Climate Vulnerability and Ecosystem Assessment for Nakuru County

2022

NAKURU COUNTY
COUNTY OF UNLIMITED OPPORTUNITIES

ALIN Arid Lands Information Network

WWF KENYA
TOGETHER FOR NATURE

VCA
VOICES FOR JUST CLIMATE ACTION

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Arid Lands Information Network (ALIN)
AAYMCA Building, State House Crescent, off State House Avenue
P.O. Box 10098 – 00100, Nairobi - KENYA
info@alin.net | www.alin.net

This research was done by ALIN in close collaboration with the Nakuru County Government, as represented by the Department of Environment, Energy, Climate Change and Natural Resources with support from the World Wide Fund for Nature (WWF) Kenya through the Voices for Just Climate Action (VCA) Programme.

About ALIN

The Arid Lands Information Network (ALIN) is a non-governmental organization (NGO) registered in Kenya with over 20 years' experience working on sustainable development issues by providing a grass-root link to policy matters in addition to empowerment activities. ALIN has been championing the use of ICTs to empower communities with usable information and knowledge to improve their livelihoods. www.alin.net

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Hakeem Khalid

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ACRONYMS

ACT	Agroecology Criteria Tool
ASTGS	Agricultural Sector Transformation and Growth Strategy
ATCs	Agriculture Training Centers
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter
C3S	Copernicus Climate Change Service
CAI	Climate Change Adaptation Index
CASSCOM	County Agriculture Sector Steering Committee
CBD	Convention on Biological Diversity
CBOs	Community-Based Organizations
CDS	Climate Data Store
CIDPs	County Integrated Development Plans
CLSPs	Climate and Landscape Smart Practices
CSA	Climate Smart Agriculture
CSIF	County-specific Strategic Investment Framework

CVA	Climate Vulnerability Assessment
DRC	Democratic Republic of Congo
EBA	Ecosystem-Based Adaptation
ECDE	Early Childhood Development Education
EMCA	Environmental Management and Coordination Act
ESG	Environmental Social Governance
FAO	Food and Agriculture Organisation
GAP	Good Agricultural Practices
GCA	Global Commission on Adaptation
GHGs	Green House Gases
GoK	Government of Kenya
ICT	Information and Communication Technology
IFMIS	Integrated Financial Management Information System
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated pest management
IPPD	Integrated Payroll and Personnel Database
KBA	Key Biodiversity Areas
KEFRI	Kenya Forest Research Institute
KPHC	Kenya Population and Housing Census
LAIFOMS	Local Authority Integrated Financial Operations Management System
MSPs	Multi-Stakeholder Platforms
NAMAs	Nationally Appropriate Mitigation Actions
NCCRS	National Climate Change Response Strategy
NCCAP	National Climate Change Action Plan
NEMA	National Environmental Management Authority
NGOs	Non-Governmental Organizations
PGS	Participatory Guarantee Systems
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SGR	Standard Gauge Railway
SSLM	Sustainable Soil and Landscape Management
TV	Television
UN	United Nations
USAID	United States Agency for International Development
WRUAs	Water Resource Users Association
4Rs	Right Source, Right Rate, Right Place, Right

GLOSSARY

Terms	Definition
Exposure	The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas.
Hazard	A dangerous phenomenon, substance, human activity, or condition that may cause the loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Climate Change	A change in the state of the climate can be identified (e.g., by using statistical tests) by changes in the mean and/or the variabilities of its properties that persist for an extended period, typically decades or longer. Climate Change may be due to natural internal processes, external forcings, or persistent anthropogenic changes in the atmosphere's composition or land use.
Adaptation	Adjusting natural or human activities in response to actual or expected disasters or their effects moderate harm or exploit beneficial opportunities.
Resilience	The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Vulnerability	The characteristics and circumstances of a community, system, or asset make it susceptible to a hazard's damaging effects.
Impacts	Specific effects of hazards or disasters are also referred to as consequences or outcomes.
Drought	It can be described as the naturally occurring phenomenon when precipitation has been significantly below normal recorded levels causing a serious hydrological imbalance that adversely affects land resource production systems.
Mitigation	Short and long-term actions, programs, or policies implemented in advance of a natural hazard or in its early stages to reduce the degree of risk to the people, property, and production capacity.
Meteorological Drought	Refers to a reduction in rainfall over a specific period, for example, a day, month, season, or year. There is no agreement on the lack of rain or the time without rain before it is considered a drought. Usually, the area affected determines these, especially in nonarid regions. Meteorological drought leads to soil moisture depletion, which almost always impacts crop production.
Agricultural Drought	Agricultural drought impacts from meteorological droughts and hydrological droughts on crop yields. This kind of drought is associated with extreme heat. It occurred when extended dry periods and a general lack of rainfall resulted in a lack of moisture in the root zone of the soil. This severely damages the plants that live in the area.

OVERVIEW

This document describes the findings of the climate vulnerability and ecosystem assessment that was conducted as a preparatory activity to facilitate the design of narrative scenarios that describe possible mitigation and adaptation paths for a just transition to low carbon and resilient climate future for Nakuru County. The tasks were undertaken through a desktop review of available documents, climate mapping, vulnerability assessment, recommendation of adaptation and mitigation pathways, and development of a story map. Climate vulnerability assessments were done using the climate change index to capture the extent of adaptation of the available measures, the Agroecology Criterion Tool (ACT) to determine the level of implementation of agroecology principles, and wet chemistry soil analysis techniques used to understand soil nutrient levels.

The tasks were undertaken through a desktop review of available documents, climate mapping, vulnerability assessment, recommendation of adaptation and mitigation pathways, and development of a story map.

The main findings from the climate vulnerability and ecosystem assessment are as follows:

1. Nakuru experiences mid-climates with warm temperatures (averages 17.5 °C) and around 762 mm yearly rainfall. On average, there are 112.63 hours of sunshine per month.
2. Areas around Rongai, Nakuru Town, Subukia, Gilgil, and Naivasha Sub-counties showed higher. In contrast, Molo, Kuresoi North, Kuresoi south, and a section of Njoro sub-counties showed the lowest temperature values.
3. Kuresoi North and Kuresoi South sub-counties received the highest precipitations compared to Gilgil and some parts of Naivasha sub-counties.
4. The climate critical threshold explorer/ expert tool (https://kenya-expert-tool.herokuapp.com/) will help users understand key adaptation challenges in their areas of interest by identifying location-specific climate changes based on specified crop temperature and precipitation thresholds for current and future climates. Using the information, users can generate a storyline about a particular crop's future in a particular location within Nakuru County.
5. The annual overall water risk is medium-high (3-4), while medium to high (0.6-0.8) drought risk values indicate a medium to a higher risk of drought; these imply that the population and agricultural activities are exposed to adverse effects of drought.
6. Commodities of interest include maize, beans, Irish potato, fruits and vegetables, flowers, livestock, poultry, and other food crops.
7. Climate hazards (landslides, drought/dry spells, excess rainfall, seasonal variability,

floods, and hailstones, changing rainfall patterns, increasing temperature, frosts, and strong winds) were identified to be critical in the agriculture sector.

8. Changing rainfall patterns, drought, and excessive rainfall negatively impacted farmers' production, post-harvest handling, marketing, and general social lives across all the agriculture areas in sub-counties in Nakuru County.

0. Farmers and other value chain actors mainly depended on indigenous information and radio. Neighbours were also critical providers of weather updates to access weather and climate information; however, this information did not translate to adaptation practices.

10. NGOs, research institutions, maize cooperatives, and county governments are the primary source of extension information; however, extension messaging did not entail climate risk and adaptation information.

11. Adaptation practices: uptake of soil fertility management practices was common. There was low uptake of natural resource management and recycling of agricultural waste practices. The high level of on-farm diversification could also imply low resilience.

12. The Climate adaptation index (CAI) was used to showcase how a set of adaptation practices guaranteed climate-risk responsiveness. Generally, the adaptation indexes across the sub-counties were not significantly different; however, Naivasha and Rongai Sub-counties show the highest climate adaptation index, followed by Nakuru Town and Molo sub-counties, while Bahati and Subukia sub-counties showed the least.

13. Through the lens of FAO agroecology principles, most farmers implemented adaptation practices that supported efficiency, recycling, regulation, synergies, and diversity and resilience dimensions.

The study recommended thirteen narrative scenarios to be implemented in the Nakuru County Climate Change Action Plan 2023-2027. The recommendations describe the possible mitigation, and adaptation paths for a just transition to low carbon and resilient climate future for Nakuru County. These recommendations are constructed against the backdrop that implementation of environmental protection and biodiversity conservation policies have been devolved to the county governments and are mainly lacking enough funding and technical expertise. Recommended practices include technological, knowledge, institutional, and financial solutions, as listed below;

1. Promotion and adoption of Sustainable Soil and Land Management (SSLM) practices.
2. Create an enabling environment for promoting and adopting agroecology and agrobiodiversity conservation.
3. Strengthen multi-stakeholder engagements/ innovation platforms to support agroecology and sustainable agriculture.
4. Strengthen Ecosystem-Based Adaptation (EBA).
5. Support promotion, uptake, and scale-up of agroforestry.
6. Promote the adoption of community-based seed banks.
7. Support for Agricultural Training Centers or model farms approach.
8. Promote access to organic farm inputs.
9. Support the adoption of local markets for farmers.
10. Strengthening agricultural extension systems to deliver increased productivity, resilience to climate change, and wealth

creation.

11. Support integrated pest management (IPM) and other alternative pest and disease management approaches.
12. Promote the adoption of renewable (clean and green) energy.
13. Promotion and adoption of sustainable waste management.

Finally, the Nakuru County Climate Vulnerability and Ecosystem Story Map (https://arcg.is/1mmL9q2) is an interactive climate story map with climate information maps, figures, and an expert tool as the primary support for the story was developed to provide insight into the climate change situation in agriculture in Nakuru County.

1. INTRODUCTION

Nakuru is derived from the Maasai language, meaning 'a dusty place'; this is because of the frequent whirlwinds that engulf the area with dust clouds.

1.1 Objectives

The main objective of this study was to conduct a climate vulnerability and ecosystem assessment for Nakuru County to facilitate the development of adaptation pathways to a just transition to low carbon and resilient climate future.

Specific Objectives Included:

1. Mapping patterns and impacts of climate change indicators related to precipitation/ temperature.
2. Ecosystem mapping and climate adaptation analysis.
3. Developing a narrative scenario that describes a possible path for a just transition to low carbon and resilient climate future for Nakuru County.
4. Combine climate projections, scenario planning, and simulation modeling through an iterative, participatory process.
5. Develop climate maps and stories that provide insights into the effect of climate change on sectors in Nakuru County.
6. Develop localized climate change case studies.

Key questions include:

1. **What climate-related hazards are experienced in Nakuru County, and what are their future projections?**
2. **How does one perceive climate change risks and their associated impacts on livelihoods?**
3. **Do the existing ecosystems (critical ecological services) have adequate resources to support sectors?**
4. **Are the existing practices in harmony with nature based on agroecology principles?**
5. **What feasible are best practices to facilitate adaptation while ensuring the least environmental impact?**

1.2 General Information on Nakuru County

Nakuru County is one of the 47 counties of the Republic of Kenya. Nakuru is derived from the Maasai language, meaning 'a dusty place'; this is because of the frequent whirlwinds that engulf the area with dust clouds. Nakuru County is among the most cosmopolitan counties in Kenya, with the dominant communities being the Kikuyu and Kalenjin. Other communities in the county include the Luo, Luhya, Maasai, Kamba, and Meru, among many others. Nakuru County is located in the Rift Valley region and is thus among the 14 Counties within the former Rift Valley Province. The primary economic activities in Nakuru include agriculture, tourism, and the service industry. Nakuru is an agricultural hub thriving in agriculture shaped by the early white settlement schemes. The human settlement in the county has been shaped by major transport infrastructure, including the early colonial rail network and road A104. The poverty level in the county is 29.1 per cent, which is lower than the National level of 36.1 per cent.

1.2.1 Geography

Nakuru County covers an area of approximately 7,498.8 square kilometers. It is located between Longitudes 35.41 ° East or 35 ° 24' 36" East and 36.6 °East or 36 °36' 0" East and Latitude 0.23 ° North or 0 ° 13' 48" North and 1.16 ° South or 1° 9`36" South (Figure 1.1). It is located in the Rift Valley and borders seven Counties of Laikipia to the north-east, Kericho to the West, Narok to the south-west, Kajiado to the South, Baringo to the North, Nyandarua to the East, and Bomet to the West. The County has 11 sub-counties or constituencies: Naivasha, Nakuru Town West, Nakuru Town East, Kuresoi South, Kuresoi North, Molo, Rongai, Subukia, Njoro, Gilgil, and Bahati. There are 55 wards in the County. The County's two major towns are; Nakuru Town, the County's headquarters, and Naivasha town, which is popular for local and international tourism because of its proximity to Nairobi, the capital city of Kenya. Nakuru and Naivasha towns are complemented by other urban centres spread across the County that include; Molo, Njoro, Gilgil, Mai Mahiu, Subukia, Salgaa, and Rongai.

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1.2.2 Demography

Nakuru County is home to 2.162 Million people per the 2019 Kenya Population and Housing Census (KPHC). This represents 4.54 per cent of the Kenyan population. The county sits on an area of 7462 square feet, thus a population density of 289.7/Km^2 with a 3.0% annual population change. In terms of gender, the males are 1,077.272. The females are slightly more than 1,084,835, while the intersex are 95. Nakuru has 616046 households, meaning that each household in Nakuru County has between 3-4 people. The county's largest population

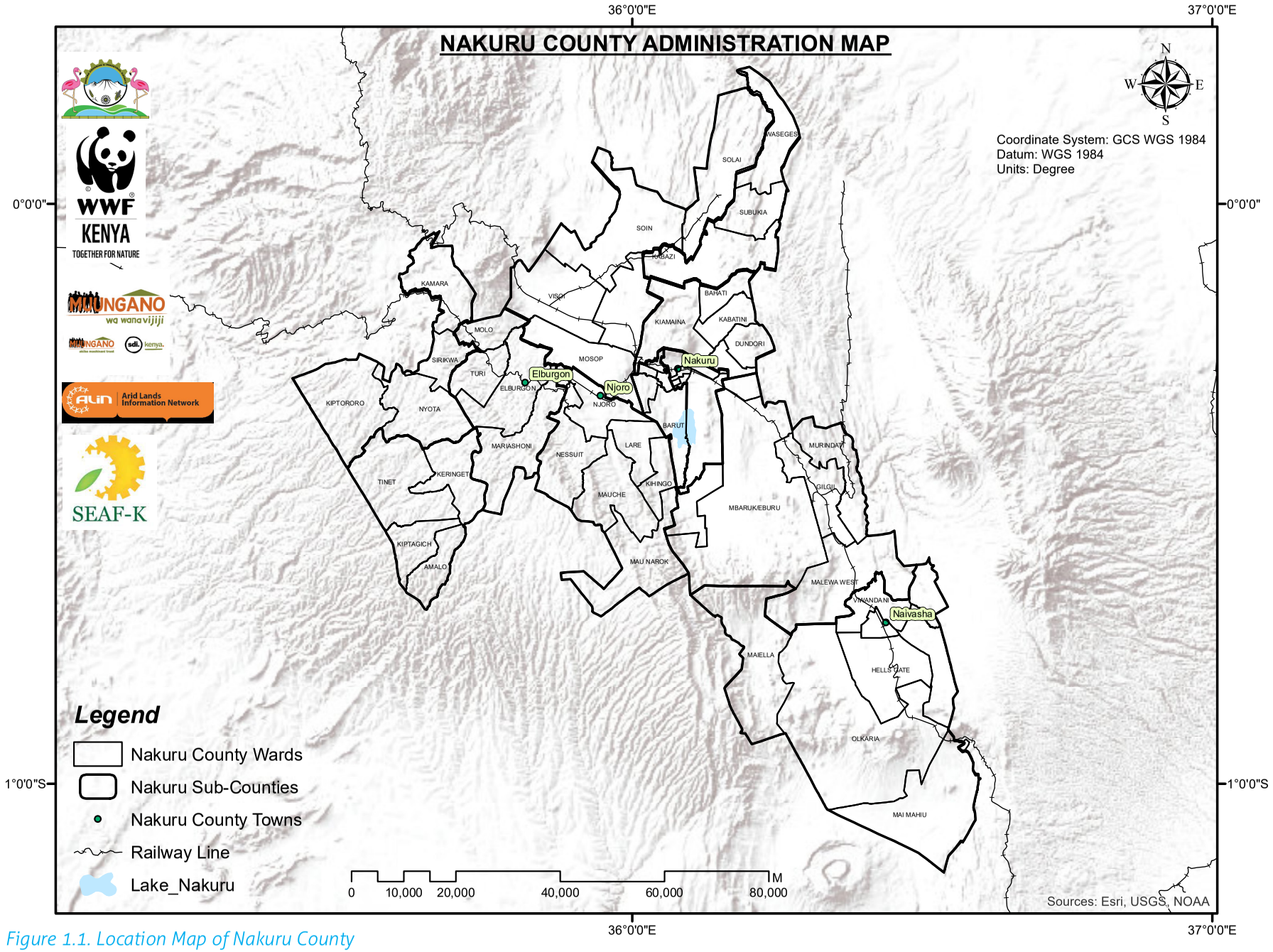


Figure 1.1. Location Map of Nakuru County

The Nakuru County is home to 2.162 Million people per the 2019 Kenya Population and Housing Census (KPHC). This represents 4.54 per cent of the Kenyan population. The county sits on an area of 7462 square feet, thus a population density of 289.7/ Km² with a 3.0% annual population change.

is individuals between 0-9 years, and the population decreases with age such that those over 80 make up the smallest population.

