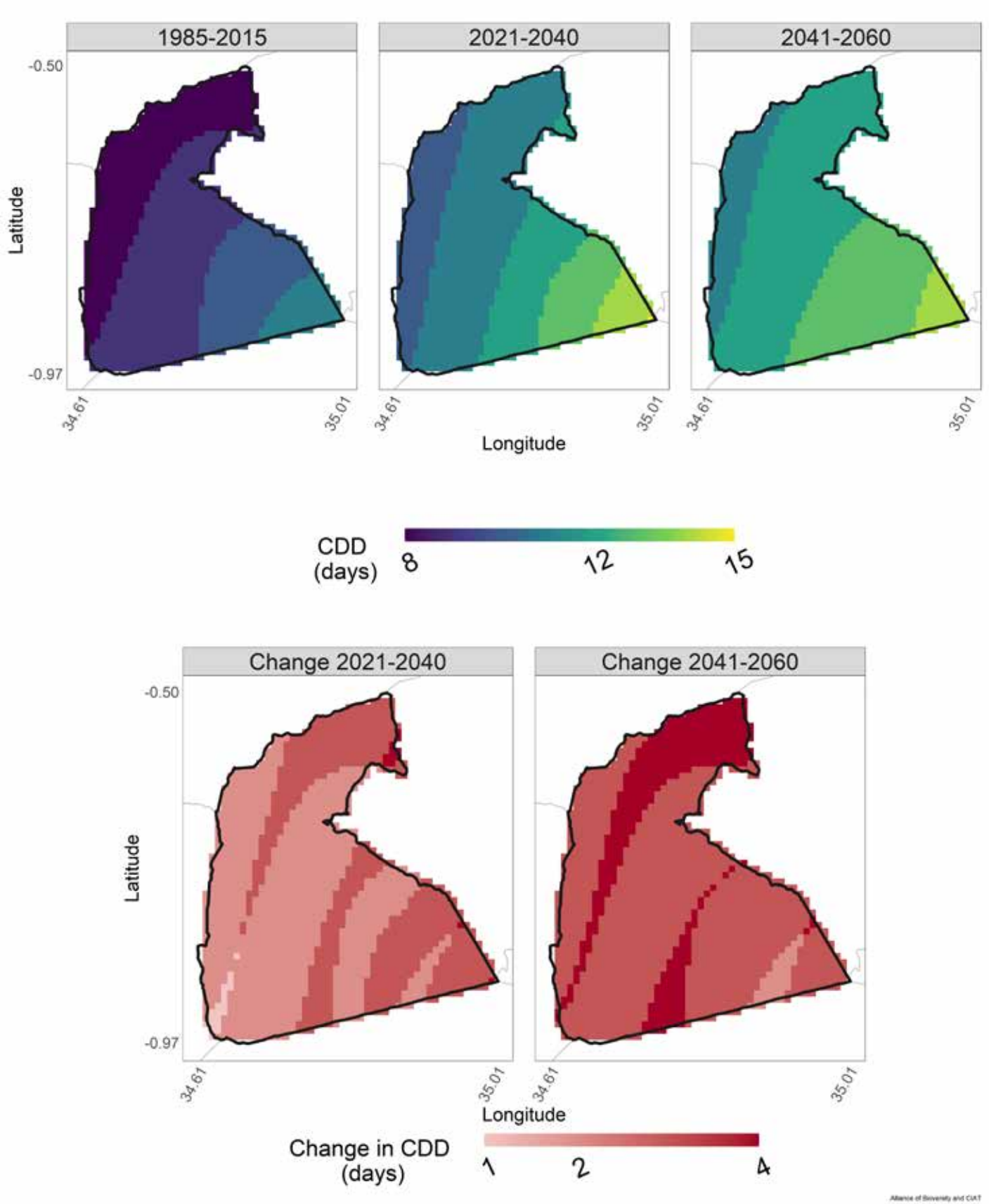

Figure 11: Average number of consecutive dry days for the long rainy season: historical values (left), future projected values (center), and projected change in values (right)

3.2 The Climate from Farmers´ Perspectives

During the stakeholder workshop most farmers agreed that they were aware of the changes in climate in their local setting. Farmers reported that rainfall patterns had become quite erratic, and they noted major shifts in seasonal rainfall. Farmers reported that the onset of both the long rains (February to June) and the short rains (August to December) had changed. They further reported that sometimes, even when the onset of rains is timely, a two-week dry spell follows, resulting in poor seed germination and necessitating replanting. This scenario affects seed resources and cropping calendars. Farmers also indicated that the rains had become much heavier than normal, with some rains happening in January, which was not the case before.

Farmers reported prolonged periods of drought. Dairy farmers in Bobasi sub-county reported that in previous years, droughts mainly occurred in January and February, but nowadays they extend into March. They also stated that daytime temperatures have risen, and concurrently so have evaporation rates, affecting crop growth. In addition, farmers described longer periods of low temperatures across the year, which used to occur only during the rainy seasons. Farmers associated heightened temperatures and drought incidence with more numerous water shortages due to sources such as wells and rivers drying up.

Farmers also reported unusually strong winds which were previously experienced in July and August and which now occur in March. Other consequences that farmers associate with climate change and variability are increased incidences of diseases and pests, especially aphids, cutworms, and whiteflies in indigenous vegetables, and soil erosion leading to the siltation of tributaries.

Climate variation has been associated with negative impacts on society. Farmers in Kitutu Chache and Bobasi sub-counties associated low agricultural production with climate change-related risks. Depressed production has led to increasing food insecurity, reduced farm incomes, and high poverty levels in Kisii County. The rates of children dropping out of school and youth engaging in illegal income-earning activities such as drug trafficking have become significantly elevated due to food scarcity. Dependency on food aid and school feeding programs has become common in the county as well.

Farmers in the Nyaribari Masaba, which lies in the lower highland AEZ, reported that they had recently experienced declining water levels and changes in rainfall patterns due to climate change. They stated that many springs are now dry and the volume of water in rivers has fallen, which has made farming difficult and access to water for domestic use expensive. They added that women nowadays spend less time on the farm because they must cover long distances in search of water for domestic use. In extreme situations, men also join the search for water and even take up household chores like feeding the children while women fetch water. Farmers related diminished water sources to the planting of eucalyptus trees, which are known for their high consumption of water, on wetlands.