Regarding population distribution per sub-county, Naivasha Sub-county has the highest population at 355,383 people, while Subukia Sub-county has the least population at a total of 85,164. The population density is, however, higher than that of Naivasha as it stands at 212. Of this population, 1,115,122 reside in rural areas, while 1,047,080 reside in urban centers. Nakuru Town West Sub-county carries the distinction of having the highest population density with a population of 199661 people and an area of 71.9 km² and has a population density of 2764, while Nakuru Town East Sub-county comes a distant second at a population density of 840 as its total population is 193926 and sits on a far larger area than Nakuru Town West Sub-county. Christianity is dominant, followed by Islam and Hindu (Figure 1.2).

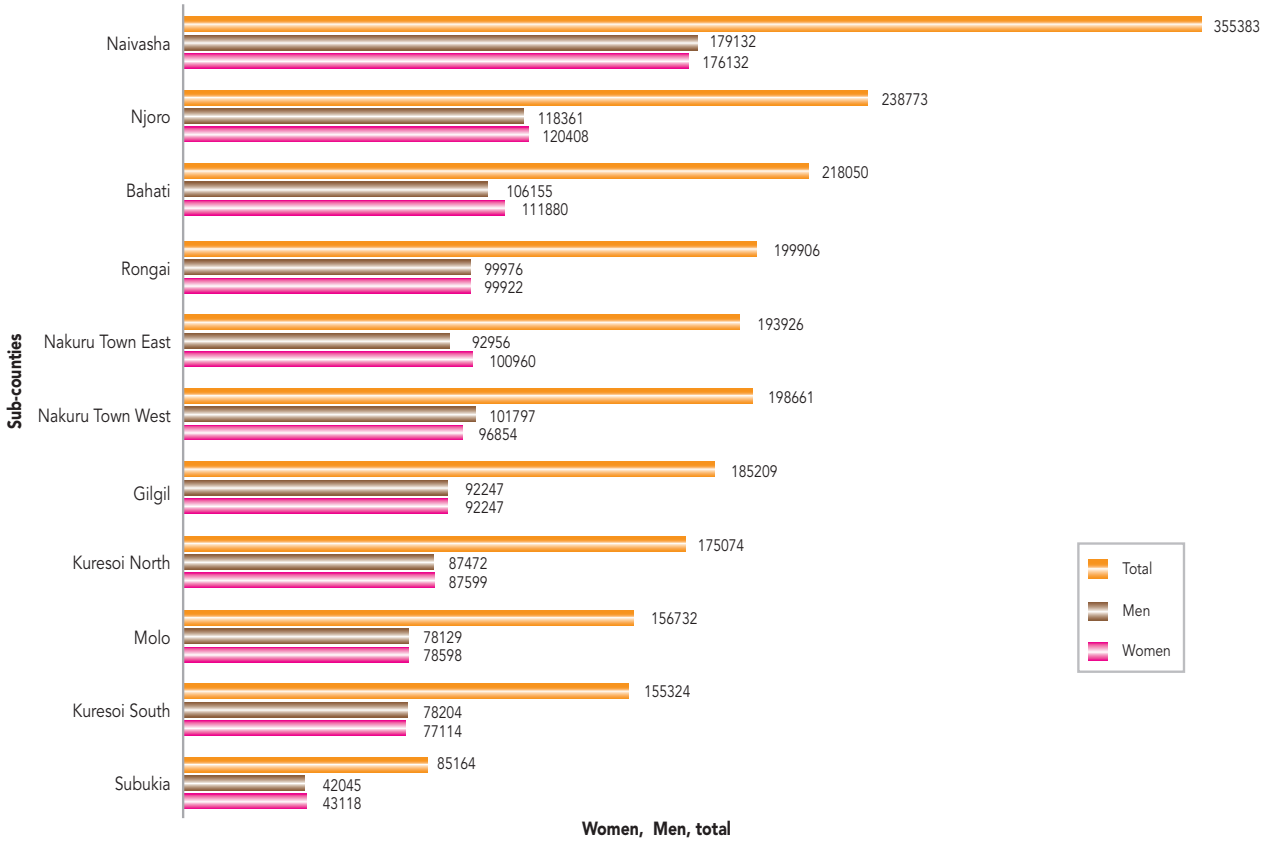


Figure 1.2. Nakuru county Census (Source: KPHC, 2019)[16]

1.2.3 Economy, Agriculture, Food Security, and Nutrition

The economy of Nakuru County is driven mainly by agriculture, manufacturing, tourism, and the service sector. The agricultural sector entails cash crop production such as wheat, coffee, pyrethrum, tea, and floriculture, and ranching and apiculture. The county has the main market, Wakulima Market, in Nakuru town, as well as hawkers' complexes and small markets in other major towns. A number of industries drive the economy of the county; they include animal feeds production companies, agricultural inputs companies, e.g., Syngenta, engineering works, manufacturing industries, e.g., Keroche, Menengai Oil Refineries, canners, dairy products, bakery, and hotel industry. There are more than 1,500 fish ponds in the county for fish farming, and fishing activities occur in freshwater lakes, e.g., Lake Naivasha. Other activities, such as boat riding and sport fishing, are available in the Lakes.

Nakuru County is among the counties with tourist attractions, thus receiving many tourists. The main tourist attraction and activities include National parks (Lake Nakuru National Park, Hells Gate National Park, and Mt. Longonot National Park), Menengai Crater, Subukia Shrine, Lord Egerton Castle, Lake Naivasha, lake Elementaita, Hyrax Hill Prehistoric site, Ol-doinyo Eburu volcano, Mau forest, and Kariandusi prehistoric site. Tourism activities contribute to a large chunk of the country's economy.

Mining activities are also part of the county's economic activities and boast minerals such as kaolin, diatomite, sand, building stones, trona, and carbon dioxide. All the economic activities herein provide job opportunities for the youths and are a source of revenue for the county.

Seventy per cent of the total land in Nakuru County is highly agriculturally productive. If measures are implemented, food production will provide a surplus for the county residents. Most households depend on agriculture, and a significant number of farmers have an average land holding of 0.77 hectares; however, 49% are poor, while 36% of the county's population are food poor. Half of the county's population does not have access to healthy and nutritious food.

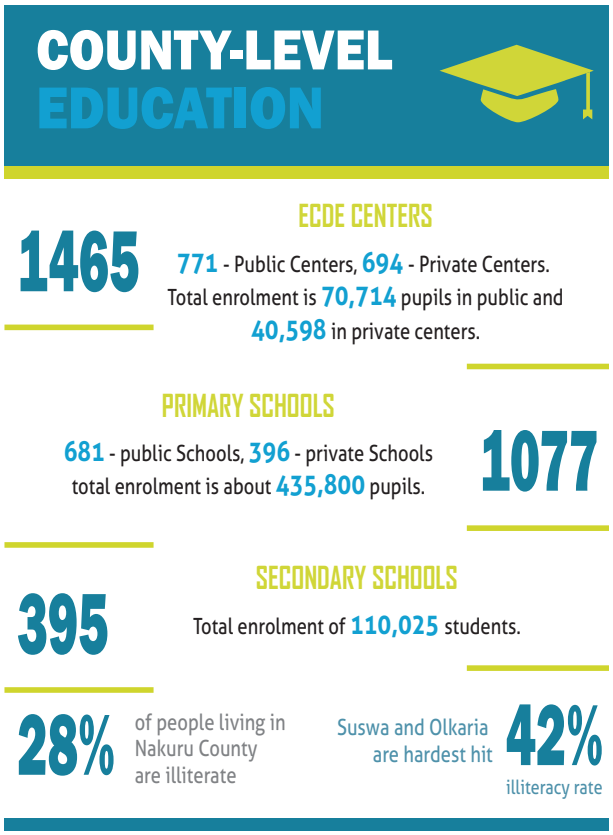
1.2.4 Livelihoods

The livelihoods of 60% of the country's population are either directly or indirectly dependent on the agricultural sector but are endangered. This is against Millennium Development Goal 1, which calls for a reduction in the number of people who suffer from hunger and whose income is less than 1 US$ a day. More than 90% of rural inhabitants engage in subsistence agriculture or agribusiness. Additionally, the urban poor has farms in rural areas and practice farming but are poorer than the urban dwellers who do not farm. Some farming activities take place in the county's significant towns but mainly of basic foodstuffs for self-consumption. Some Nakuru residents are either formally employed in manufacturing or service.

This is against Millennium Development Goal 1, which calls for a reduction in the number of people who suffer from hunger and whose income is less than 1 US$ a day.

1.2.5 Education and Literacy Levels

The county-level education comprises early childhood development education (ECDE) and vocational training services. The county, however, has 1077 primary schools, of which 681 are public while 396 are private. The total enrolment is about 435,800 pupils. There are 1.465 ECDE centers, of which 771 are public while 694 are private. 70,714 children are enrolled in these public ECDE centers, and the private ECDE centers host about 40,598 pupils. There are 395 secondary schools with a total enrolment of 110,025 students. 28% of the people living in Nakuru County are illiterate; however, this is most common among the minority communities. The Department of Education states that the areas around Suswa and Olkaria are hardest hit at an illiteracy rate of 42 per cent.



1.2.6 Development Challenges

Nakuru County is faced with several challenges that impede development. These challenges include inadequate physical and financial resources, low literacy levels, and poverty.

Additionally, small-scale farmers have scarce land resources, thus limiting their productivity. Likewise, inadequate financial resources prevent the county from meeting its developmental objectives. The revenue collected from the county and the allocation from the National government are still below the county targets. Thus capital intensive projects cannot be conducted.

Low literacy levels in the remote parts of the county present impediments to development. The illiterate cannot engage in modern constructive developmental activities. The high poverty levels in the county are an essential factor limiting development. Most people, as mentioned earlier, thrive through agriculture. However, poor farmers have limited resources to acquire agricultural inputs such as certified seeds, fertilizers, and agrochemicals. Likewise, they lack technology, information, and financial support, which leads to low agricultural productivity.

> *The present physical infrastructure in Nakuru County is not sufficient to spur faster growth, as envisaged in the 2018 – 2022 County Integrated Development Plans (CIDPs).*

1.2.7 Transport and Infrastructure

The transport network in Nakuru County is divided into road networks, rail networks, and airstrips.

i. Road Network

The entire road network in Nakuru County is approximately 12,491km. Out of which paved roads are 993.7 km, gravel roads are 4,500 km, and earth roads are 6,998km. The road infrastructure can be described as 20% good, 35% fair, and 45% poor. Some roads, especially in affluent agricultural areas, including Kuresoi North and South, Molo, Njoro Subukia, Naivasha, and Gilgil, are still in deplorable condition, leading to delays in transporting agricultural produce to the market, making farmers incur losses for perishable goods. The in-progress, the Nairobi- Nakuru Highway, will ease traffic on the A104 road since this is a major highway connecting Kenya to Uganda, Rwanda, South Sudan, and the Democratic Republic of Congo (DRC).

Transformation of the Giotto Waste Disposal Site. Photo credit: Elmad Ogara - County Government Nakuru.

ii. Rail Network

The old railway line traverses through Nakuru County to Uganda, transporting cargo mainly from the port of Mombasa to the Malaba border. On the other hand, the Standard Gauge Railway (SGR) passes through Mai Mahiu to Naivasha before proceeding to Narok County. The contentious dry port in Naivasha due to the SGR is expected to boost economic activities in the County if its plans are not changed.

iii. Airport and Airstrips

Currently, Nakuru County does not have an existing airport. However, there are plans to expand the airstrip at Lanet Military Base for commercial services. This will improve economic integration with the rest of the nation and open an international market for products within the County, including direct export of horticulture and floriculture.

1.2.8 Information and Communication Technology (ICT)

The rapid uptake of ICT has seen a significant rise in investment in ICT infrastructure across the County. An estimated 82.5 per cent of households in Nakuru County own a mobile phone, whereas the mobile network coverage in the County is more than 91 per cent. Internet access is at 16.3 per cent, access to television at 56.6 per cent, and radio access is at 90.8 per cent (KIHBS 2015-16).

The County Government has put in place strategies towards the adoption of ICT, and some of the ICT platforms utilized in the County include; Integrated Financial Management Information System (IFMIS), Integrated Payroll and Personnel Database (IPPD), Local Authority Integrated Financial Operations Management System (LAIFOMs) and ZIZI.

> *Also, with the support of the Presidential Digital Communication Unit, the County has provided free internet service through WIFI hotspots, popularly known as 'Bilawaya,'*

Also, with the support of the Presidential Digital Communication Unit, the County has provided free internet service through WIFI hotspots, popularly known as 'Bilawaya,' thus promoting access to internet services. In addition, there are several post offices across the County despite facing fierce competition from other courier service providers and services provided by Public Service Vehicles.

1.3 Climate Change, Biodiversity and Ecosystems in Kenya

The changing temperature and distorted rainfall patterns in Kenya are the key indicators of climate change witnessed in Kenya. Temperatures have increased in the past fifty years in many parts of the country. Impacts of temperature increase include the depletion of glaciers on Mount Kenya and sea level rise. These temperature increases negatively affect biodiversity and ecosystem services in the country. Likewise, rainfall patterns indicate increased irregularity and variability with neutral to slightly decreasing trends in annual rainfall over most areas in Kenya; in other instances, unprecedented droughts and floods have been noted. Climate change and other factors have been shown to affect biodiversity and ecosystems.

1.3.1 Drivers of Climate Change Vulnerability in Kenya

Kenya has continued to be vulnerable to climate change, and the threat this poses to achieving long-term development goals has been recognized. As a result, Kenya initiated a concerted national effort to respond to climate change, which commenced with the National Climate Change Response Strategy (NCCRS) development in 2010[1]. The vulnerability of Kenya to climate change is driven by a number of factors that can be classified under social, economic, physical, and environmental factors.

1. Social factors

Some Kenyan communities (such as the Maasai and Samburu) keep large herds of animals as signs of social well-being. Such large herds result in overgrazing, thus enhancing grounds for floods. Also, herbivores produce large amounts of methane gas when they digest vegetation, thus increasing methane levels in the atmosphere; methane is also a greenhouse gas.

The lifestyles of Kenyans are also a contributor to climate change. The consumption of goods such as clothing, plastics, and electronics by individuals and households is linked to the emission of greenhouse gasses. Likewise, the increased use of power in homesteads and food consumption resulting in waste contributes to greenhouse gas emissions.

2. Economic factors

Cutting trees, industrialization, and agricultural practices are the main economic factors driving climate change in Kenya. Deforestation for economic purposes such as lumbering and charcoal production reduces the number of trees and vegetation, which play an essential role in regulating atmospheric carbon dioxide levels, leading to the increased greenhouse effect.

Agricultural practices such as using nitrogen-containing fertilizers lead to the emission of nitrous oxide gases which have a greenhouse effect. Likewise, some pesticides and herbicides used in agricultural practices contain fuels that have a greenhouse effect. Therefore, as the automation of agriculture increases, the impacts on climate also increase.

3. Physical factors

Kenya is situated on the equator and is thus expected to receive moderate rainfall and experience reasonable temperature ranges diurnally. However, some parts of the country have higher altitudes than others, while some regions have flat or rugged topographies. The plateaus are prone to flooding when the errant rains come, but Kenya's physical characteristics generally do not broadly impact climate change.

In Kenya, greenhouse gas emission is constantly increasing; for instance, they increased by the highest margin of 17.92% from 2018 to 2019.

4. Environmental factors

The increased emissions of greenhouse gases by industries and automobiles contribute mainly to climate change. Burning fossil fuels are the key contributor to greenhouse gases which lead to the greenhouse effect. The global level of carbon dioxide (the most significant contributor to the greenhouse effect) has risen to 48% of its pre-industrial levels. In Kenya, greenhouse gas emission is constantly increasing; for instance, they increased by the highest margin of 17.92% from 2018 to 2019. This is due to increased industrialization, an increase in the number of automobiles, and a decline in forest cover.

1.3.2 Biodiversity and Ecosystem Threats in Nakuru County

In ecosystems and biodiversity, threats are human activities and processes that cause or may cause destruction and/or impairment of biodiversity targets. The national biodiversity threat assessment scores for Kenya indicate

that the potential of threat abatement for reducing species extinction risk is higher than the potential of habitat restoration; thus, the critical importance of conservation rather than rejuvenation. The threats to ecology and biodiversity in Nakuru County are as follows:

1. Climate change

Climate change significantly impacts biodiversity due to subsequent habitat shifting and alteration. Temperature extremes due to climate change have a high impact on plant species as well as aquatic animals. Likewise, increased rainfalls and storms raise the water level in local lakes, thus displacing mammals and birds around the lakes, especially the resident types, rather than migratory birds.

2. Agriculture

STAR analysis shows that agriculture and forestry are the two main economic activities affecting species extinction risk in Kenya; thus, reducing these threats offers the highest potential for enhanced species survival. The collective impact from small and large farms has been found to have a high impact on birds and other small animals. Planting exotic trees that lower the water table has been found to destroy habitats. Likewise, agro-industry grazing, ranching, and farming greatly impact terrestrial mammals. At the same time, poor livestock management practices lead to land degradation, which enhances the loss of grazing potential for wild species.

3. Residential and commercial development

Residential and commercial development has been found to turn green areas into highly fragmented and unsuitable habitats. Therefore, many species disappear, reducing diversity by only accommodating adaptable indigenous and invasive alien species. Housing and urban development have high impacts on birds and affect bird biodiversity.

4. Mining and quarrying

Mining and quarrying impact aquatic and terrestrial organisms because they destroy habitats, thus affecting both plants and animals. These activities lead to the removal of the surface features which interfere with the natural habitats. Additionally, dust, noise, and pollution from these activities negatively impact plants and animals while exposing the land to adverse environmental conditions such as flooding.

5. Transport and service sectors

Transport and service sectors significantly impact birds, especially through collisions and electrocutions of birds on power lines, thus leading to mass mortalities. This is common in large birds such as cranes, storks, vultures, flamingos, and other birds of prey because their larger size makes it difficult for them to maneuver between power lines. Roads and railroads significantly impact terrestrial mammals because they degrade and fragment critical habitats while obstructing migratory pathways.

6. Biological resource use

Using biological resources such as wood and animals for food and other uses significantly impacts biodiversity. Hunting for bush meat is compounded by drought, food insecurity, and poverty, reducing the animal and plant population. Likewise, illegal hunting for commercial uses leads to population declines of the targeted species, even in protected areas. Retaliatory killing responses from human-wildlife conflict lead to the losses of considerable mammal species. Human encroachment near protected areas due to increasing populations also poses threats to biodiversity, which is displaced. Charcoal burning and fuelwood collection destroy forest and woodland habitats, significantly impacting animals and plants. Uncontrolled fishing and

harvesting of other aquatic resources interfere with the ecological balance of the aquatic ecosystems, thus affecting biodiversity.

7. Modifications of natural systems

The impacts of construction of dams and other similar water management structures impact the bird habitat, especially Flamingo species. Likewise, overharvesting water for urban supplies and farming affects the natural systems in the lakes and other natural water bodies, thus impacting the biodiversity of the aquatic habitats and the surrounding.

8. Pollution

Both industrial and agricultural effluents have the most significant impact on all ecosystems. Specifically, water pollution from urban centers and agricultural run-off leads to eutrophication in the wetlands, which can lead to aquatic mortalities. Such mortalities affect other organisms in trophic levels that depend on aquatic bio-life. General pollution from Nakuru town has adversely affected Lake Nakuru on more than one occasion.

1.3.3 Impacts of Climate Change on Various Sectors

Climate change is one of the most important issues in this recent era across Kenya. The impact of climate change influences Nakuru County. Eventually, Sub-counties and wards are at a high risk of natural disasters because of their geographical location and other reasons such as having low-lying landscapes, poverty, population, illiteracy, alteration of seasonal patterns, low-quality infrastructure etc. This section highlights insights into the effects of climate change on the various key sectors in Nakuru County. Common effects of climate change-related hazards in Nakuru County include landslides, drought/dry spells, excess rainfall, changing rainfall patterns, increasing temperature, floods, hailstones, frost/extreme cold, and strong winds. Eventually, various sectors of Nakuru County are very much vulnerable to climate change.

Sub-counties and wards are at a high risk of natural disasters because of their geographical location and other reasons such as having low-lying landscapes, poverty, population, illiteracy, alteration of seasonal patterns, low-quality infrastructure

By taking some effective policies, Nakuru County can decrease the impact of climate change, such as greening the community, energy efficiency, choosing renewable resources, and eating wisely. Nakuru County should plant more trees to maintain carbon dioxide and oxygen levels in the atmosphere. In addition, The County must be very sincere about this vulnerable disaster and be careful to take effective policies to combat this challenge.

1. Human health and productivity

Climate change impacts threaten the health of farmers by affecting the food, water, air, and weather experienced. The severity of these health risks will depend on the ability of public health and safety systems to address or prepare for these changing threats, as well as factors such as an individual's behaviour, age, gender, and economic status. Impacts will vary based on where a person lives, how sensitive they are to health threats, how much they are exposed to climate change impacts, and how well they and their community can adapt to change.

2. Agriculture

Agriculture is one of the most important sectors across Nakuru County. Because of the impact of climate change, the agricultural sector is impacted tremendously. The rate of crop production decrease because of changing the pattern of the temperature, moisture etc. Especially plant growth is stunted. Thus, agricultural land loses its productivity gradually. Even, Climate change acts as a brake. As we have a huge population, we need more crop production to maintain the food demand. Due to global warming, the quantity of food production is going down.

3. Water Resources

As the temperature of the atmosphere increases day by day, the pattern of the water cycle is highly affected. The water crisis is an important issue in this world, and the main reason for this problem is climate change. On the other hand, some sub-counties in Nakuru may face some vulnerable problems because of the changing climate. The water level in lakes like Nakuru, Naivasha, Baringo is rising, and the rate of flooding, waterborne disease, crop production, and damage to different infrastructures is increasing gradually. As Nakuru County is located in that kind of geographical location, the lake water level rise can be very much hazardous for the people across the County, especially the population of the low land areas.

On the other hand, water quality and quantity are impacted by increasing precipitation, decreasing precipitation, and increasing water temperatures in lakes and streams. The available freshwater is also decreased because of climate change-related effects.

4. Forestry and biodiversity

Climate impacts the structure and function of forest ecosystems and plays an essential role in forest health. A changing climate may worsen many forest threats, such as pest outbreaks, fires, human development, and drought. Climate changes, directly and indirectly, affect the growth and productivity of forests as the temperature, rainfall, weather, and other factors change. Besides, elevated levels of carbon dioxide affect the growth of different plant species. These changes influence complex forest ecosystems in many ways.

The water level in lakes like Nakuru, Naivasha, Baringo is rising, and the rate of flooding, waterborne disease, crop production, and damage to different infrastructures is increasing gradually.

On the other hand, as the temperature increases and the water level rises because of climate change, the total biome of the earth is also impacted. There are so many trees and animals in Nakuru County that are affected.

5. Tourism

Tourism is one of Kenya's largest and fastest-growing economic areas. The climate change phenomenon is expected to continue throughout the 21st century and beyond with serious ramifications, including increased occurrence and intensity of adverse weather events such as storms, ocean warming, droughts, and glacier melting. The regional manifestation of climate will be highly sensitive to tourists and destinations, requiring adaptation from all tourism stakeholders. The effects of climate change are already becoming

evident at various destinations worldwide. Global climate change has also begun influencing decision-making in the tourism sector. The natural environment, climate, and personal safety influence destination choice. Experts believe that global climate change is expected to impact all three elements at the regional level significantly.

Tourists have a more exceptional ability to adapt to the effects of climate change as they can avoid destinations suffering from the adverse impacts of climate change or change travel timing to avoid unfavourable climate conditions. Tourists' response to climate change's impact on destinations and other attractions will reshape the tourism industry's demand patterns. Understanding and anticipating the potential seasonal and geographic shifts in tourism demand will be critical for major stakeholders in the sector. Tourists from temperate countries currently dominating international travel are expected to adapt their plans to take advantage of new climatic conditions closer to home. The shift in travel patterns will have huge implications, including more spending in residents and neighbouring nations and less in warmer countries currently frequented by tourists from temperate regions.

The effects of climate change in safari destinations are already being felt in many countries. In mid-2012, flooding led to a three-day closure of the main road to the Maasai Mara National Reserve, one of the most popular tourist destinations in Kenya, severely affecting tourism activities in the area.

6. *Transport and Infrustructure*

Road and air transport are considered major contributors to climate change, making up 23 per cent of CO_2 emissions. Transport is also vulnerable to climate change effects, particularly due to many facilities like roads and bus terminals in flood zones. Extreme weather increases weather variability, and roads designed for a particular climate range may fail more quickly. These additional costs to design and retrofit, as well as decreasing user reliability.

Climate change may have multidimensional adverse impacts on the safety, performance and longevity of existing bridges and, in extreme cases, could even result in the loss of some bridges due to extreme temperatures, higher flood levels and velocities and bushfires.

1.3.4 Climate Change and Biodiversity Protection Policies in Kenya

Climate change refers to the long-term (typically decades or longer) changes in global temperature, precipitation, wind patterns, and other climate measures that can be statistically verified. The climate in Kenya is influenced by global, regional, and localized climate conditions. Some of the country's climate variability is due to the El Niño Southern Oscillation, which has caused periods of drought and flooding over decades. The effects of climate change on biodiversity are immense. The National Climate Change Action Plan (NCCAP), 2018-2022[2], analyzed the existing institutional structures and proposed some institutional frameworks spelling out the roles of climate change response. It recommended formulating and enacting a framework for climate change law, which led to Climate Change Act, 2016[3]. The county governments were tasked with integrating and mainstreaming climate change actions, interventions and duties into their CIDPs. National Environmental Management Authority (NEMA)[4] was tasked with monitoring and enforcing compliance with climate change interventions on behalf of the Climate Change Committee.

Kenya has put in place interventions to tackle biodiversity loss. These intervention strategies include environmental policies and legislation, community involvement, national biodiversity assessment and documentation, sustainable management, and biodiversity conservation, including fair and equitable benefit-sharing. Also, technical and scientific research support, information dissemination, capacity-building, and integrated national planning for development. The efforts aimed to preserve the threatened areas, human livelihoods, and threatened species and reverse the loss of biodiversity, indirectly addressing the challenges that result from human activities responsible for biodiversity loss and environmental change. Other efforts aimed at supporting sustainable development and protecting bio-resources, their habitats, and the ecosystems while at the same time supporting bio-entrepreneurship.

> *The National Climate Change Action Plan (NCCAP), 2018-2022, analyzed the existing institutional structures and proposed some institutional frameworks spelling out the roles of climate change response. It recommended formulating and enacting a framework for climate change law, which led to Climate Change Act, 2016.*

Protecting Kenya's natural habitats and biodiversity is guided by Articles 42 and 70 of the Constitution of Kenya, 2010, and the Environmental Management and Coordination Act (EMCA), 1999[5]. In Article 42, the constitution gives every person the right to "a clean and healthy environment." At the same time, Article 70 empowers anyone whose right to a clean and healthy environment is violated to seek legal redress. Therefore, anyone who contributes to making the environment unhealthy can be sued. Finally, Article 360 (1b) requires the state to work towards a 10% forest cover. The Environmental Management

and Coordination Act (EMCA), 1999; Forest Conservation and Management Act, 2016[6], The East African Community Polythene Materials Control Bill, 2016; and Fisheries Management and Development Act, 2016, likewise guide biodiversity protection and conservation. The Acts stipulated that the NEMA coordinates the management of biodiversity resources in Kenya.

Other institutions, such as County Governments, also enact their acts to achieve the objectives of NEMA and EMCA or to support the EMCA, which has inherent weaknesses. Additionally, Kenya ratified the Convention on Biological Diversity (CBD), a negotiated biodiversity agreement committed to the sustainable use of biodiversity. Kenya, therefore, participates in the CBD's international programs of work in dry and sub-humid lands biodiversity, agricultural biodiversity, inland waters biodiversity, forest biodiversity, mountain biodiversity, marine and coastal biodiversity, and forest biodiversity. The National Biodiversity Strategy & Action Plan 2019-2030 is a document with guidelines on biodiversity conservation actions. Some of the specific conservation efforts and strategies based on the policies are described herein.

Kenya, therefore, participates in the CBD's international programs of work in dry and sub-humid lands biodiversity, agricultural biodiversity, inland waters biodiversity, forest biodiversity, mountain biodiversity, marine and coastal biodiversity, and forest biodiversity.

1. *In-situ conservation efforts and strategies*

In-situ conservation efforts and strategies include protecting areas such as National Parks, National Reserves, Sanctuaries, Marine Reserves, and Forest Reserves through in-situ management by the Kenya Wildlife Service or Kenya Forest Service or conjointly with communities. Their primary goal is to protect wildlife as defined in the broadest sense by the Wildlife Bill 2009. In marginalized areas, in-situ conservation can be done by licensed private ranches.

2. *Ex-situ conservation efforts and strategies*

In Kenya, ex-situ conservation facilities are mainly for plant biodiversity conservation. Conservation is done in The National Gene bank for cultivated and wild species of economic value. The Kenya Forest Research Institute (KEFRI), which supports forestry research, also maintains ex-situ conservation through collections at the Seed Centre in Muguga and live plants in Nairobi Arboretum. Botanical and zoological gardens hold plant and animal collections for research, education, conservation, and recreation. Urban centers and municipalities have parks and gardens, for instance, Uhuru Gardens and Uhuru Park, Jamhuri and City Parks, Kericho Arboretum, and Muliro Gardens.

3. *Integrated Agricultural Development*

Agricultural developments are made in a way that benefits biodiversity. Pasturelands, woodlands, croplands, and wetlands are integrated with typical agricultural ecosystems, benefiting some wild animals and plants. However, integrating agricultural development with natural habitats requires careful implementation that ensures compatibility without heightening human-wildlife conflict.

4. Rangeland Management

Rangelands are marginal areas dominated by grass and grass-like species that may be interspersed with woody species. Rangeland covers about 70% of the Kenyan land area and holds large populations of wild animals and plants. Conservation of rangelands includes grazing management that promotes increasing and sustaining livestock production; this has been established to decrease rangeland diversity in favour of grassland communities. In riparian and aquatic habitats surrounded by dry lands, ranching practices that protect water quality, such as excluding livestock by introducing buffer zones, work well in biodiversity conservation. Prescribed grazing, livestock exclusion, and the creation of paddocks are ranching practices that conserve and protect local biodiversity. Appropriate stocking rates are critical in biodiversity management and conservation.

5. Integrated land use planning

Most biodiversity is usually higher on marginally productive land, which is not ideal for agriculture. Therefore, sustainable resource use does not contradict biodiversity conservation. The land policy provides a framework for land use planning, allowing the use of each part of the landscape for purposes that best suits it. Biodiversity can thus benefit if the planning of land use considers it.

Integrated land use planning should be used to protect communities from climate risks in several ways, including (i) limiting the urban, infrastructure and economic activities development in hazard-prone areas, (ii) ensuring that the built environment can withstand climate extremes, (iii) strengthening the resilience of natural ecosystems that work as buffer areas against hazards, ensuring the protection of natural environments and planning for nature-based solutions.

6. Public awareness

Increasing public awareness is one critical step in biodiversity conservation. This can be done through educational, incentive, and voluntary programs (e.g., the Lewa Marathon and Save the Rhino Marathon). Generally, the guiding principles of the policies on biodiversity conservation include preventive, precautionary, polluter paying, public participation and access to information, good governance, sectoral integration, and ecosystem (integrated) approach.

1.3.5 Climate Change and Biodiversity Protection Policies in Kenya

The County Government Act, 2012[7] is an Act of Parliament that requires counties to produce a ten-year spatial plan to guide development. This Act allows the county Government of Nakuru to formulate its climate change and biodiversity conservation plan. Agriculture, tourism, infrastructure, health, natural resources, and especially biodiversity are the main sectors that are most vulnerable to climate change. Thus policy measures should be framed to address these sectors. The Climate Act 2016 offered the regulatory framework for enhanced response to climate change through mechanisms and measures to achieve low carbon climate resilient development through mainly mainstreaming climate change responses into development planning, decision making, and implementation.

Based on the National Climate Action Plan 2018-2022, Nakuru County framed its Act in 2021 termed The Nakuru County Climate Change Act, 2021. This is an Act of the Nakuru County Assembly established to put in place the framework and mechanisms for mobilization

and facilitation of the county government, communities, and other stakeholders to respond effectively to climate change through appropriate adaptation and mitigation measures as well as actions and related purposes. The Act established the County Climate Change Steering Committee, the County Climate Change Planning Committee, the County Climate Change Unit, and the Ward Climate Change Planning Committees, whose mandate is to enhance climate resilience through development management, implementation, regulation, and monitoring of adaptation and mitigation measures and actions. Nakuru County Climate Change Action Plan is a 5-year plan that contains the county climate change management plans for the stipulated periods. Issues of climate change prevention are also captured in other development plans such as the Nakuru County Spatial Development Plan (2015-2025), Nakuru County Annual Development plans and budgetary process, Clean Energy Policy, and Public Health and Sanitation Act, 2017.