3.3 Climate Vulnerabilities across Agriculture Value Chain Commodities

3.3.1 Dairy Cow

Dairy cows in Kisii County are mainly impacted by extreme rainfall and dry spells. These hazards affect all stages of the dairy value chain. Water scarcity decreases fodder quality and quantity, thus hindering feed availability and supply. This situation requires farmers to use alternative strategies such as commercial feeds, hay, and silage, which are expensive and sometimes unavailable due to ineffective distribution systems (Auma, 2018). The high cost of feeds may lead to inadequate feeding, which decreases milk production and quality. Dampened production leads to shortages and reduced quantities for milk bulking, impairing marketing due to heightened transport costs. Poor feeding also lessens cows' immunity, exacerbating their vulnerability to diseases such as foot and mouth disease, consequently elevating the costs incurred for veterinary services. During dry spells, the quality and content of fodder is lower because high temperatures lead to yellowing and stunted growth. The quality of silage is also affected by evaporation, which contributes to molding and decreased shelf life. High temperatures associated with dry spells diminish the quality of milk since most farmers lack cold storage. At the marketing stage, farmers have low profit margins due to high production costs from feed acquisition and disease management. During dry spells, milk fetches higher prices from cooperatives because of limited supply, but profit margins remain low due to production costs.

Extreme rainfall is a major drawback to input supply because it drives up the occurrence of pests and diseases, along with the demand for veterinary services. Additionally, extreme rainfall can result in the destruction of infrastructure such as roads, thus making it difficult for agrovets to access suppliers and for veterinary service providers to reach farms. This scenario renders livestock inputs or veterinary care unavailable at the required time. High moisture content can bring about the spoilage of feeds, fodder, and supplements, thus affecting the quality and quantity of milk. Depressed milk production affects farmers' incomes and quality of life due to the competition between market and family consumption.

Women are more likely to suffer from these climatic hazards because they are more involved in the dairy value chain, but they lack the financial capacity and knowledge to deal with extreme events. During dry spells, women are more engaged in searching for water for the livestock, and they travel increasingly long distances as water sources dry up and water levels go down. Women are also more involved in the time-intensive and strenuous search for fodder. These challenges also affect men and youths, who support the search for fodder and water. Young people are the primary participants in spraying animals against pests like ticks; their health is endangered by exposure to chemicals without sufficient personal protective equipment. People living with disabilities are especially affected because their health is compromised due to underlying conditions, and they have limited access to knowledge, resources, and services to respond effectively to challenges posed by climate hazards.

3.3.2 Local Chickens

The most problematic hazards to the local chicken value chain in Kisii County are heat stress and dry spells. Heat stress has severe effects: elevated incubation temperatures lower hatching rates, and excess heat leads to early chick mortality. High temperatures cause chickens to pant, and heightened respiratory rates dampen their egg-laying potential. At the production stage, heat stress leads to reduced feeding, less body weight, decreased feed efficiency, and lower egg production and quality. High temperatures raise the risk of dehydration and heat stroke deaths in the flocks. During the post-production stage, heat stress can result in reduced quality and greater perishability of chicken products; more eggs break due to decreased shell thickness, and broilers under transportation from farms spoil easily in high temperatures. Additionally, high temperatures lead to diminished weight, driving down the incomes of producers at market.

During dry spells, feed sources shrink because green matter from farms dries out. In addition, low yields of groundnut, sunflower, and other seeds mean fewer are available for feed processing. Due to shortages, farmers frequently depend on expensive purchased feeds, raising their production costs. Feed shortages may compel farmers to sell their chicken below value to reduce stocks, or they may have to leave their birds to scavenge, exposing them to predators. During dry spells, there is a heightened incidence of external parasites such as red mites and diseases like New Castle, Fowl pox, Fowl cholera, and Gumboro, and management of these pests and diseases drives up production costs. High temperatures associated with dry spells lead to increased post-production losses due to the reduced shelf-life of chicken products, a risk that is aggravated by a lack of storage facilities in Kisii County. The effect of dry spells on the output market is felt mostly at the point of selling. Farmers lack bargaining power when low production causes them to sell to individual consumers in local markets.

3.3.3 Bananas

The most relevant climatic hazards identified for the banana value chain were moisture stress and dry spells. Moisture stress affects all stages of the value chain. During the early stages of crop establishment, moisture stress causes loose packaging of soil, leading to plantlet wilting and losses. At the production stage, on the other hand, moisture stress offers an opportunity by creating conditions favorable for easier ploughing; however, it also affects orchard establishment by causing stunted plant growth, wilted leaves, and premature ripening of fruits. When moisture stress is extreme, it can result in banana orchards dying. Moisture stress lessens bunch weight, worsens the texture and appearance of fruits, and leads to poorly formed hands that make pre-processing activities costlier, eventually resulting in low demand and reduced market prices. All these factors contribute to a loss of income for farmers and traders.

Dry spells also affect all stages of the banana value chain. They constitute a major threat to banana crop establishment since limited water supplies lead to stunted growth and tissue death in plantlets, resulting in low production. On the other hand, dry spells are considered an opportunity since they make ploughing easier, but they also delay planting, eventually affecting the cropping calendar. Dry spells also impact crop growth, and lead to stunted growth, dried-out leaves, poor yields, and reduced incomes. During post-harvest handling, dry spells are a severe threat since they diminish the quality and weight of bunches, leading to lower volumes for bulking. They also hinder processing activities like peeling and slicing, thus affecting the quality and quantity of end products. When there is insufficient water for cleaning away dirt and contamination, the quality of fingers is further marred. At the output stage, dry spells can result in poor-quality bunches, bringing about low market prices. In very severe cases, dry spells can totally interrupt the market network, causing traders to search for better products in other regions or diversify their trade to other products.

Women and youths are more vulnerable to these climatic hazards since they have limited access to financial services and resources to implement adaptation strategies such as water harvesting and conservation measures. Even though women play a major role in the banana value chain, especially in providing labor for harvesting and post-harvest activities, they are more likely to suffer from the effects of climate hazards due to sociocultural factors: men control farm proceeds and make major land decisions. A lack of policies to promote and implement water harvesting and conservation measures in Kisii County poses a hindrance to the banana value chain. Most banana production is rain-fed, and thus threatened by changing and unpredictable rainfall patterns.

3.3.4 Indigenous Vegetables

The hazards that are most likely to affect the indigenous vegetable value chain are dry spells and extreme rainfall. Dry spells affect seed germination, and seed sown during dry spells is vulnerable to attack by soil pests. Both sets of circumstances lead to low plant population and diminish expected production volumes. Dry spells affect soil fertility because inadequate moisture impedes decomposition and the integration of manure and fertilizers, reducing the nutrients available for the plants. On the other hand, land preparation is easier during dry spells because sun exposure suppresses soil pests. However, dry spells can delay land preparation because of hard pans, which are labor-intensive and expensive to break. Moisture stress increases the incidence of crop wilting and may result in suboptimal quality and quantities of vegetables, thus affecting farmers' livelihoods and reducing their incomes. However, during post-harvest handling, dry spells create an opportunity because they ease transportation, reduce spoilage, and facilitate value addition by enabling easy solar drying. Nevertheless, extreme temperatures coupled with poor handling result in conditions that favor increased rates of spoilage and rotting, leading to low volumes. Inadequate supply in the face of high demand leads to increased prices, which affect the purchasing power of the resource-poor, endangering their nutrition security.

Extreme rainfall is a major threat at the input stage since it complicates the preparation of land for planting, brings about the leaching of nutrients, and increases incidences of soil disease-causing micro-organisms. Extreme rainfall also causes deficient germination due to poor water infiltration, waterlogging, and the washing away of seeds. These occurrences both increase production costs if farmers must buy more seed for replanting. In hilly places, excess rainfall leads to mudslides and soil erosion; lowlands experience flooding risk that renders planting and germination difficult due to waterlogging. At the production stage, extreme rainfall raises the cost of production due to heightened pesticide usage and increased labor requirements for planting and weeding. During post-harvest handling, sorting and preparing vegetables becomes costlier and more time-consuming, and high rates of spoilage and wastage result in low volumes. Impassable roads delay deliveries to market outlets and lead to increased transportation costs that shrink profit margins.

4. Adaptation to Climate Change and Variability

4.1 Factors Determining Future Vulnerability and Impacts of Climate Change

Although all households in a community are exposed to risks and adverse impacts associated with climate change and could be rendered vulnerable, some households or individuals are most at risk: people living with disabilities, youths, women, and older people (Stringer et al. 2009). Although the causes of vulnerability to climate change impacts are multi-dimensional, the most important include food insecurity, poverty, recurrent droughts, land degradation, inequitable land distribution, and dependence on rain-fed agriculture. Other issues also undermine adaptive capacity and thus exacerbate vulnerability at the household level, like sociocultural factors such as beliefs, practices, and values. Related problems include a lack of access to important natural resources such as land and water; inadequate social services; a lack of markets; poor infrastructure, including roads and storage facilities; insufficient access to information, including skills, knowledge, and data; suboptimal access to credit services; weak institutional arrangements; a lack of empowerment to participate in political processes: environmental degradation; and the loss of employment opportunities.

4.2 Adaptation Options to Climate Change

4.2.1 Ongoing Adaptation Practices

To mitigate ongoing climatic changes, farmers have embraced various adaptation strategies relevant to each value chain and the hazard (Figure 11). To minimize impacts on bananas and local vegetables, farmers have adopted climate-smart agriculture (CSA) technologies, innovations, and management practices, including conservation agriculture (CA) principles such as zero tillage, the use of cover crops, mulching, and crop rotation. Other CSA practices include drip irrigation, manuring, rainwater harvesting, and soil and water management strategies such as zai pits, terraces, bund stones, cut-off drains, and small check dams. Other practices specific to the banana value chain include bagging the fruits on the tree to protect against damage from insects, pathogens, wind, leaf and petiole scarring, dust, light, hail, sunburn, and bird feeding. Another practice is de-suckering, or removal of excess and unwanted shoots in order to avoid competition with the main plant for water and nutrients.

Farmers have embraced the use of improved and certified seed varieties including drought-tolerant and early-maturing varieties. They are also turning to early planting to ensure maximum utilization of limited amounts of rainfall. Another adaptation strategy is the use of well-decomposed farmyard manure (FYM) instead of inorganic fertilizers, preferable because inorganic fertilizers are costly, deplete soil organic carbon, and are unavailable in most seasons. About 18% of farmers used organic manure for annual crops in the first season, and 15% did so in the second season, while 33% used organic manure for perennial crops (ASDSP, 2014). FYM and compost can become part of sustainable farming systems that sequester and enhance soil organic carbon and improve soil structure and fertility. Additionally, crops grown under manure are more resilient to droughts than those under inorganic fertilizers.

To improve on post-harvest handling, farmers have embraced the construction of collection shades and grading facilities. Banana farmers have adopted technologies like ripening chambers and crates for primary packaging. Value addition is also present at the post-harvest stage of the banana value chain; products like crisps, wine, and flour fetch a better price in the market. For local vegetables, solar drying has been adopted at the post-harvest stage for preservation and storage. Other techniques utilized by farmers in Kisii County include covering banana bunches with dry leaves for protection against scorching and moisture stress, using refrigeration facilities, and employing information technology to facilitate marketing and linkages.

To better utilize the available land and to improve dairy production, dairy farmers have embraced the use of zero grazing because it requires small plot sizes. To overcome the challenges that climactic hazards pose to fodder production, including stunted growth and reduced production, farmers have employed strategies including the formulation of feed via cooperatives, feed conservation, and the use of by-products and crop residues. Farmers are also using chaff cutters to ensure better utilization of available fodder, especially Napier grass. Farmers also practice crop rotation that incorporates Napier grass with other crops such as potatoes and sweet potatoes. Fodder conservation, in the form of hay and silage, is gaining popularity across Kisii County. In 2014, feed conservation was done by only 6% of households (ASDSP, 2014). Farmers have also adopted diversification, growing other fodder varieties like drought-tolerant Boma Rhodes grass; Lucerne grass, which is highly palatable and has a high feeding value; Bracharia grass; and Rhodes grass. To improve animal fertility and production, farmers use artificial insemination (AI) services, hormones, embryo transfer, and enhanced nutrition. To manage animal diseases, farmers engage in good husbandry practices, the use of local herbs such as Bracharia and Desmodium, and treatment methods including deworming, routing, spraying, and vaccination. Farmer have also adopted bulk marketing through cooperatives which ensure bargaining power and sustainable milk prices.

4.2.2 Potential Adaptation Practices

Farmers proposed other adaptation practices to avert the climate hazards identified in the selected value chains (Figure 11). Across the various stages of the banana value chain, proposed adaptation options were similar for moisture stress and dry spells. At the input stage, farmers suggested using water purification to achieve the desired water quality for media preparation. The use of soilless media such as coco pits, vermiculate, and aeroponics techniques in tuber development may enable better water utilization. Farmers also brought up the need for the continuous promotion of CSA practices such as CA with more capacity building using the training of trainers approach. The promotion of irrigation and Zai pits during planting may also help avert water shortages. Post-harvest losses are a major challenge in the banana value chain; hence, farmers expressed a need for support by the county government in order to construct modern post-harvest cold storage facilities for banana preservation to minimize losses due to over-ripening. Enhanced capacity building in post-harvest practices such as de-handing could reduce losses from mechanical damage and fungal infections. Technology transfer, product development, and value addition, meanwhile, may help maximize profits. At the output stage, farmers indicated a need for automated machines to help in grading and the use of e-marketing. The development of a banana policy that will support pricing and market regulation, finally, may help reduce exploitation by middlemen.