1.3.6 Agroecology, Climate Change and Biodiversity Resilience

Globally, there is an increasing call to transform food systems towards more sustainability and resilience, as evidenced by the ongoing dialogues towards the upcoming United Nations (UN) food summit. This implies the need for rethinking and recreating our supply chains. Agroecology has been identified as one of the food system transformation pathways due to its potential to realize climate resilience (Sinclair et al. 2019). Already, the Global Commission on Adaptation (GCA) has included recommendations on the use of agroecological practices to build the resilience of smallholder farms and pledged a commitment to the action track of agriculture and food security to enable access to agroecological practices for 60 million smallholders[8]. Agroecology territoriality, context specificity, and Agile (bottom-up) approach based on knowledge co-development make it adequate to drive climate resilience in farming systems (Flippert et al., 2019).

Biological diversity is critical in stabilizing ecosystem functioning in environmental fluctuation. Specifically, species diversity has been found to influence ecosystem productivity in human-managed ecosystems. A resilient ecosystem can return to its normal patterns and processes after ecological disturbance damage it. Likewise, ecosystem conservation is important in building communities' resilience to climate change's impacts. For instance, good conservation practices of water catchment areas ensure that communities downstream continue to enjoy a regulated flow of water even during dry seasons. Therefore, climate change and human activities disturb biodiversity, but several actions can be taken to improve biodiversity and ecological resilience. The existing national and county-level policies are framed to promote climate change prevention and enhance biodiversity resilience. Additionally, the existing policies are more theoretical than practical, with

...good conservation practices of water catchment areas ensure that communities downstream continue to enjoy a regulated flow of water even during dry seasons.

numerous bodies and committees. However, the country, specifically Nakuru County, is still faced with climate change and the destruction of biodiversity because the available policies do not give specific action plans but only offer frameworks whose practical aspects are uncertain.

Agroecology could therefore bridge the ecological and social dimensions, people-centred, and knowledge-intensive aspects that are part of the agricultural food systems in Nakuru County. Using agroecological pathways would imply developing food systems that address the root causes of problems while providing holistic solutions. Beyond climate resilience, agroecology contributes to over 7 of the Sustainable Development Goals (SDGs) by contributing to no poverty (SDG 1), zero hunger (SDG 2), good health and wellbeing (SDG 3), decent work and economic growth (SDG 8), responsible consumption and production (SDG 12), climate action (SDG 13) and life on land (SDG 15). Agroecology's connection to climate resilience is based on these core principles (diversity, efficient use of natural resources, nutrient recycling, natural regulation, and synergies). It can guarantee resilience and reduction of greenhouse gases (GHGs) in agricultural systems if well-implemented.

A number of smallholder farmers' practices are collectively regarded as agroecological;

Nakuru County, is still faced with climate change and the destruction of biodiversity because the available policies do not give specific action plans but only offer frameworks whose practical aspects are uncertain.

for instance, mixed and agroforestry systems have been considered more resilient than the specialized unit. Practices like intercropping legumes with cereals resulted in higher moisture content and increased nutrient recycling, shielding the crop and the people against the adverse impacts of climate change (Ndiso et al., 2017). The value of such mixed systems, including diversification and agroforestry systems, is considered appropriate in reducing vulnerability and is well recognized by the IPCC Special Report on Climate Change and Land (IPCC, 2019). This, therefore, implies that agroecological approaches could be an entry point for enhancing resilience to future climatic shocks while guaranteeing the protection of existing biodiversity.

1.4 Climate Vulnerability Assessment

The extent to which different sectors, especially agricultural systems, are vulnerable to climate change impacts is location specific owing to, among other reasons, the nature/intensity of climate hazards and the ability of the local systems to adapt to or mitigate related impacts. A climate vulnerability assessment (CVA) is conducted to ascertain the vulnerability of specific regions. Climate vulnerability assessments (CVA) analyze the extent to which human and ecological systems are likely to be affected by climate variability and change (USAID, 2014). The two broad approaches that could be adopted in assessing climate vulnerability; are the "top-down" and the "bottom-up" methods (Dessai & Hulme, 2004). The top-down approach starts by analyzing climate change impacts, while the bottom-up approaches analyze the people affected by climate change. Some refer to the two as biophysical and social vulnerability, respectively (Brooks, 2003). Top-down approaches are usually preferred at global, national, and regional levels, while bottom-up approaches start their analysis at the local level (e.g., households, villages, communities). The selected approach largely depends on the available knowledge, data, technical abilities, and capacity (people, time, and money) (Nelitz et al., 2013).

1.5 Ecosystem Mapping

Biodiversity is declining rapidly as human activities, especially agriculture, drive global-scale species loss and ecosystem changes. Managing ecosystem threats requires using data to show the risky areas and prioritizing conservation decisions that should be integrated as best practices. Ecosystem mapping is conducted to help understand the performance of ecological systems. This information is critical when conducting climate change vulnerability assessments due to the interconnectedness of climate change and biodiversity. Threat maps are used to visualize the distribution, seasonality, and intensity of threats. Nakuru County is one of the Counties with rich Biodiversity in Kenya, and finance implies the need for understanding the interconnectedness of biodiversity and production systems while ascertaining emerging threats.

1.6 Rationale of the study

Considering the United Nations Commodity and Development Report (2019)[9], Kenya is entirely vulnerable (31st most vulnerable country) to, yet unready (37th least prepared country) to battle climate change effects. However, the 2030 Agenda for Sustainable Development adopted by the United Nations provides a roadmap with sustainable development goals (SDGs). In particular, SDG 12, on sustainable production and consumption patterns, links with other goals such as eliminating hunger and conserving the environment through a food systems approach. This calls for the transformation of food systems at the global and local levels (including a shift of paradigm from merely supplying food to providing high-quality diets) to ensure the multidimensional goal of sustainability.

Agroecology is an important driver for enhancing sustainable food systems- and the progressive realization of the right to adequate and safe food in the context of the Constitution of Kenya 2010. Agroecology has the potential to facilitate a transition towards more productive, sustainable, and inclusive food systems. Its potential derives from its ambition to connect environmental sustainability and social innovation, production and consumption, global concerns, and local dynamics through the support of locally adopted solutions. Agroecology seeks to optimize the interactions between plants, animals, humans, and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced. It can enable counties and communities to produce healthy and nutritious food while protecting the environment and ensuring social inclusion.

Despite the availability of numerous progressive environmental and biodiversity protection policies at the national and county levels, implementing agroecology, smart landscape practices, and nature-based solutions into research, policy, and practice in Nakuru County is limited. Lack of technical expertise and meek budgetary allocations are impediments to implementing such policies. The rationale for integrating agroecology into the Nakuru County Climate Change Action Plan (2023-2027) is justified on various grounds, including;

- Environmental degradation of agro ecosystems, including soils and water.
- Adverse impacts of climate change on food production systems.
- Increased food security threats and food demands with an increasing population.
- High costs of alternative farm (crops, livestock, and fisheries) inputs.
- General global and local shifts in market demand to safer food exports-organic products and food produced through regenerative practices.
- Lack of a policy and regulatory framework for promoting and scaling up agroecology.
- Increased pollution by farm chemicals in the various ecosystems, especially agro and terrestrial ecosystems.
- Increased contamination of farm inputs pollutants in food chains.
- Increase in environmental pollution from industrialization and the need to reduce gas and chemical emissions.

2. METHODOLOGY

The tasks were undertaken through a desktop review of available documents, climate mapping, and vulnerability assessment to obtain information on the following aspects:

2.1 Document Search and Review

A rapid review of the literature collated all documents related to climate change policies, strategies/plans, programs, and projects across Nakuru County in Kenya. A search of documents from various databases, including Google Scholar, Open Access Journals, and websites of the national governments of Kenya and the County Government of Nakuru, was done. Some searched websites included Think hazard, Kenya hazard profile, and Kenya climate change profile. Data generated was used to describe the climate vulnerability and to develop adaptation practices that enhance resilience in Nakuru County.

2.2 Mapping Climatic Conditions

The patterns and impacts of climate change indicators for Nakuru County were examined by mapping several precipitation/temperature (flood/drought)-related characteristics at a regular grid scale. Indicators included various droughts, from the distribution of meteorological and hydrological drought risks to social vulnerability and indices related to water infrastructure. The climatic conditions for Nakuru County are primarily controlled by the elevation of the area (Figure 2.1).

The study used several publicly available datasets ranging from demographics and socioeconomics to natural resources and climate (population, water development database, development Indicators, land-use dataset, water stress database, and Earth trends searchable database, among others). The relevant agro-climatic indicators showing agricultural suitability information were explored based on temperature and precipitation, taking the interest of smallholder farmers into account.

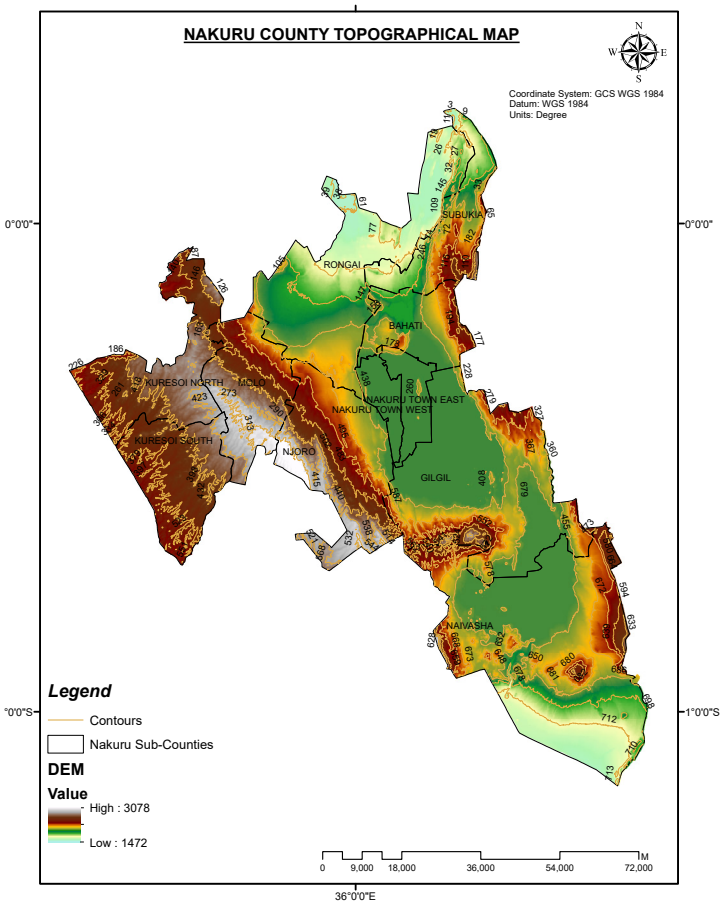


Figure 2.1. Nakuru County Elevation map

The future projections were based on the ERA5-Land reanalysis dataset and a selection of five models (IPSL-CM5A-MR, HadGEM2-ES, MPI-ESM-LR, NorESM1-M, &GFDL-ESM2) from the Coupled Model Intercomparison Project 5 (CMIP5) climate models ensemble (Jones et al., 2011; Brands et al., 2013; Samuelsson et al., 2015; McSweeney and Jones, 2016; King et al., 2018) based on temperature days and precipitation day under RCP8.5, a high emissions scenario. To harmonize the 9 km resolution of the reanalysis product and the much coarser climate projections, the climate signal was regridded to the era5-land grid using the nearest neighbour on the historical data (superimposed change). This allowed a comparison between the current and future climate (Thépaut, 2014).

To illustrate these findings to the public and sensitize decision-makers to the challenges and opportunities of climate change in Nakuru County, temperature and precipitation information was designed and implemented in an interactive toolbox (expert tool) embedded in the climate story map. For both temperature and precipitation indicators, projections are available up to 2100. The climate expert tool provides an integrated perspective on climate change by putting together diverse information on climate change impacts to address questions relating to agriculture, rising temperature, drought conditions, and water resources tailored to specific crops. The subsequent analysis of maps allowed several policy-relevant messages to be extracted.

The climate expert tool provides an integrated perspective on climate change by putting together diverse information on climate change impacts to address questions relating to agriculture, rising temperature, drought conditions, and water resources tailored to specific crops.

2.3 Climate Vulnerability Assessment

Climate vulnerability assessment involved hazard identification and mapping of impacts and identification of Climate responsive measures as discussed herein. A household survey was conducted to capture information on climate hazards, impacts on agriculture systems, the existing capacities at the farmer level in managing the risks, and the general practices taken up based on identified adaptation practices across sub-counties in Nakuru County. The Kobo Collect tool kit was used in the data collection process. The sample size was 200 households. A total of 9 sub-counties (Bahati, Kuresoi (North & South), Naivasha, Njoro, Subukia, Gilgil, Molo, Municipality (Nakuru Town West & Nakuru Town East) and Rongai) were considered based on spatial area and climate differentiation of sub-counties across Nakuru County. On average, the sample represented 20 households per sub-county. The data were summarized using descriptive statistics (frequencies and percentages) for each sub-County. Key indicators analyzed were related to the climate

adaptation index and agroecology dimensions to understand hazards, impacts, capacity aspects (access to extension, insurance, finance, etc.), and climate adaptation index while ascertaining the extent to which farming practices address the ten principles (FAO, 2018) of agroecology. Data analysis for the quantitative data was done using Excel/SPSS.

2.3.1 Climate Adaptation Index Analysis

Solidaridad's Climate Change Adaptation Index (CAI) tool captured information about climate change-related hazards and their exposure levels. The tool developed two scores 1) a **Climate Risk Score** to contextualize climate risk and vulnerabilities and 2) the **Climate Adaptation Index,** which was to score the adaptation practices promoted based on available measures. When conducting assessments using the CAI tool, semi-standard groups of questions were asked to understand the hazards, exposure level, adaptation practices, and capacity. Consistency in scoring was critical for removing subjectivity.

Critical steps in using the CAI tool.

- Step 1: Climate hazard scoring: Assesses key hazard risk in the region/landscape
- Step 2: Exposure scoring: Assesses exposure elements using two categories
- Step 3: Vulnerability scoring: Assesses vulnerability elements based on two predefined categories (sensitivity and capacity)
- Step 4: Climate Adaptation Index (CAI): Measures the contribution of climate risk responsive farm practices reducing vulnerability and increasing resilience. Scores and weights each adaptation practice from the predefined categories, as illustrated in Figure 2.2.

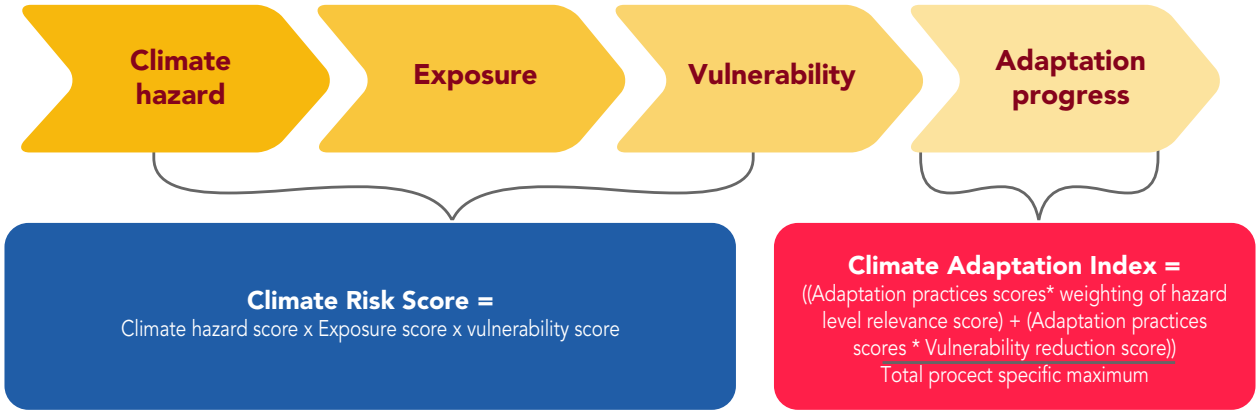


Figure 2.2. Critical Steps in Using the Climate Adaptation Index (Source: Solidaridad)

Climate hazard, exposure, vulnerability scores, and Climate Adaptation Index (CAI) scores for each farmer were subsequently summarized in an excel sheet and subject to analysis in Gen-stat statistical software to find relationships between variables (gender, level of education, access to finances, access to extension services) for each sub-county.