To avoid climate hazards in the local chicken value chain, farmers might use aerated boxes, cages, and trucks for chicks and chicken transportation at the input and post-production stages. The use of refrigeration and cooler boxes during transportation and the establishment of regional storage centers for ease of accessibility could help ensure the quality of vaccines. In addition, during production, automated incubators and aerated structures in brooding areas, proper sanitation, and routine vaccination could minimize losses from heat stress. To boost value addition, farmers might establish chicken slaughter slabs with cold storage facilities. The formation of groups, structured marketing, contractual marketing, and collective pricing can prevent exploitation by middlemen.

Farmers also recommended various CSA strategies as potential adaptation options that cut across the most relevant climate hazards, dry spells and extreme rainfall, in the local vegetables value chain. These include use of certified seed, upscaling soil

and water conservation measures, the utilization of organic and farmyard manure, of foliar feeds, and of herbal pesticides. Farmers favor the adoption of good agricultural practices (GAPs) across all stages of the value chain, such as early or timely planting, proper sanitation, timely weeding, the use of recommended fertilizers, and precise fertilizer application. They also advise standardized packaging, e-marketing, and standardized pricing.

In addition, farmers urged a number of adaptation practices to mitigate the effects of dry spells and extreme rainfall on the dairy cow value chain: the production of fodder using hydroponics, intensive feeding, fodder conservation practices such as the use of hay and silage, and good husbandry practices like proper housing, strategic deworming, vaccination, and the use of injectables to control ticks. Farmers also support a number of technological and scientific innovations, including the adoption of improved genetics, such as embryo transfers and sexed genes; the implementation of modern production systems and mechanization, for example computerized feeding and silage baling machines; and value addition through milk pasteurization and chilling. Solutions like collective marketing through farmers' cooperatives and contractual pricing based on quality and weighting could drive profitability in the value chain.

Adaptation strategies used in selected value chains in Kisii County

Banana	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Moisture Stress Consequences	Moisture stress affects planting of plantlets due to loose soils	Moisture stress makes land preparation easier; fast sprouting of wicks is prevented; stunted growth, wilted leaves, small bunches, and premature ripening; low productivity	Reduced-weight bunches and poorly-formed hands fetch low prices; pre-processing activities made more difficult	Low prices due to poor texture and low weight; low quality produce attracts less consumers
Magnitude of Impact	Moderate	Major	Major	Minor-Severe
Farmers' Current Coping Strategies	Water harvesting and storage; covering soil with polythene to reduce moisture loss; use of greenhouses misters	Adoption of climate-smart agriculture practices like mulching, water harvesting by building water pans, agro-forestry, manuring, bagging of banana fruits, and drip irrigation; conservation agriculture for soil water conservation	Construction of collection sheds and grading facilities; adoption of ripening technologies; use of crates for primary packaging	Covering banana bunches with dry leaves to protect from scorching and moisture loss; use of scales in buying and selling; use of information technology for climate and extension information
Potential Adaption Options	Use of reserves and water purification systems for planting and media preparation; use of moisture-retaining planting media such as cocoa peat vermiculite; introduction of aeroponic technologies	Training the trainers in conservation agriculture techniques and climate smart agriculture; community irrigation projects; use of zai pits in planting	Construction of banana pack houses with sorting, grading, storage, and cold facilities; technology transfer for product development and value addition; raising awareness of practices like de-handling to reduce wastage from fungal infections	Use of automated grading machines; policy framework to regulate market prices; use of internet to market produce
Underlying Factors	Low-income farmers, particularly youth, are not able to harvest and store water; lack of government support in water projects	Although they provide most of the labor, women are affected because the land for and revenue from bananas is controlled by men	A lack of collection centers, grading shades, and cold storage facilities; poor roads	Lack of policies supporting banana value chain; lack of sufficient government support for market facilities
Dry Spell Consequences	Low production due to insufficient water supply and moisture stress; stunted growth and dying in extreme conditions	Dry spells make land preparation easier and facilitate the transformation of vegetation to organic manure; stunted growth and dying of leaves lead to poor yields; delays in planting interfere with the farm business plans	Reduced volumes for bulking; pre-processing activities become more difficult; insufficient water for cleaning leads to lower-quality produce	Poor quality bananas fetch low prices; quality issues can disrupt the market if traders move markets
Magnitude of Impact	Major	Severe	Major-Severe	Major
Farmers' Current Coping Strategies	Rainwater harvesting and storage; use of surface water; use of shade nets to decrease heat intensity	Practicing zero tillage; Practicing climate-smart agriculture like zero tillage, mulching, use of cover crops, and drip irrigation; rainwater harvesting storage; drought-tolerant varieties	Construction of collection and storage facilities; technology transfer in pre-processing activities; rainwater harvesting and installation of de-handling rails	Construction of grading and storage facilities; branding and packaging bananas; use of information technology to link farmers with ready markets
Potential Adaption Options	Harvesting and storage of water in the nursery; use of soilless media to retain moisture; use of hydroponic technologies	Increasing awareness of conservation and climate-smart agriculture; establishing technology transfer centers at the sub-county level for adoption of good agricultural practices	Procuring packaging equipment and machines for post-harvest handling; technology transfers for processing and value addition; capacity-building for agronomic practices, de-handling for prevention of fungal infections	Use of automated machines for grading; reinforced policy framework to regulate market infrastructure and pricing; use of media channels and open-air markets to promote banana produce
Underlying Factors	Youth are particularly impacted by a lack of existing, government-directed water supply projects due to their lack of economic power to adapt to prevailing conditions	Women are particularly impacted by the lack of government initiatives on water provision and disempowering cultural barriers	Poor roads and a lack of collection sheds and storage facilities lead to reduced quality, wastage, and poor prices	A lack of policy in the banana value chain has resulted in poor marketing systems that are vulnerable to exploitation; insufficient market facilities lead some farmers to sell bananas significantly under value

Chicken (Local)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Heat Stress Consequences	Low hatchability; reductions in feed consumption, production, and supply	Low feed consumption; increased costs of management, including for disease control; reduced growth due; low productivity	Increased costs for new or modified storage facilities; increased perishability of chicken products; low sales and low income	Decreased sales and interconnections in the market; decline of the quality and pricing of chicken products
Magnitude of Impact	Moderate-Severe	Moderate-Severe	Moderate-Major	Minor-Moderate
Farmers' Current Coping Strategies	Use of aerated boxes and open trucks during transportation; transporting vaccines and drugs in refrigerated trucks and cooler boxes	Use of automated incubators and brooders; use of saw to regulate hatching temperature; constructing aerated structures for brooding; proper sanitation; use of pesticides to control pests; regular litter changes	Use of aerated cages and trucks; use of aerated structures in market centers; establishing shade structures	Adoption of aerated cages; adoption of refrigeration; contract farming; structural marketing, marketing promotion, and advertising
Potential Adaption Options	Adoption of aerated boxes and open trucks for chick transportation; transporting drugs in refrigerated trucks and/or cooler boxes; establishing regional vaccine storage centers	Use of automated incubators; constructing aerated structures in brooding areas; proper sanitation; routine vaccination	Use of aerated cages and trucks for transportation; establishment of aerated aggregation centers and cold storage facilities; construction of chicken manure yards and application of manure management techniques; establishment of chicken slaughter slabs for value addition	Establishing cold storage and aerated cages at market centers; establishment of chicken slaughter slabs; collective, structured marketing and pricing; contract farming; adoption of structured marketing, promotion, and advertisement
Underlying Factors	Women and youth lack economic empowerment and control over resources for poultry farming	Gender discrimination exists in educational programs; lack of economic empowerment bars women and youth from purchasing inputs	A lack of qualified personnel to influence the process; lack of advanced storage facilities to reduce wastage	Poor policies governing marketing procedures; women's access to markets is limited by cultural beliefs that they should not be involved in trading
Dry Spell Consequences	Reduced hatching; reduced supply and increased cost of feeds; increased incidence of diseases; high cost of vet services, treatments, and vaccines	Reduced rate of feeding; increased disease vectors; high cost of disease treatment and pest management	Efficiency in storage thus reducing molds on products; availability of ready markets; easy accessibility to markets due to good road conditions; increased supply to customers according to demand	Market linkages improve with passable roads; consumers are easier to reach; trade in the value chain is increased
Magnitude of Impact	Minor-Severe	Minor-Major	Moderate-Major	Moderate-Major
Farmers' Current Coping Strategies	Synchronization and use of incubators and serial hatching; use of homemade feeds and leftovers (e.g., termites, grass); use of local herbs	Use of automated brooders and incubators; use of sawdust and open hatching boxes to regulate temperature; increase in aerated structures; more water feeders; proper sanitation and pesticides for pest control; regular litter changes; ring vaccination	Use of aerated cages and fabricated trucks; aerated structures in market centers; creating shaded structures	Adoption of aerated cages for display; value addition under refrigeration; Contractual engagement with buyers, structural marketing, promotion, and advertisement
Potential Adaption Options	Advanced, solar-powered incubators; adoption of locally available materials for feed preparation; group purchasing; establishing value chain groups to access drugs	Use of automated incubators; aerated structures for brooding; proper sanitation and routine vaccination	Aerated cages and trucks for transportation; establishment of aerated aggregation centers and cold storage facilities; construction of chicken manure yards and application of manure management techniques	Establishment of cold storage and aerated cages at market centers; establishment of chicken slaughter slabs; collective, structured marketing and pricing; contractual engagement with buyers; contractual marketing, structured marketing, promotion, and advertisement
Underlying Factors	Market fluctuations affect feed availability leading to low poultry productivity; poor price regulation policies for chicken treatment and vaccines	Lack of early warning systems and professional advice; reduced feed availability during dry spells; low productivity disproportionately affects women and youth	Poor storage systems leads to spoilage or lower quality of produce; lower productivity reduces income; women and youth are disproportionately affected	Pricing is not regulated leading to exploitation of farmers

Dairy (Cow)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Dry Spell Consequences	Vets can easily access farms when road conditions are good; increased artificial insemination (AI) services; high operational costs; reduced availability of feeds and supplements; high costs of AI storage	Inadequate water for spraying; high cost of vaccines; inadequate feed availability; feed supplementation and rationing	Inadequate milk supply; farm accessibility improved by passable roads; enhanced storage of fodder to maintain quality	Enhanced promotion activities and sales; increased prices for consumers; enhanced linkage of farmers with consumers
Magnitude of Impact	Moderate-Major	Moderate-Major	Major	Major
Farmers' Current Coping Strategies	Growing local grasses for their nutritional profile; feed conservation; on-farm feed formulation with crop byproducts and residues; natural service bull schemes; AI; improving nutrition to improve fertility; use of hormones and embryo transfer	Cross-breeding; good dairy husbandry practices including, cut and carry, tethering, paddocking and zero grazing	Boiling, pasteurization, and value addition (making mala, yoghurt, butter, milk powder, cheese); Establishing collection points and centers; purchase of equipment and means of transportation; use of hay barns, standing hay, polytubes, and trench silage	Sales through barazas, churches, field days, exhibitions, trade fares, and ASK shows; utilization of prevailing market prices; quality; use of weight for pricing; measurement by pints; formation of farmers' groups; use of social media and value chain platforms
Potential Adaption Options	Regular vaccination; good animal husbandry practices; strategic deworming and tick control; use of hydroponics to produce fodder; use of synchronizations, sexed semen	Motorized plunge dips and injectables to control ticks and worms; routine vaccination; improved genetics for resistant breeds; zero grazing; mechanical/computerized feeding	Establishing collection centers for milk pasteurization, chilling, and value addition; purchase of appropriate milk handling equipment; use of silage bailing machines	Use of media and radio conferencing; pricing based on quality and weight, contractual agreement on prices and market surveys; use of business cohorts to link buyers to famers
Underlying Factors	Unfavorable government policies mean that clinical services are privatized, leading to increased prices; high costs of AI; reduced availability of quality semen and equipment	Poor storage facilities cause feed spoilage; low adoption of technology due to economic status	Reduced availability of spraying for pest control due to poor water harvesting systems; lack of piped water	High cost of vaccination caused by weak and outdated government policies; low purchasing power among farmers; shortages of raw materials for vaccine manufacture
Extreme Rainfall Consequences	Poor accessibility of clinical services along with increased demand; increase spoilage of feeds and supplements; poor accessibility of AI services	Increased demand for spraying; high incidences of pest and diseases; increased incidences of bloating; increased production of fodder and milk	Increase in raw materials for processing; enhanced processing activities and bulking; poor accessibility of produce	Poor accessibility and high costs; milk fetches low prices due to high supply; inadequate linkage of farmers to buyers
Magnitude of Impact	Major	Major	Major	Major
Farmers' Current Coping Strategies	Deworming, vaccination and spraying; wilting and drying of feeds; formation of famer groups with AI kits; purchase of motorbikes to access farms	Routine spraying, deworming, and treatment; improved hygiene and routine vaccination; wilting and drying of feeds	Feed conservation; farm-based preservation; value addition activities; road improvement; construction of hay barns; increased sales	Promotion at churches and ASK shows; utilizing prevailing market prices; increased preservation and value addition; formation of famers' groups; use of social media and value chain platforms
Potential Adaption Options	Intensify routine deworming, vaccination, and spraying; enhance fodder conservation (hay and silage); use super-ovulation; purchase of four-wheel vehicles	Use of spray races and clips or injectable pesticides; routine vaccination; wilting and drying of feeds; use total mixed rations (TMR)	Processing at milk plants; hay and silage processing; establishment of cooling plants; improved road maintenance; expansion of hay buns; commercial hay and silage making	Use of mass and electronic media; market research; computerized or digital weighing for pricing; market information platforms for pricing
Underlying Factors	Poor accessibility of clinical services caused by poor roads; insufficient institutional budgets to support farmers; high cost of vaccines; inadequate feed availability	Reduced availability of supplements because of diminishing land size, weak policy and regulations, and low purchasing power	Low purchasing power for pest control measures causes increased incidences of pests and diseases; lack of government subsidies for veterinary drugs	Poor road infrastructure; high supply and low demand reducing prices; high cost of production