2.3.2 Agroecology Dimension Analysis

The developed adaptation practices implemented by farmers were scored against the Agroecology Criteria Tool (ACT) to determine the level of implementation of each aspect under each element. The ACT contains 62 criteria reflecting activities supporting agroecological change on farms and wider food systems. The ACT methodology is based on the analytical framework of Gliessman (2014) and the FAO's 10+ elements of agroecology within the five levels of food system change. In the framework, each element has a list of relevant criteria. The following FAO elements are represented in the tool: diversity, synergies, efficiency, resilience, recycling, co-creation, sharing of knowledge, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy. This analysis similarly yields recommendations on additional practices to be implemented by farmers if a good transition towards agroecological farming has to be achieved by farmers in Nakuru County. The principles are critical for implementing best practices and developing an enabling framework for scaling up agroecology in ecosystems (Biovision & IPES-Food, 2020), as illustrated in Figure 2.3.

> *The Agroecology Criteria Tool (ACT) contains 62 criteria reflecting activities supporting agroecological change on farms and wider food systems.*

Figure 2.3. Framework for scaling up Agroecology in Ecosystems to Support Agroecological Transitions.

2.4 Pathways for Low carbon and resilient climate future for Nakuru County

Narrative scenarios that describe possible mitigation and adaptation paths for a just transition to low carbon and resilient climate future for Nakuru County were developed based on management practices implemented by farmers. A menu of practices was yielded based on climate and landscape smart practices (CLSPs) that aim to reduce vulnerability while guaranteeing the resilience of the agriculture system. The subsequent analysis of adaptation pathways allowed several potential projects and policy-relevant messages to be extracted.

2.5 Development of Nakuru County Climate Story Map

The approach to developing the climate information maps is by downscaling global climate models to the Kenyan context, specifically Nakuru County, and developing an information interface that meets users' needs. This involved combining historical data, climate projections, scenario planning, and simulation modeling through an iterative, participatory process, developing climate maps and stories that provide insights into the effect of climate change on sectors in Nakuru County, and developing localized climate change case studies. To ensure maximum uptake and dissemination of information, the results were put together into an interactive atlas with stories allowing the user to select different variables.

Findings from a review of available documents, climate mapping, and vulnerability assessment for Nakuru County are summarised in the following aspects.

3. FINDINGS

3.1 Climatic Conditions for Nakuru County

The month with the highest relative humidity is November (71.03 %). The month with the lowest relative humidity is February (45.41 %). The month with the highest number of rainy days is November (14.83 days). The month with the lowest number of rainy days is February (3.00 days). The climate here is mild and generally warm and temperate. The rain in Nakuru falls mostly in the winter, with relatively little rain in the summer. The Köppen-Geiger climate classification is Csb. The temperature here averages 17.5 °C | 63.5 °F. The rainfall here is around 762 mm | 30.0 inches per year. Figure 3.1 shows the climate graph for Nakuru County.

In Nakuru, the month with the most daily hours of sunshine is February, with an average of 10.28 hours of sunshine. In total, there are 318.72 hours of sunshine throughout February. The month with the fewest daily hours of sunshine in Nakuru is January, with an average of 8.47 hours a day. In total, there were 253.97 hours of sunshine in January. Around 3423.07 hours of sunshine are counted in Nakuru throughout the year. On average, there are 112.63 hours of sunshine per month, as illustrated in Figure 3.2.

Precipitation is the lowest in January, with an average of 21 mm | 0.8 inches. In April, the

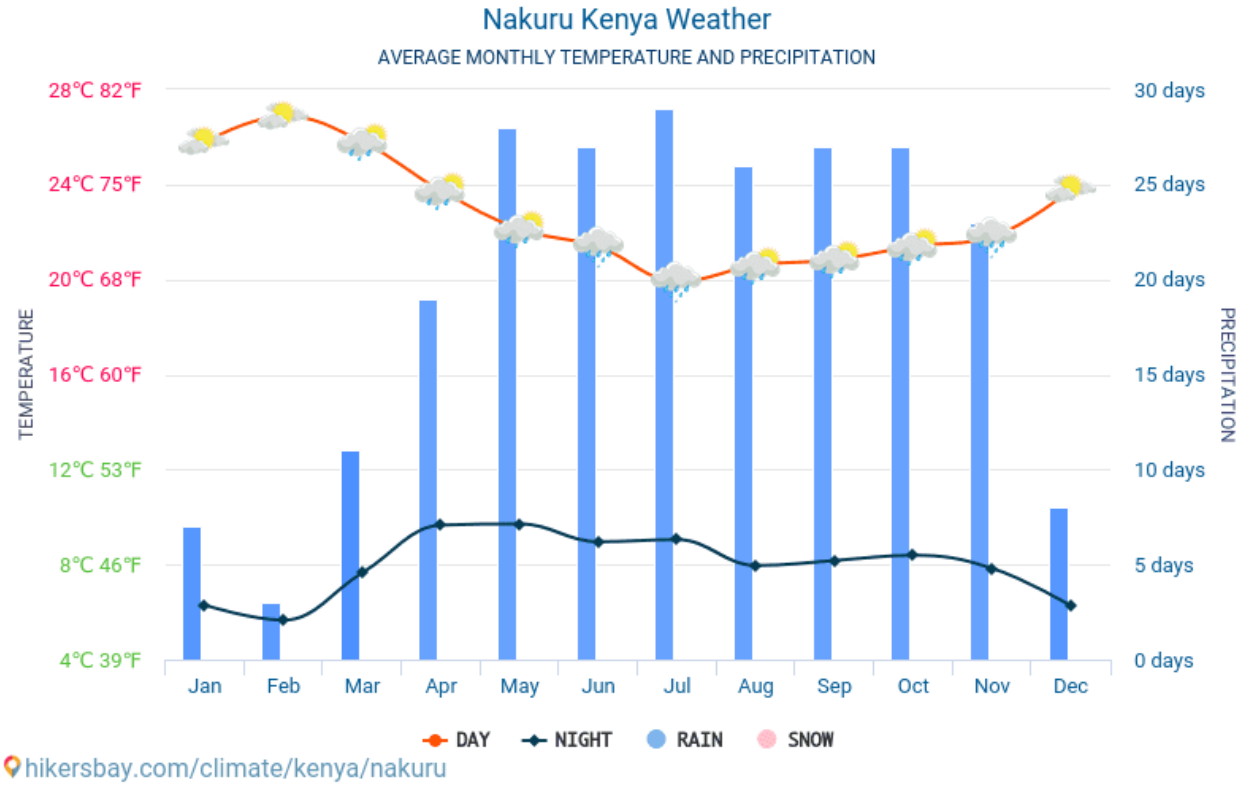


Figure 3.1a. Climate (Precipitation and Temperature) Graph by month for Nakuru County.

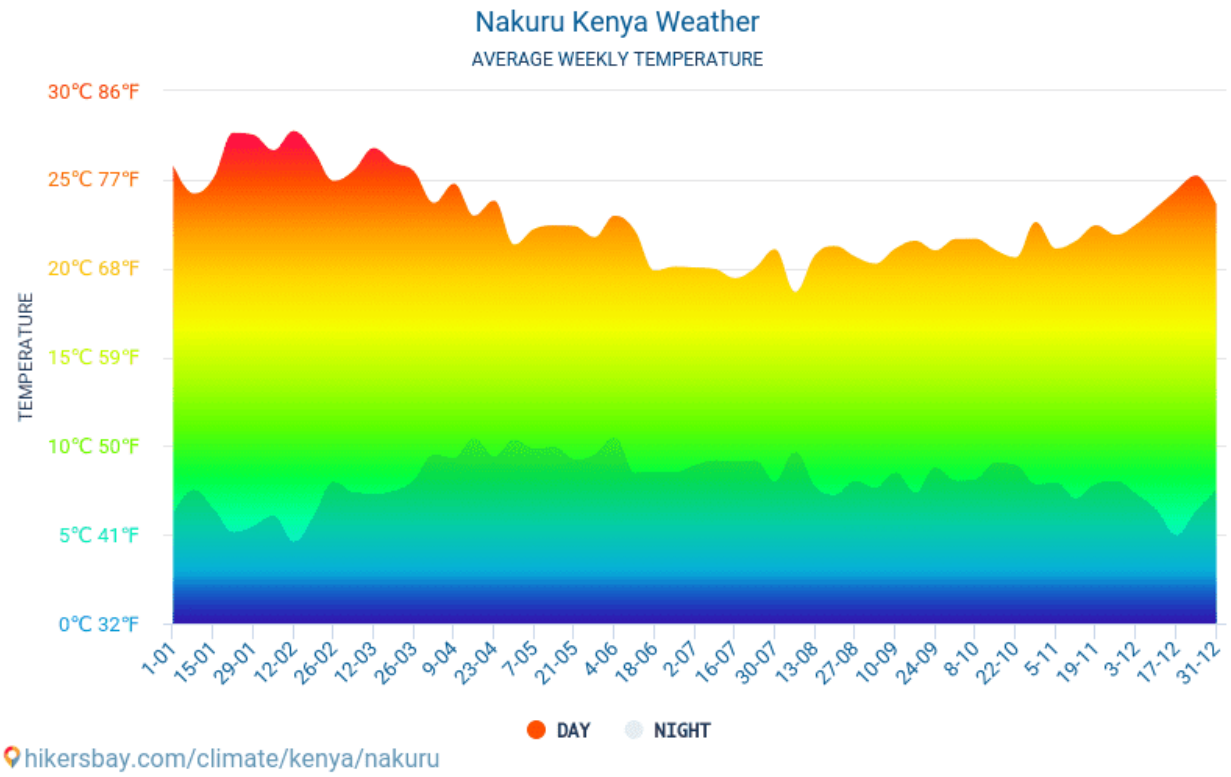


Figure 3.1. Climate (Precipitation and Temperature) Graph by month and weekly for Nakuru County.

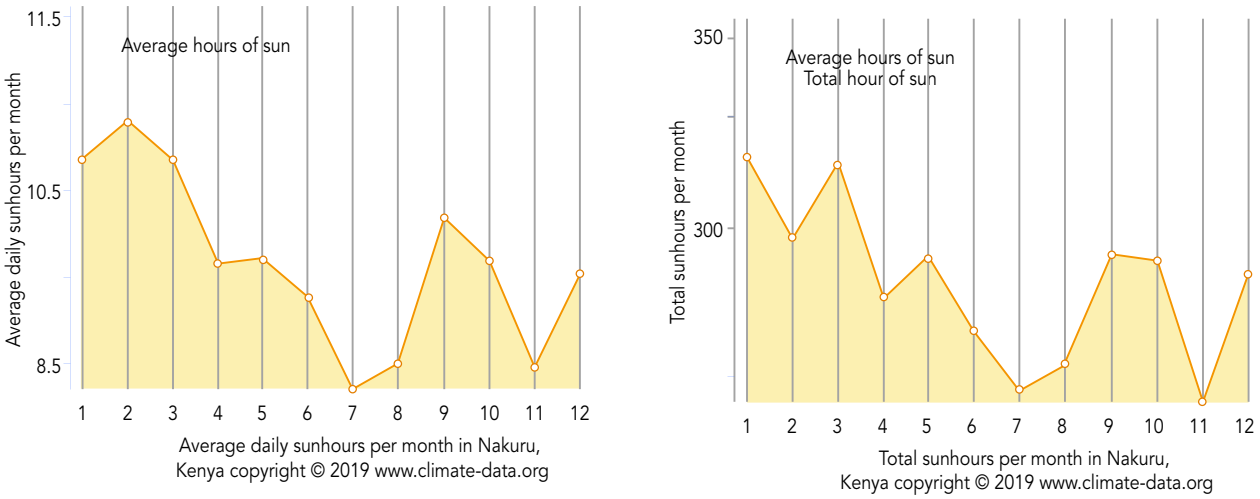


Figure 3.2. Average and total hours of sunshine in Nakuru County.

precipitation reaches its peak, with an average of 109 mm | 4.3 inches. At an average temperature of 19.4 °C | 67.0 °F, March is the hottest month of the year. At 16.0 °C | 60.8 °F on average, July is the coldest month of the year. Between the driest and wettest months, the difference in precipitation is 88 mm | 3 inches. The variation in annual temperature is around 3.4 °C | 6.2 °F, as shown by monthly averages in Figure 3.3.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	18.4 °C (65.2) °F	19.3 °C (66.8) °F	19.4 °C (67) °F	18.2 °C (64.8) °F	17.4 °C (63.4) °F	16.7 °C (62.1) °F	16 °C (60.8) °F	16.1 °C (60.9) °F	16.9 °C (62.3) °F	17.4 °C (63.2) °F	17 °C (62.6) °F	17.4 °C (63.4) °F
Min. Temperature °C (°F)	12.6 °C (54.7) °F	12.5 °C (54.5) °F	12.9 °C (55.1) °F	13 °C (55.4) °F	12.6 °C (54.7) °F	11.8 °C (53.2) °F	11.2 °C (52.1) °F	11.1 °C (52.1) °F	11.1 °C (52) °F	12 °C (53.6) °F	12.6 °C (54.7) °F	12.7 °C (54.8) °F
Max. Temperature °C (°F)	24.4 °C (75.9) °F	26.1 °C (78.9) °F	26 °C (78.7) °F	23.8 °C (74.8) °F	22.8 °C (73) °F	22 °C (71.7) °F	21.1 °C (70) °F	21.3 °C (70.3) °F	22.6 °C (72.8) °F	22.9 °C (73.2) °F	21.9 °C (71.4) °F	22.6 °C (72.8) °F
Precipitation / Rainfall mm (in)	21 (0)	21 (0)	53 (2)	109 (4)	74 (2)	53 (2)	61 (2)	78 (3)	53 (2)	94 (3)	100 (3)	45 (1)
Humidity(%)	52%	45%	51%	66%	69%	68%	69%	70%	64%	65%	71%	63%
Rainy days (d)	3	2	5	9	7	7	9	9	6	9	11	6
avg. Sun hours (hours)	10.3	10.6	10.2	9.4	9.4	9.1	8.3	8.5	9.8	9.4	8.5	9.3

Data: 1991 - 2021 Min. Temperature °C (°F), Max. Temperature °C (°F), Precipitation / Rainfall mm (in), Humidity, Rainy days. Data: 1999 - 2019: avg. Sun hours

Figure 3.3. Nakuru County Weather and Climate for Every Month.

3.1.1 Historical climate for Nakuru County

19 "bioclimatic" variables (average for 1970-2000) are derived from monthly temperature and precipitation values to generate more biologically meaningful variables. This data was released in January 2020. The data is available at a spatial resolution of 30 seconds (~1 km^2). The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation), seasonality (e.g., annual range in temperature and precipitation), and extreme or limiting environmental factors (e.g., the temperature of the coldest and warmest month, and precipitation of the wet and dry quarters). A quarter is a period of three months (1/4 of the year), as illustrated in **Appendix II**.

Areas around Rongai, Nakuru Town, Subukia, Gilgil, and Naivasha Sub-counties showed relatively high temperatures; highest annual mean temperature (about 23.6°C), highest mean diurnal range of temperature (about 15.77°C), highest maximum temperature of the wettest month (about 32.90°C), highest minimum temperature of the coldest month (about 16.1°C), highest annual temperature range (about 19.9°C), highest mean temperature of the wettest quarter (about 24.25°C), highest mean temperature of the driest quarter (about 23.68°C), highest mean temperature of the warmest quarter (about 24.37°C), highest mean temperature of the coldest quarter (about 22.85°C) compared to Molo, Kuresoi North, Kuresoi south, and a section of Njoro sub-counties showed lowest temperatures; Annual mean temperature (about 6.0°C), lowest mean diurnal range of temperature (about 10.11°C), lowest maximum temperature of the wettest month (about 14.70°C), lowest minimum temperature of the coldest month (about 0.5°C), lowest annual temperature range (about 12.5°C), lowest mean temperature of the wettest quarter (about 7.8°C), lowest mean temperature of the driest quarter (about 7.18°C), lowest mean

temperature of the warmest quarter (about 7.88°C), lowest mean temperature of the coldest quarter (about 5.82°C) as illustrated in **Figure 3.4**.

In addition, areas within Kuresoi North, Kuresoi South, Molo, Rongai, Subukia, some parts of Njoro, and Nakuru Town Sub counties experienced the highest isothermality (about 86.18(°C) and low-temperature seasonality (about 55.9°C), compared to Naivasha and Gilgil sub-counties which experience lowest isothermality (about 72.20°C) and highest-temperature seasonality (about 55.98°C).