Vegetables (Indigenous)

	Provision of Inputs	On-Farm Production	Harvesting Storage and Processing	Product Marketing
Drought (Dry Spell) Consequences	Microorganisms that cause disease and pests are suppressed; land preparation is made easier; germination is hindered; low crop yields; seeds are attacked by soil pests; low nutrient availability	Formation of hardpans; Delayed planting and poor germination; loss of livelihoods; reduced yields; damaged roots; increased costs of spraying	Drying and preservation are enhanced; lower rates of spoilage and rotting; passable roads ease transport	High demand increases prices fetched by produce; increased consumer prices
Magnitude of Impact	Moderate-Major	Moderate-Major	Minor-Moderate	Severe
Farmers' Current Coping Strategies	Conservation agriculture like mulching and minimum tillage; use of drought tolerant seeds, seed dressing, and timely planting; split application; dry planting technology; application of well-decomposed manure	Timely land preparation; application of mulches; shallow cultivation; hand weeding; timely dry planting; supplementary irrigation; seed dressing	Construction of collecting sheds; sorting under shades; use of appropriate packaging materials; use of transport vehicles e.g. motorbikes, trucks and buses/ passenger vehicles	Use of appropriate promotion modes such as digital platforms; reducing quantity and increasing prices because of high demand; market segmentation
Potential Adaption Options	Conservation agriculture; use of high yielding and certified seeds; increase use of organic manure; use of foliar fertilizer and split top-dressing; use of recommended type and fertilizer ratios	Scheduled sequence planting; timely on-farm operations like weeding; use of good agricultural practices	Observe high standards of hygiene in the post-harvest periods; use of micro-hold packaging material; use of air-conditioned vans or trucks	Branding and using standardized packaging; use of e-marketing/on-line platforms; standardized pricing using kilos
Underlying Factors	Non- utilization of land due to prevailing dry weather conditions; delayed application of fertilizers and manure; low economic empower-ment to practice irrigation; lack of credit and insurance institutions to protect farmers against dry spell	Delayed planting, weeding, and spraying; lack of credit and insurance institutions inadequate agricultural extension officers and weather forecast advisors	Some areas have better road networks than others and poor networks hinder post-harvest activities	Lack of government policy on pricing and quality standards; lack of specific markets for indigenous vegetables; low empowerment for branding; insufficient transport vehicles to maintain quality
Extreme Rainfall Consequences	Nutrient leaching, mud slides, increases in disease-causing microorganisms; land preparation becomes more difficult; increased occurrence of waterborne and vector-borne diseases; poor crop performance; washing away of seeds; repurchasing seeds incurs extra costs	Land preparation becomes more difficult; nutrient leaching; poor water infiltration; increased cost of weeding and spraying pesticides; increased cost of labor	Farming becomes more-time consuming and expensive; increased risks of contamination; increased spoilage; and impassable roads delays supplies	Extreme rainfall disrupts promotion activities; increased transport costs; high competition and low pricing; high wastage; reduced farmer morale; increased contamination and spoilage; time wastage
Magnitude of Impact	Major	Moderate-Major	Moderate	Moderate-Major
Farmers' Current Coping Strategies	Construction of structures for soil and water conservation; agroforestry; fertilizer and manure application; use of certified seeds, seed dressing; composting, mulching, and soil and water conservation	Soil conservation measures such as mulching, terraces, cut-off drains; land preparation before onset of rains; timely planting; row planting; combination of shallow tillage and hand planting; mulching or herbicides to suppress weeds	Timely harvesting; spreading vegetable produce in cool dry places; use of appropriate packaging material and solar drying; use of appropriate transport and waterproof packaging material	Market research, lower prices, and price setting; proper timing; use of appropriate promotion media and mobile technology
Potential Adaption Options	Soil and water conservation measures; use of certified seeds; use of well decomposed farmyard manure	Row planting, use of drainage; timely planting; use of plastic mulch; soil conservation measures; use of drip irrigation and green house technologies; combining shallow tillage with hand pulling; use of herbal pesticides	Storing vegetables in cold, dry environments; use of appropriate packaging material and solar driers; use of appropriate means of transport	Increasing quantity and lowering prices; using appropriate promotional media; market research and price setting
Underlying Factors	Socio-cultural opinions limit the access of women and youth to land; limited economic empower-ment reduces their access to production inputs	Women and youth have limited access to land and agricultural extension services and are economically disempowered due social and cultural practices	Farmers need capital to buy packaging materials and transport goods from one place to another; there is no specialized vegetable market; lack of policy frameworks for production, marketing, and value addition	Lack of policy framework for pricing and quality standards, lack of institutionalized and organized markets

Figure 12: Climate variabilities and adaptation strategies across selected value chains in Kisii County

5. Policies and Strategies on climate change

The development of policies and programs and their effective implementation play a key role in decision-making, since they affect actions and outcomes related to climate risk management and resource use. In response to climate variability and change, Kisii County has adopted several national policies in its implementation of climate change adaptation and mitigation interventions (Table 1).

Table 1: National policies targeting climate change adaptation and mitigation

Policy	Year	Policy objective(s) achieved at the county level	Interventions contributing to climate change adaptation and mitigation	Challenges and policy gaps
National Climate Finance Policy	2018	Establish mechanisms to mobilize climate finance.	Development of County Climate Change Fund (CCCF) regulations	Insufficient political good will
NCCAP	2013-2017; 2018-2022	Increase forest cover to 10%; rehabilitate degraded lands, including rangelands; strengthen the resilience of the wildlife and tourism sector.	Formulation of by- laws to control deforestation Planting of trees on public land and along rivers to increase vegetation cover Reclamation of riparian land by replacing blue gum trees Backfilling of quarries to reclaim land for arable use	Weak coordination and collaboration among major sectors involved in climate change issues
		Boost food and nutrition security through improved productivity and resilience in the agricultural sector in a low-carbon manner.	Provision of extension services to poultry farmers for improved production Establishment of 2 fruit processing plants for bananas and avocadoes with collaboration with development partners Provision of inputs, including AI services, chicks, fertilizers, certified seed, banana suckers, and avocado seedlings	Weak coordination and collaboration between public- and private-sector actors Inadequate personnel to handle climate change issues
		Reduce risks to communities and infrastructure resulting from climate-related disasters such as droughts and floods.	Construction of a community-based radio station (Radio Internet "RANET") that will help deliver accurate and timely weather forecasts and climate information Participatory scenario planning (PSP) programs that aid in planning for climate risk interventions	
		Enhance resilience of the Blue Economy and water sector by ensuring access to and efficient use of water for agriculture, manufacturing, domestic purposes, wildlife, and other utilizations.	Replacement of blue gum trees with indigenous trees along water catchment areas Training and sensitization forums on the maintenance of water reserves Drilling of boreholes to provide clean and portable water Construction of water schemes to make water points accessible to homesteads Purchase and delivery of water tanks to schools Protection and restoration of water-related ecosystems including hills, forests, wetlands, rivers, streams, aquifers, and springs	

Policy	Year	Policy objective(s) achieved at the county level	Interventions contributing to climate change adaptation and mitigation	Challenges and policy gaps
National Climate Change Framework Policy	Sessional Paper No. 3 of 2016	Enhance adaptive capacity and build resilience to climate variability and change, while promoting a low-carbon development pathway.	Formulation of a Climate Change Policy and Bill that has already been passed by the County Assembly.	A lack of technical expertise and skills to handle climate change issues
Kenya Climate-Smart Agriculture Strategy (KCSAS)	2017-2026	Enhance the adaptive capacity and resilience of farmers, pastoralists, and fisher-folk to the adverse impacts of climate change.	Promotion of urban and peri-urban aquaculture systems like raised ponds Purchase of aqua-feed for production Equipping of fish multiplication centers Purchase of milk coolers for dairy development	Inadequate funds for climate change adaptation and risk management
		Develop mechanisms that minimize greenhouse gas emissions from agricultural production systems.	Installation of solar lighting systems at Kisii Agriculture Training College Investments in alternative energy sources like solar and biogas	Delayed planning due to delayed funds disbursement due to lengthy approval processes
		Create an enabling regulatory and institutional framework.		
		Address cross-cutting issues that adversely impact CSA; four broad strategic areas have been identified for KCSAS.	Promotion of improved seeds, including drought-tolerant and early-maturing crop varieties Promotion of value addition	
The National Adaptation Plan (NAP)	2015-2030	Consolidate the country's vision on adaptation supported by macro-level adaptation actions that relate with the economic sectors and county level vulnerabilities to enhance long term resilience and adaptive capacity.	Integration of climate change issues into the CIDP with a monitoring and evaluation framework for quarterly reporting on key achievements by key departments e.g. water, forestry, environment and agriculture. The County government is implementing a 'Governor's Manifesto' which incorporates climate change adaptation targets for key departmental ministries	
Agriculture Sector Development Strategy (ASDS)	2010-2020	Revolutionize agriculture and re-orient it towards the establishment of economic and commercial enterprises to provide youth employment and improve livelihoods.	Provision of extension services in the milk, banana, and local chicken value chains Provision of innovation grants to vulnerable and marginalized groups	

6. Institutional Capacity on Climate Change

Institutional resources and capacity are important considerations for improving farmers' adaptive capacity and climate change resilience because they shape resource use actions and outcomes. In Kisii County, many institutions – including the government, private companies, non-governmental organizations, and community-based organizations – are working on issues related to climate change, agriculture, water, or food security (Table 2). Their interventions include research and extension, early warning systems, capacity building, the provision of technology and technology transfer, enhancing market linkages, offering financial and credit services, disease surveillance, and the provision of agro-inputs such as seeds, chicks, fertilizers, and pesticides.

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

Off-farm services	Institutions	Specific interventions in Kisii County	Challenges
Agricultural research and extension services	Kisii directorates of crop development, livestock, fisheries, and cooperatives KALRO-Kisii Centre	On-farm demonstrations of new crop and livestock technologies, innovations, and management practices	Poor coordination and collaboration among institutions leads to duplication and overlap of roles Inadequate expertise (researchers and extension workers) leading to limited access to extension services to facilitate demand-driven research and increased use of improved technologies Limited funding Weak research farmer-extension links Low adoption of recommended technologies due to high cost of farm inputs and high poverty levels
	Kisii Agricultural Training Centre	Trainings in GAPs	
	Department of Energy, Water, the Environment, and Natural Resources	Rehabilitation of community water schemes Connecting households to piped water Drilling of boreholes Construction of additional water harvesting structures like tanks	
	Kenya Forestry Service Kenya Forest Research Institute	Promotion of conservation of forests and forest genetic material Protection of water catchment areas Farm and dry land management	
	National Environment Management Authority	Promotion of sustainable environmental management by integrating environmental considerations into development policies, plans, programs and projects	
	Directorate of Livestock Private Veterinary Officers	AI services Animal selections that suit different AEZs	
	Kenya Dairy Board (KDB)	Training and technology transfer	
	KALRO Kisii University Jomo Kenyatta University of Agriculture and Technology	Varietal and breeds development Technology transfer On-farm research trials	
Regulatory services	Kenya Plant Inspectorate Service	Provision of inspectorate services on all matters related to plant health and quality control of agricultural inputs and produce, such as certification of the quality of seeds and fertilizers	Limited regulatory expertise results to inadequate surveillance and certification of agricultural inputs thus exposing farmers/consumers to counterfeits
	Pest Control Products Board	Regulation and approval of pest control products Monitoring of the quality of pest control products already in the market	
	KDB	Inspection and licensing of milk handling premises Surveillance of the quality and safety of milk and milk products	