Kuresoi North and Kuresoi South sub-counties received the highest mean annual precipitation (about 1784 mm), highest precipitation of the wettest month (about 293 mm), high precipitation of the driest month (about 74.0mm), highest precipitation of the wettest quarter (about 677.0 mm), highest precipitation of the driest quarter (about 251.0 mm), highest Precipitation of Warmest Quarter

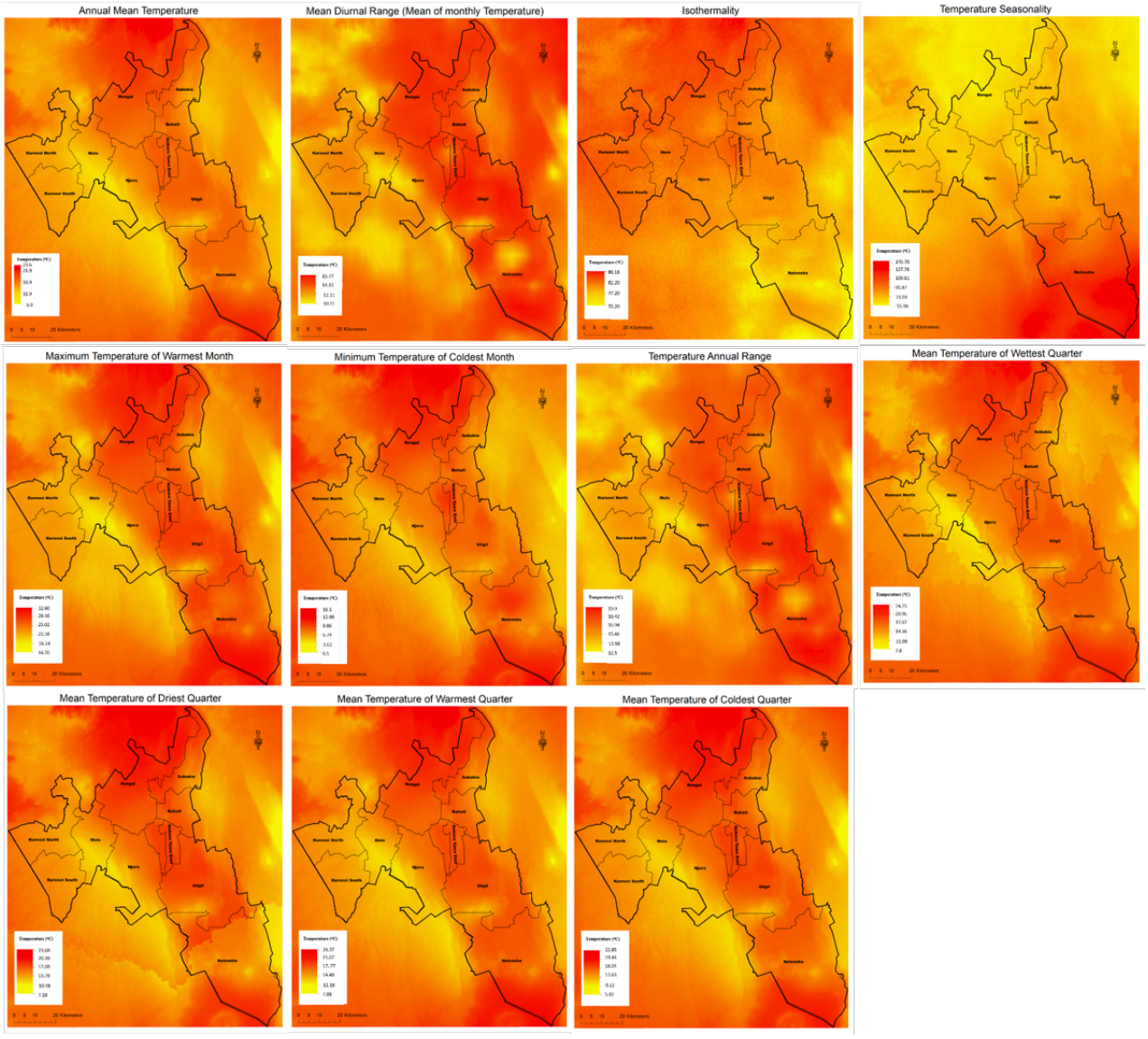


Figure 3.4. Maps of Bioclimatic Variables (Temperature) for Nakuru County. (Source: Fick & Hijmans, 2017)

(about 473.0 mm), and highest Precipitation of Coldest Quarter (about 544.0 mm). On the other hand, Gilgil and some parts of Naivasha sub-counties received the lowest mean annual precipitation (about 608.0 mm), low precipitation of the wettest month (about 93 mm), lowest precipitation of the driest month (about 17.0), lowest precipitation of the wettest quarter (about 210.0 mm), lowest precipitation of the driest quarter (about 59.0 mm), lowest precipitation of the warmest quarter (about 142.0), and the lowest precipitation of the Coldest Quarter (about 68.0 mm). On the other hand, Naivasha and Subukia sub-counties have the highest precipitation Seasonality (about 76.74 mm). In contrast, some parts of the Njoro sub-county have the lowest Precipitation Seasonality (about 30.77 mm), as illustrated in **Figure 3.5**.

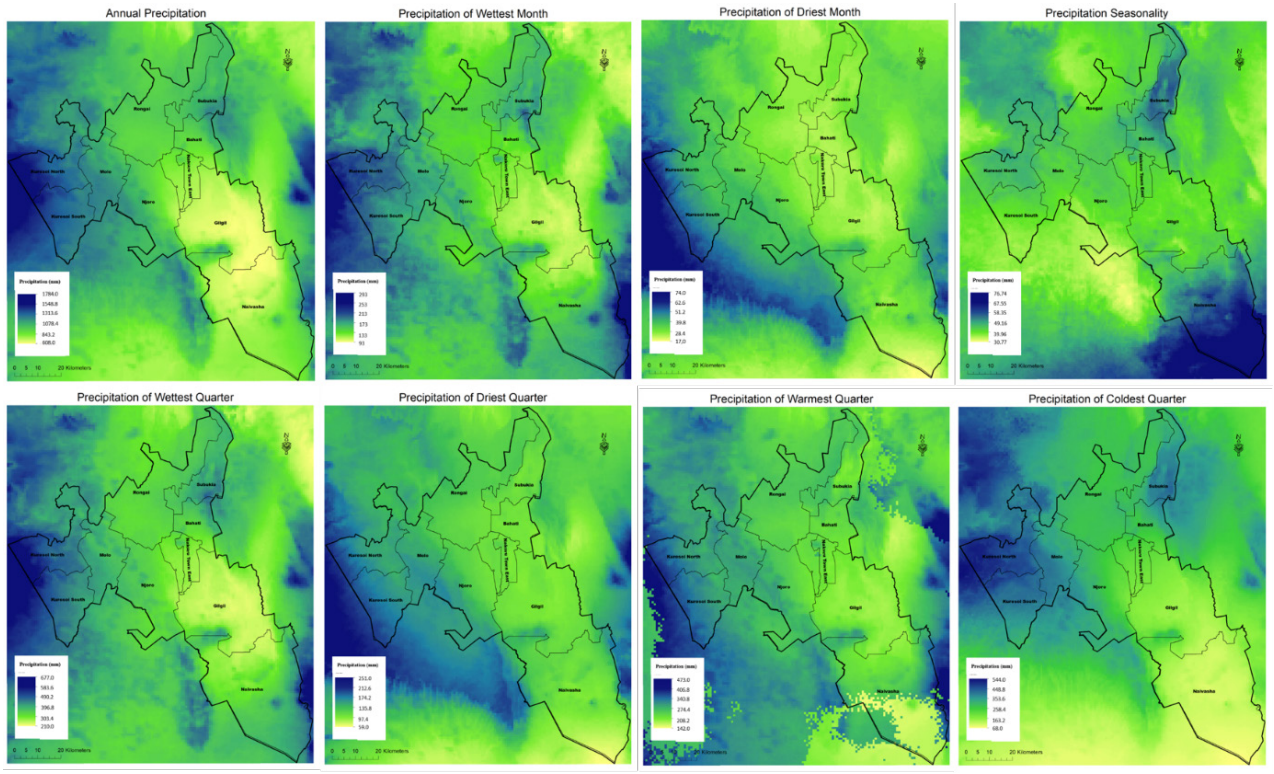


Figure 3.5. Maps of Bioclimatic Variables (Precipitation) for Nakuru County. (Source: Fick & Hijmans, 2017)

3.1.2 Mapping the Future of climate for Nakuru County

This process of combining current and future projections of climate information ultimately resulted in a climate data tool **(critical threshold explorer/expert tool)** with bias-corrected ERA5 and CMIP5 temperature data from the Climate Data Store (CDS) of the Copernicus Climate Change Service (C3S) (Matsaba et al., 2020).

The **critical threshold explorer/expert tool** is a climate information tool that discloses and allows exploration of climate impact for a tailored situation. The user can manually insert the desired temperature threshold and the months of interest. Thus, users can examine the risk of temperature increases for specific crops during specific periods. Agriculture

sector (dairy, poultry, crop) - specific indicators are used, such as temperature thresholds above, which yield drop. Functioning of the critical threshold explorer/expert tool are explained as follows:

- **Step 1:** Select temperature or precipitation,
- **Step 2:** Select the climate variable,
- **Step 3:** Select the crop-specific temperature threshold,
- **Step 4:** Select the future period,
- **Step 5:** Select the growing months of the crop,
- **Step 6:**Clickable maps showing the number of days above the temperature threshold in the growing season,
- **Step 7:** Figure showing the monthly temperature variation of the selected location in the map for different periods.

These thresholds should be defined by experts and user groups, as illustrated in **Figure 3.6** below.

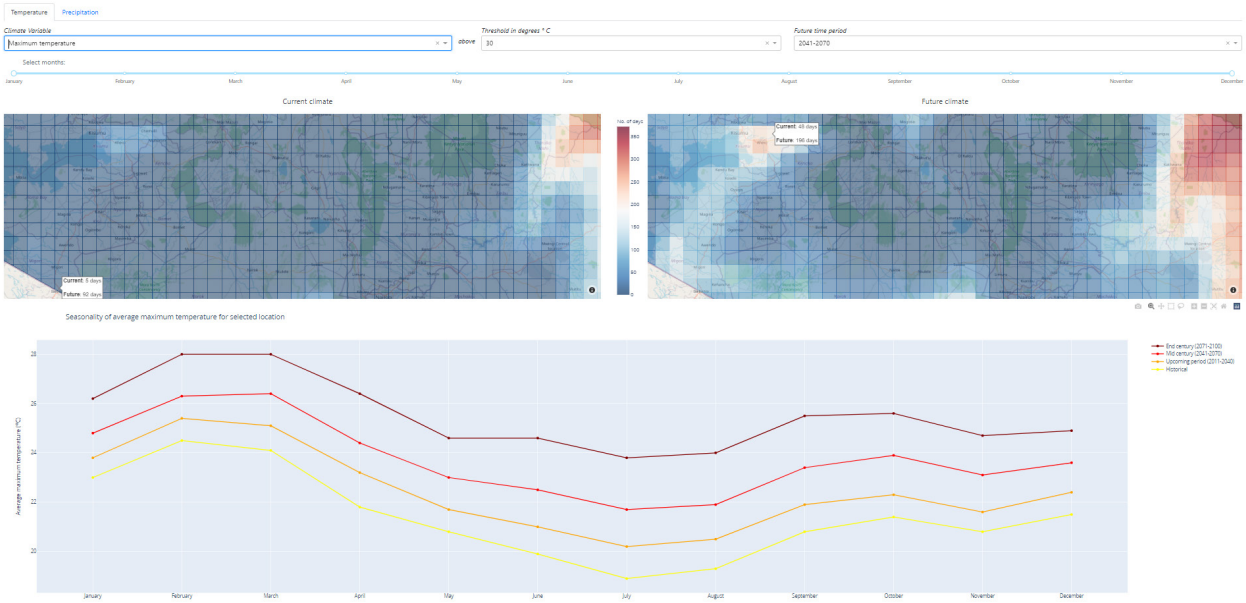


Figure 3.6. Illustration of the expert tool with current and future climate information for Nakuru County.

The **critical threshold explorer/expert tool** generates user indicators based on specified agriculture sector (dairy, poultry & crop) temperature and precipitation thresholds for current and future climates. Sector-specific graphs and maps are generated, allowing users to explore specific sectors' vulnerability to climate change. For example, if you know above which temperature a crop is damaged, you can use the application to find the future number of days above this value during the growing season.

Additionally, during the user needs assessment, it became apparent that the timing of the onset of the rainy season is crucial for farmers. Therefore, the tool includes projections on the range of the start/end day of the rainy seasons. A key finding was that only looking at an "average year" provides limited information. Therefore, information on the variation between years is a valuable and unique addition.

The climate **critical threshold explorer/ expert tool (https://kenya-expert-tool.herokuapp.com/)** will help users identify key adaptation challenges in their areas of interest by combining the effects and visualizing the main conclusions in risk maps, highlighting areas where adaptation is more urgent. Using the information, users can generate a storyline about a particular crop's future in a particular location within Nakuru County. A case study on how to use climate maps to investigate how climate change will affect maize farming in Nakuru County is provided herein.

Traditional maize growing season (during long rains) in Nakuru County (Rongai) usually starts in March, and maize is harvested around July. Maize cannot deal very well with temperatures above 30 degrees Celsius. However, due to climate change, the maximum temperature days above will increase to 8 days. Around 2050, maximum temperatures will exceed the harmful threshold for maize regularly. Rising temperatures can impact maize production. Increased maximum (day) temperature has a more significant, negative impact on yield compared to increased minimum (night) temperatures (Lobell et al. 2011) due to increased crop water requirements and rising temperature. Therefore, crops in most locations will experience enhanced water stress. Average optimum temperatures for temperate, highland tropical, and lowland tropical maize lie between 20 and 30°C, 17 and 20°C, and 30 and 34°C, respectively Cairns et al., 2013). However, due to climate change, the projected maximum temperature exceeds the lowland tropical threshold and could reduce maize yields by 2050.

Based on projections, it would be important to shift the maize growing season from March to July to cooler months of May to September when the projected maximum temperature is below 30°C. Therefore, it would be important to explore the option of harvesting water during long rains (from May to July) and utilizing it to grow crops during the short rain period when the temperature is favourable. Shifting the growing seasons for both maize to months with a lower temperature will mean more water for irrigation is needed to meet the crop water requirements. Hence, water retention, storage, and irrigation could provide more flexibility in the growing season (Klein Holkenborg 2020). Agroforestry could be implemented to mitigate heat as far as possible.

Using the information, users can generate a storyline about a particular crop's future in a particular location within Nakuru County.

3.1.3 Patterns and impacts of droughts on Nakuru County

Drought can be generally defined as a temporary meteorological event that stems from a deficiency of precipitation over an extended period compared to some long-term average conditions. This study examined the patterns and impacts of droughts across Nakuru County by mapping several drought-related characteristics at a regular grid scale. Indicators cover various aspects of droughts, from the distribution of meteorological and hydrological drought risks to social vulnerability and indices related to water infrastructure. Nakuru County (which belongs to arid and semi-arid areas) has a higher probability of drought occurrence. Nakuru County does not normally experience climate-driven water scarcity, hence the higher per capita river flow loss in drought years. Nakuru County is lagging behind the rest of the world on many indicators related to drought preparedness. Overall agricultural economies are much more vulnerable to adverse societal impacts of meteorological droughts. Water basins within Nakuru County have an unreliable and vulnerable nature of river discharge. The large drought deficits and durations are highlighted, pointing to the danger of focusing on drought mitigation measures on river flows alone. The ability of Nakuru County to satisfy its water needs during drought conditions is examined using storage-related indices, as illustrated in Appendix III, shown in Figure 3.7.

Drought always starts with a shortage of precipitation (compared to normal or average amounts) but may (or may not, depending on how long and severe it is) affect streams, soil moisture, groundwater, etc. It is a recurring natural event and a normal part of the climate of all world regions, regardless of how arid or humid they are. Droughts develop slowly, are difficult to detect, and have many facets in any region. It is, thus, one of the most complex natural phenomena that are hard to quantify and manage and has multiple and severe social and economic impacts.

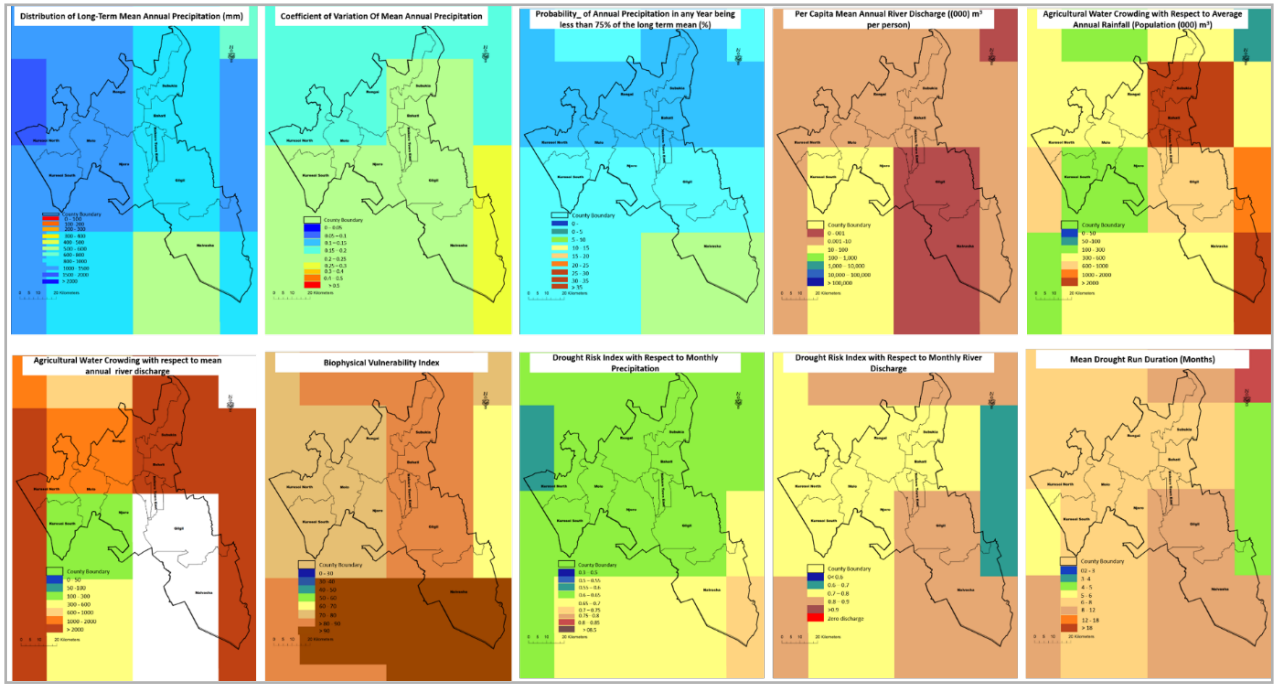


Figure: 3.7. Map of drought patterns and impacts on Nakuru County. Source: (Eriyagama, 2009).

The magnitude of these impacts is determined by the level of development, population density and structure, demands on water and other natural resources, government policies and institutional capacity, technology, and the political system. These points of departure set the scene and scope for this study.

3.1.4 Baseline Annual Water Risk Profile for Nakuru County

Baseline water depletion measures the ratio of total water consumption to available renewable water supplies. Higher baseline water depletion values indicate a larger impact on the local water supply and decreased water availability for downstream users. Total water consumption includes domestic, industrial, irrigation, and consumptive livestock uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Baseline water depletion is similar to baseline water stress; however, instead of looking at total water withdrawal (consumptive plus non-consumptive), baseline water depletion is calculated using consumptive withdrawal only.

Based on the water Risk Atlas, the overall water risk for Nakuru County is high (3-4). The change indicators and weighting for Nakuru County have a default weighting of 69% water quantity risk, 12% water quantity risk, and 18% regulatory and reputation risk. The high overall water risk measures all water-related risks by aggregating all selected indicators from the Physical Quantity, Quality, and Regulatory & Reputational Risk categories. Baseline annual water risk indicators have higher values indicating higher water risk, as shown in **Table 3.1**.

Generally, areas across Nakuru County experience Low to Medium (0.25-0.50) inter-annual water variability, indicating low to medium variations in available water (both renewable surface and groundwater) supply from year to year. Additionally, the low to medium (0.33-0.66) values of seasonal

Table 3.1. Baseline Annual Water Risk Atlas Metadata for Nakuru County areas. (Source: Hofste et al., 2019).

Indicators	Weightings
Overall water Risk	High (3-4)
Physical Risk Quantity	High (2-3)
Water Stress	Low (<10%)
Groundwater Table Decline	Insignificant Trend
Inter-annual Variability	Low - Medium (0.25-0.50)
Seasonal Variability	Low - Medium (0.33-0.66)
Drought Risk	Medium-High (0.6-0.8)
Riverine flood risk Stress	Extremely High (more than 1 in 100)
Coastal flood risk	Low (0 to 9 in 1,000,000)
Physical Risks Quality	High (3-4)
Untreated Connected Water	High (90-100%)
Coastal Eutrophication Potential	Low (<-5)
Regulatory and Reputational Risk	Extremely High (4-5)
Unimproved/no drinking water	Extremely High (>20%)
Unimproved/no sanitation	Extremely High (>20%)
Peak RepRisk country ESG risk index	High (60-75%)

variability measures indicate low to medium variations of available water supply within a year. The insignificant groundwater table decline trend indicates higher unsustainable groundwater withdrawals. An extremely High (more than 1 in 100) percentage of the population is expected to be affected by riverine flooding in an average year, accounting for existing flood-protection standards. Therefore annual flood risk is assessed using hazard (inundation caused by river overflow), exposure (population in a flood zone), and vulnerability is high. The medium to high (0.6-0.8) drought risk values indicate a medium to a higher risk of drought across the Nakuru area. Therefore the population and assets are exposed, and the vulnerability of population and assets to adverse effects.

The high (3-4) physical risk quality values indicate higher water quality risks (aggregated by all selected indicators from the Physical Risk Quality category). Untreated connected wastewater measures the percentage of domestic wastewater connected through a sewerage system and not treated to at least a primary treatment level. Wastewater discharge without adequate treatment could expose water bodies, the general public, and ecosystems to pollutants such as pathogens and nutrients. The indicator compounds two crucial elements of wastewater management: connection and treatment. Low connection rates reflect households' lack of access to public sewerage systems; the absence of at least primary treatment reflects a country's lack of capacity (infrastructure, institutional knowledge) to treat wastewater. Together, these factors indicate a country's current capacity to manage its domestic wastewater through two main pathways: extremely low connection rates (below 1 per cent) and high connection rates with little treatment. High (90-100%) values indicate high percentages of point source wastewater discharged without treatment within Nakuru County.

Wastewater discharge without adequate treatment could expose water bodies, the general public, and ecosystems to pollutants such as pathogens and nutrients.

Unimproved/no sanitation reflects the percentage of the population using pit latrines without a slab or platform, hanging/bucket latrines, or directly disposing of human waste in fields, forests, bushes, open bodies of water, beaches, other open spaces, or with solid waste (WHO and UNICEF 2017). Specifically, the indicator aligns with JMP's unimproved and open defecation categories— the lowest tier of sanitation services. Higher values indicate areas where people have less access to improved sanitation services.

The Peak RepRisk country ESG risk index quantifies business conduct risk exposure related to environmental, social, and governance (ESG) issues in the corresponding country. The index provides insights into potential financial, reputational, and compliance risks, such as human rights violations and environmental destruction. RepRisk is a leading business intelligence provider specializing in ESG and conducting risk research for companies, projects, sectors, countries, ESG issues, NGOs, and more, leveraging artificial intelligence and human analysis in 20 languages. WRI has elected to include the Peak RepRisk country ESG risk index in Aqueduct to reflect the broader regulatory and reputational risks that may threaten water quantity, quality, and access. While the underlying algorithm is proprietary, our inclusion of the Peak RepRisk country ESG risk index, normally unavailable to the public,

is a value-add to the Aqueduct community. The peak value equals the highest index level in a given country over the last two years. The higher the value, the higher the risk exposure.

3.1.5 Future Water Risk Profile for Nakuru County

Water stress is an indicator of competition for water resources and is defined informally as the ratio of demand for water by a human society divided by available water. Absolute projected change in water stress shows a lower value, indicating less future water completion among users across Nakuru County. Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. The higher water risk indicator values show more competition among water users within Nakuru County. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability, as shown in **Table 3.2**.

Table 3.2. Absolute projected Water Risk for Nakuru County (Value in Year To 2030). (Source: Hofste et al., 2019).

Indicators	Weightings		
	Pessimistic	Business as usual	Optimistic
Absolute projected change in water stress	Low (<10%)	Low (<10%)	Low (<10%)
Absolute projected change in seasonal variability	Medium-high (0.66-1.0)	Medium-high (0.66-1.0)	Medium-high (0.66-1.0)
Absolute projected change in water supply	10-30 cm	10-30 cm	30-100 cm
Absolute projected change in water demand	1-3 cm	1-3 cm	1-3 cm

Climate vulnerability assessment results across Nakuru County sub-counties are discussed under climate adaptation analysis and agroecology dimension analysis.

3.2 Climate Vulnerability Assessment for Nakuru County

3.2.1 Climate Adaptation Index Analysis

Climate Adaptation analysis for Nakuru County involved the identification of crops of interest, common climate change-related hazards, exposure, vulnerability scores, and adaptation scores across sub-counties, as explained herein.

3.2.1.1 Commodities

Commodities of interest include maize, beans, Irish potato, fruits and vegetables, flowers, livestock, poultry, and other food crops. Most farmers across all sub-counties grow beans, maize, Irish potato, and fruits and vegetables and also keep livestock and poultry (**Figure 3.8**).

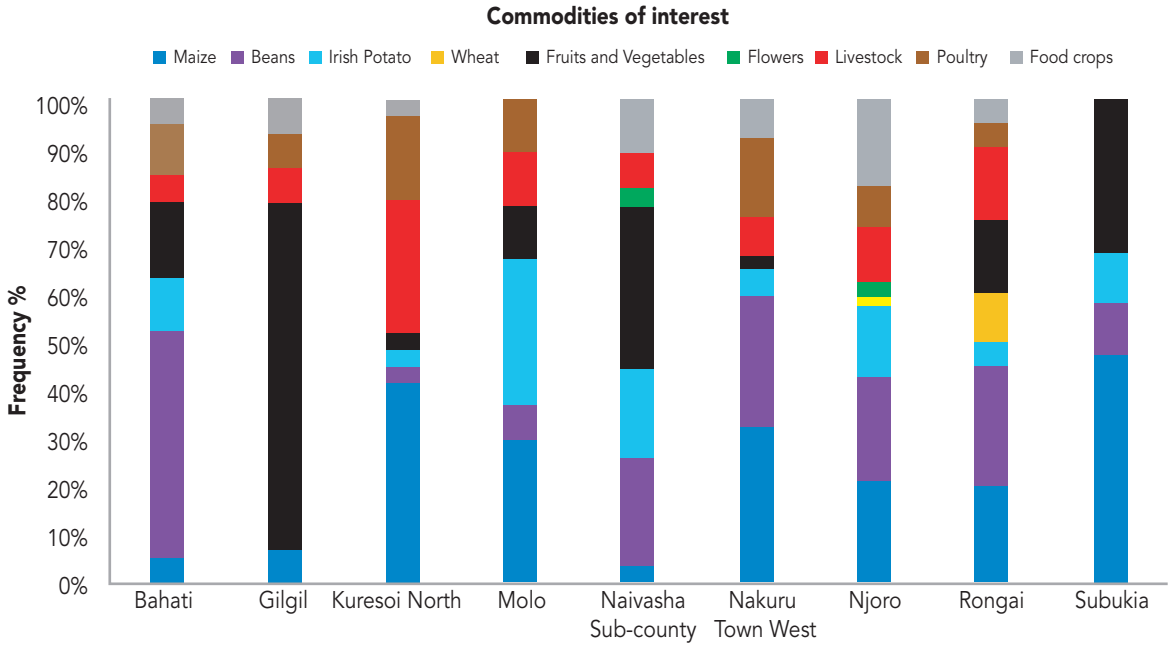
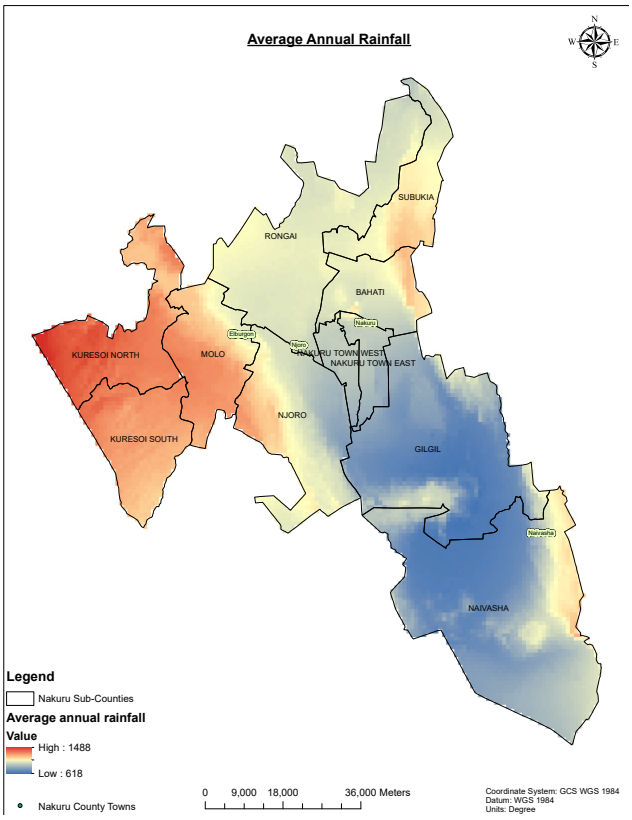


Figure 3.8. Identified commodities of interest across sub-counties

3.2.1.2 Climate Hazards in Nakuru County

The hazards identified across Nakuru County include landslides, drought/dry spells, excess rainfall, changing rainfall patterns, increasing temperature, floods, hailstones, frost/extreme cold, and strong winds. Increasing temperature is a major concern in Gilgil, Naivasha, and Njoro sub-counties. Common across the board was changing rainfall patterns, while drought/ dry spell is mainly experienced in Molo, Naivasha, Nakuru Town, and Njoro. Excess rainfall was a major problem in Nakuru Town, Njoro, and Subukia, while the strong wind was identified as a problem in Njoro, Nakuru Town, Gilgil, Naivasha, and Rongai, respectively. In addition, farmers in the Njoro sub-county experience most of the identified climate change-related hazards **(Figure 3.9**).



Common across the board was changing rainfall patterns, while drought/dry spell is mainly experienced in Molo, Naivasha, Nakuru Town, and Njoro. Excess rainfall was a major problem in Nakuru Town, Njoro, and Subukia, while the strong wind was identified as a problem in Njoro, Nakuru Town, Gilgil, Naivasha, and Rongai, respectively.

Figure 3.9a. Average annual rainfall across the sub-counties

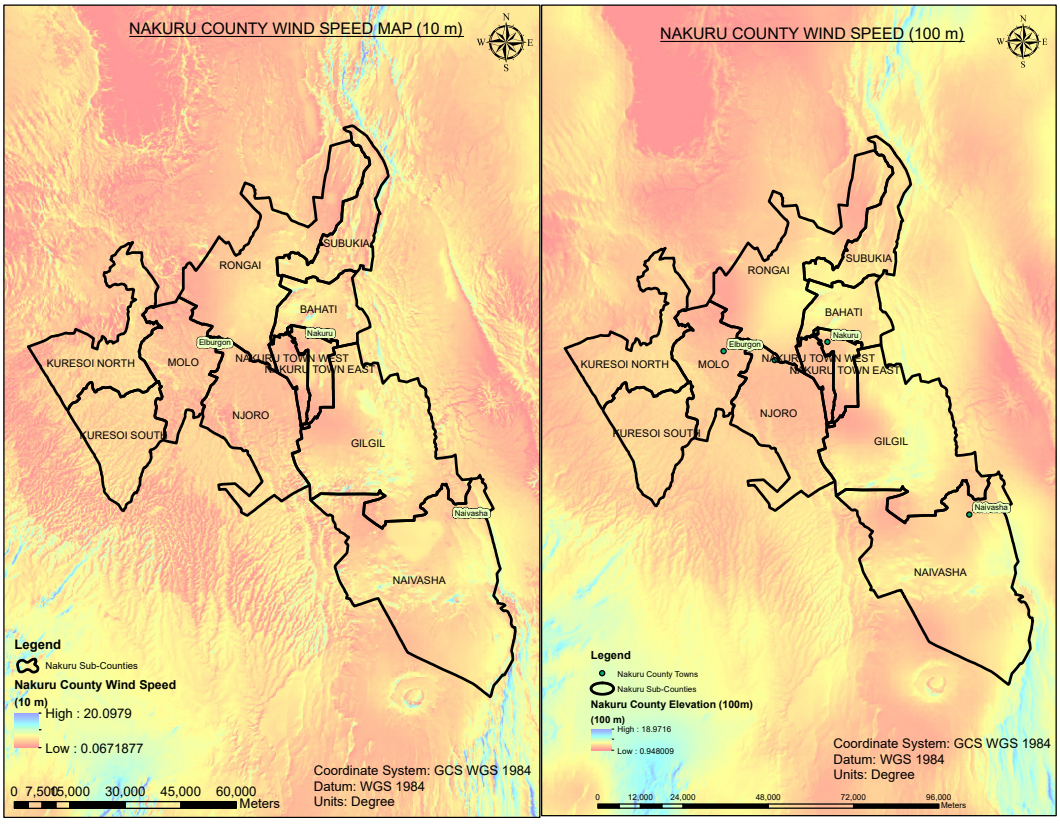


Figure 3.9b. Wind speed across Nakuru sub-counties

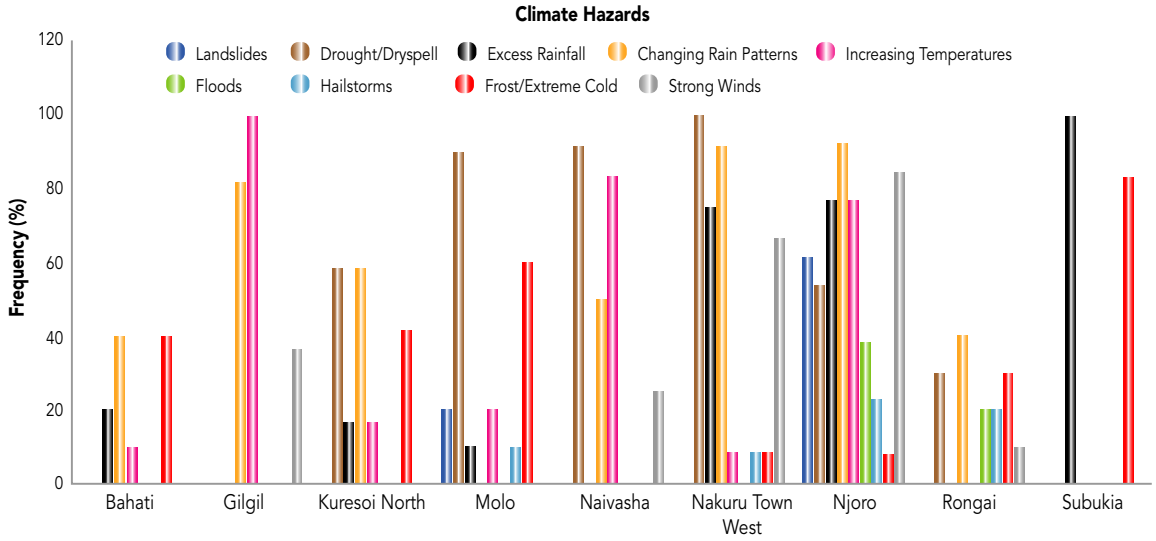


Figure 3.9c. Identified Climate change related hazards across the sub-counties

Sub-counties in Nakuru Town have the highest hazard scores, followed by Njoro, Gilgil Molo, and Subukia, respectively, while Bahati sub-county has the lowest hazard scores **(Figure 3.10)**.