Off-farm services	Institutions	Specific interventions in Kisii County	Challenges
	Kenya Bureau of Standards	Development of standards and quality control Provision of facilities for the examination and testing of commodities and inputs	High cost of key inputs such as seed, pesticides, fertilizer, drugs and for resource-poor farmers
Climate Risk Management (Adaptation planning, Early warning systems --EWS) and Participatory Scenario Planning -PSP	Kenya Meteorological Department (KMD) in collaboration with Experts from County Departments (e.g. agriculture through support by the Agriculture Sector Development Support Program (ASDSP)	Warnings about disasters like mudslides and landslides. Support for the planning of farm activities and cropping calendars	Deliberate operational planning for climate change is still limited; in many cases, climate adaptation planning is reactive rather than proactive. Limited budgetary allocation to climate risk management and adaptation.
	ADA (Adaptation) Consortium (Partners include: National Drought Management Authority, National Treasury, Climate Change Directorate, NEMA, Ministry of Devolution and ASALs and the Council of Governors.	Support county government to mainstream climate change into development and planning through the County Climate Change Fund Mechanism	
Climate Information Services (CIS) and agro weather advisories	KMD	Weekly bulletins and seasonal weather forecasts in the local language via media channels such as local radio and TV stations, social media platforms like WhatsApp, and short message service through phones	Inadequate synergies between the weather advisory providers and decision makers Technical format and language of the climate and weather forecasts which not easily understood by decision makers Limited technical capacity to interpret and use probabilistic forecasts in decision making.
Non-financial subsidies such as inputs and trainings	Kisii County Government	Provision of subsidized farm inputs (AI services, certified seeds and fertilizers)	
	UNGA feeds, Bidco, Ultravetis, Vital Animal Health, East Africa Seeds Co. Ltd., Kenya Seeds Co. Ltd., Osho Chemicals, Murphy Chemicals Ltd., Bayer East Africa, and Baraka Fertilizers Ltd.	Distribution and sale of agro-chemicals and other farm inputs Provision of training and demonstrations on the use of these inputs	
	Agroplant Technical	Supply of tissue culture banana seedlings	
	Cooperative Societies	Support in the production, post-harvest, and marketing processes	
	Insurance companies such as Jubilee	Lack of linkages between technical knowledge support and access to finance	
Financial services such as rural credit schemes	One Acre Fund	Financing (credit) for subsidized farm inputs like seed, fertilizer, and pesticides	Inadequate financial products and services well-designed for farmers'
	Micro-finance institutions (e.g. Musoni microfinance-USAID Development Credit Authority)	Provide credit at lower interest rates	

Off-farm services	Institutions	Specific interventions in Kisii County	Challenges
	Savings and Credit Cooperative Societies (SACCOs) and other cooperative societies	Support for farmers to access credit and loans at low interest rates	
	Banks, including the Kenya Commercial Bank, the Agricultural Finance Corporation, the Cooperative Bank of Kenya, and Equity		High interest rates that limit access to finance to small and medium enterprises Stringent institutional and evaluation criteria Inadequate financial products and services well-designed for farmers'
	Development partners including the European Union, USAID, World Bank, United Nations Development Programme, and United Nations Food and Agriculture Organization	Project financing including technical capacity and value chain development	Limited long-term sustainable impacts due to lack of ownership of donor projects
	Mobile service providers such as Safaricom, Airtel, and Telcom	Mobile banking services	System failure and delays Network vulnerabilities and power outages Lack of information on how to access and operate certain features in mobile money platform
Market services, infrastructure, and linkages	Kenya Meat Commission	Meat value addition Provision of ready markets Increased productivity and competitiveness	Weak, poor, and inadequate farmers' organizations, associations, and cooperative societies Lack of agriculture marketing policy and regulations Poor rural infrastructure Inadequate product markets and marketing infrastructure Low investment in storage and processing facilities Inadequate market information system
	KDB	Engages in various activities to promote domestic, regional and international markets for Kenyan milk and milk products	
	New Kenya Cooperative Creameries	Processing, value addition and marketing of milk	
	Meru Greens Horticulture Epz Limited	Provide market for fruits and vegetables	
	Twiga Foods	Provision of a ready market for fruits and vegetables	
	Mobile service providers such as Safaricom and Airtel	Provision of online marketing platforms	

7. Synthesis and Outlook

This profile analyzes four key agriculture value chains in Kisii County: bananas, local chickens, dairy milk, and local vegetables. The VCCs were selected by stakeholders because of their contribution to the county's economy, their resilience to current and future climate changes, and the involvement of economically and socially vulnerable groups within them. However, all these commodities are threatened by the identified climatic hazards, namely dry spells, extreme rainfall, moisture stress, and heat stress. To avert the impacts arising from the climatic hazards, farmers and other stakeholders use adaptation strategies. Kisii County is also endowed with various institutions, projects, and programs meant to enhance farmers' resilience and adaptation to climate change and variability impacts.

Despite a good climate and high agricultural potential in Kisii County, it is ranked among the poorer counties in Kenya and has a high food deficit. It is necessary to rejuvenate the agricultural sector with a focus on the promotion of irrigated agriculture that is not rain-fed, upscaling programs for water harvesting, and installation of community boreholes across the County. Opportunities exist for increasing value addition to agricultural products to lengthen their shelf life and fetch better prices. Kisii County can put greater efforts into value addition for bananas, chicken, vegetables, and fruits to enhance the productivity of the agricultural sector.

To support better access to extension, veterinary, and credit services among socially vulnerable groups such as women, youths, and people living with disabilities, policies could be put in place that unlock productivity constraints. Policy gaps in mainstreaming climate change interventions are a major hindrance to climate risk management in Kisii County. The county government is in the process of instituting policy and governance structures with the development of draft Climate Change Policy and Bill and the CCCF regulations.

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10. Annexes

10.1 Glossary

Absolute poverty: "Absolute poverty" measures poverty in relation to the amount of income necessary to meet the basic needs of a household, such as food, clothing, and shelter (KNBS, 2018).

Adaptation: Adjustment in agro-ecosystems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Adaptive capacity: This is the ability of a system to adjust its characteristics in order to expand its range under existing climate variability and future climate change.

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

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

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

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

Climate-smart agriculture: Agriculture that sustainably increases productivity and resilience, reduces or removes greenhouse gases, and enhances the achievement of national food security and development goals.

Dependency ratio: Within a population, the dependency ratio is the ratio of people in a dependent age group under age 15 or aged 65 and older, to those in the economically productive age group between 15 and 64 years of age. For instance, a child dependency ratio of 0.45 means there are 45 children for every 100 working-age adults (PRB, 2019).

The Representative Concentration Pathways (RCPs): Four greenhouse gas concentration trajectories adopted by the IPCC for its AR5. The four RCPs, RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5, 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.

Food poverty: Households and individuals whose monthly adult equivalent food consumption expenditure per person is less than KSh 1,954 in rural and peri-urban areas and less thanKSh 2,551 in core-urban areas are considered to be food-poor or live in "food poverty" (KNBS, 2018).

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

Mitigation: In the context of climate change, mitigation refers to human intervention to reduce the sources or enhance the sinks of greenhouse gases, for instance by using fossil fuels more efficiently, by switching to solar energy or wind power for industrial processes, and by expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere.

Perception: The process by which we receive information or stimuli from our environment and transform it into psychological awareness

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner.

Vulnerability: The degree to which a geophysical, biological, and socioeconomic system are susceptible to, and unable to cope with, adverse effect of climate change, including variability and extremes.

Zai pits: Zai are holes usually excavated with a diameter of 0.3-0.6 m and 0.3 m deep". The holes harvest rain water at farm level and have the potential to boost soil water holding capacity by up to 5 times while collecting up to 25% of the runoff in the immediate area surrounding the hole

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