The above perceptions align with the literature, especially on drought and precipitation conditions in Nakuru County, especially drought/dry spells and changing rainfall patterns. Nakuru County (which belongs to the Köppen-Geiger climate classification) has a high probability of drought. In drought years, the highest per capita river flow loss occurs across Nakuru County, especially Nakuru Town, Njoro, Naivasha, Gilgil, and Subukia areas, leading to climate-driven water scarcity. This effect is experienced due to climate-driven water scarcity and is exacerbated by changing climate, rainfall, and temperature patterns.

3.2.1.3 Impacts of Climate Change Hazards on Agricultural Production in Nakuru County

Climate change and variability in Nakuru County impact the farming systems and livelihoods of the people. The study revealed

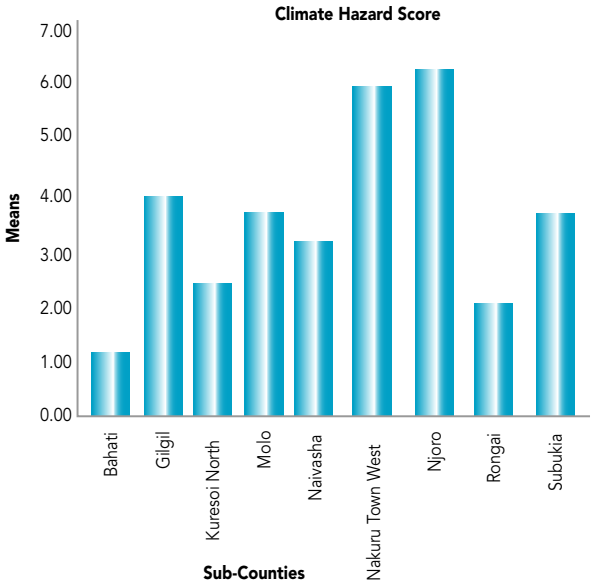


Figure 3.10. Identified climate hazard scores across the sub-counties

several socio-economic and ecological impacts across the agricultural value chains. The study revealed differentiated impacts of climate change-related hazards across sub-counties in Nakuru County on production, post-harvest management, marketing, and the social life of farmers.

Impacts of climate change-related hazards on

agricultural production include soil erosion, hard soil pans, river pollution (siltation and pesticide effluence), increased pest and disease incidences, repeated planting due to poor germination/crop performance, repeated purchase of farm inputs (fertilizer, seeds), loss of soil fertility (leaching of nutrients), too much use of chemicals, decreased pesticide/herbicide efficiency, shifting planting calendar/delays in planting (farmers not sure when to plant), alteration/reallocation of predetermined farm budget and physical damage of produce (**Figure3.11**).

On post-harvest management, impacts of climate change-related hazards included poor grades/reduced quality, low volume of produce leading to income loss, planning problems due to less reliable forecasts, reduced post-harvest shelf life, increased spoilage and physical damage of crops, moisture loss and chemical change, delayed delivery, processing-loss of crop value, reduced consumption of produces/increased consumption of competitive alternatives, physical break down of crops, e.g., freezing injuries, too much use of chemical preservatives, and high cost of post-harvest handling and management was common across all the sub-Counties (**Figure 3.12**).

On produce marketing, poor market linkages were common across all the sub-counties. Destruction of roads, poor access to markets, delayed/distorted markets, depressed sales/low returns, spoilage of excess products, and high promotion costs was reported in many sub-counties across Nakuru County **(Figure 3.13)**.

Increased hunger, crime, school dropouts, and teenage pregnancy were identified as major social impacts of climate change and variability across Nakuru County. Sickness resulting from loss of human labour and displacement of people and families were common in Molo, Naivasha, Njoro, Rongai, and Subukia Sub counties. Increases in teenage pregnancy were also common in Naivasha, Nakuru Town, Njoro, and Subukia sub-Counties **(Figure 3.14**).

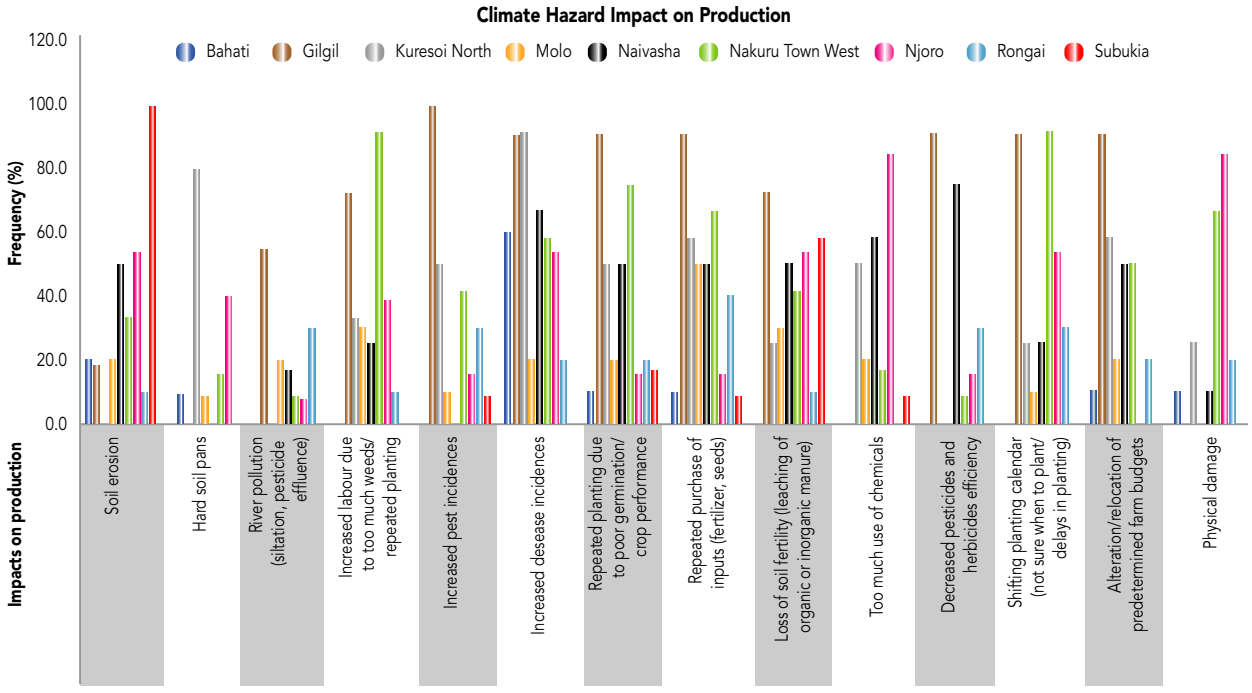


Figure 3.11. Impacts of climate change-related hazards on production across sub-counties

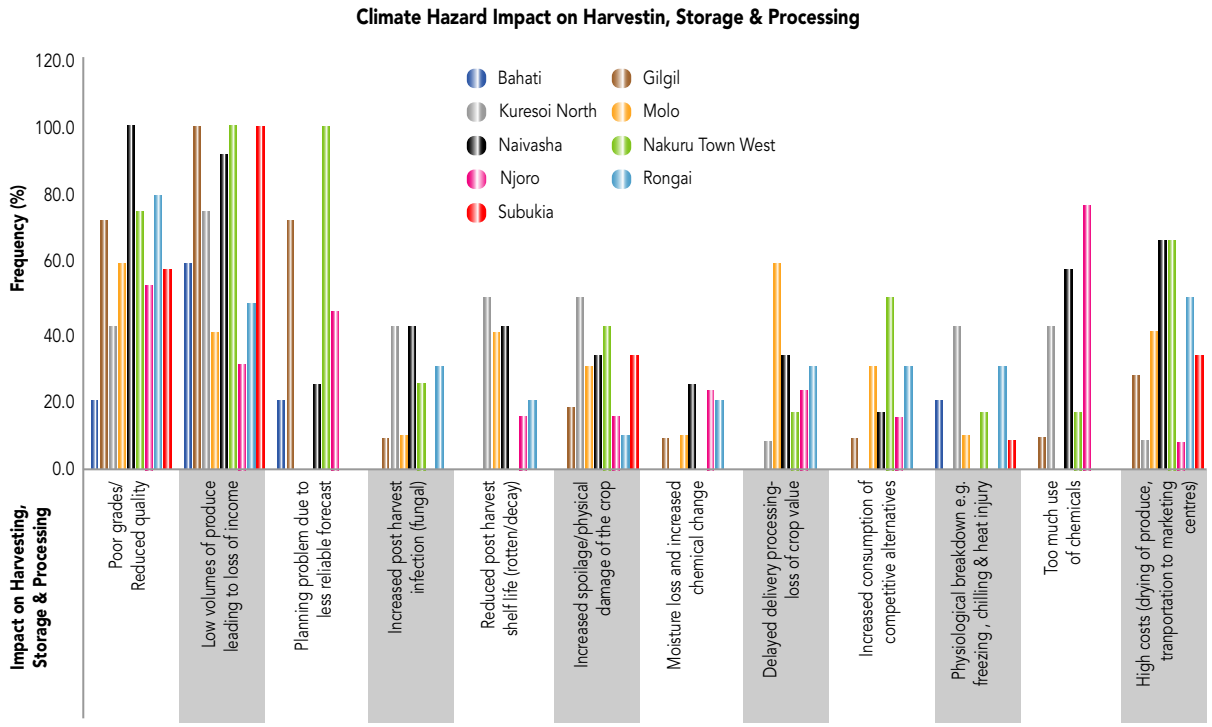


Figure 3.12. Impacts of climate change-related hazards on post-harvest handling across sub-counties

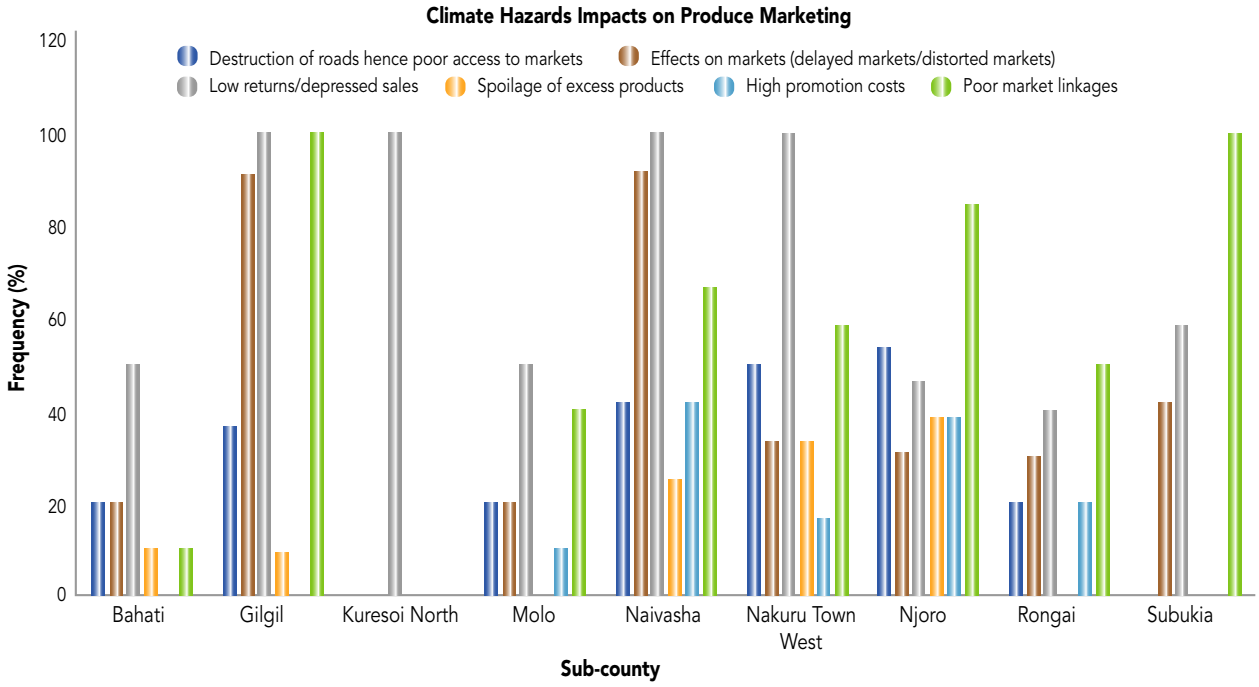


Figure 3.13. Impacts of climate change-related hazards on market access across sub-counties

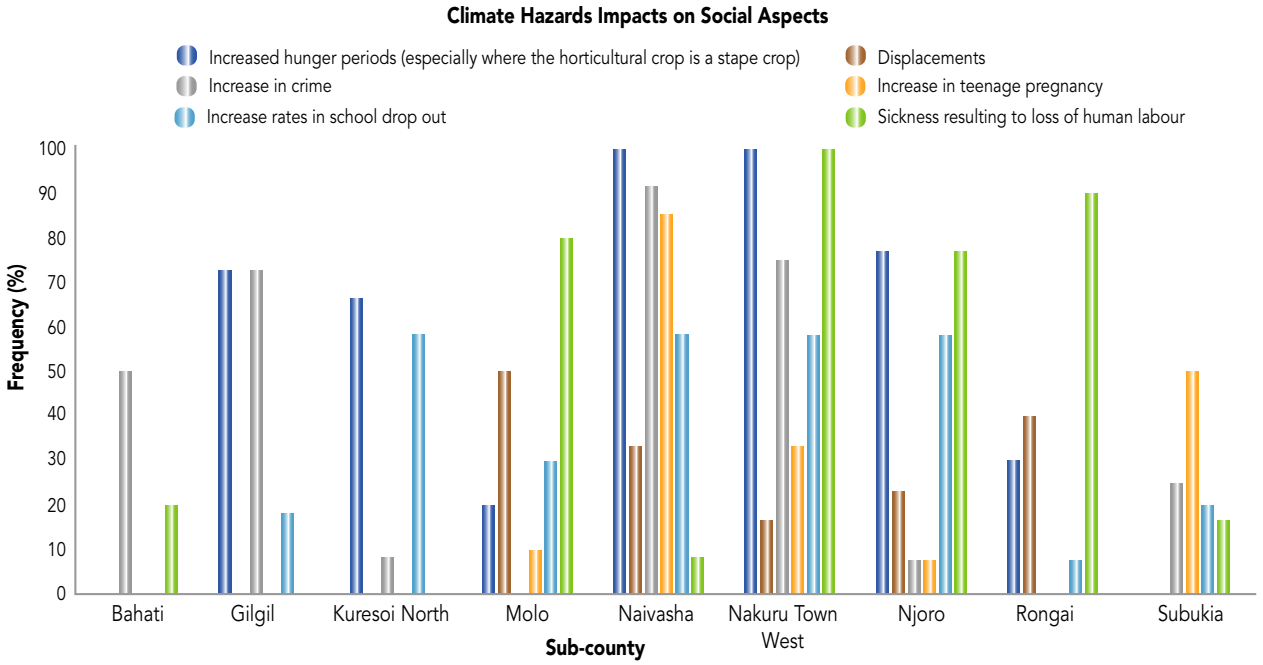


Figure 3.14. Impacts of climate change-related hazards on social aspects across sub-counties

3.2.1.4 Exposure of the Agriculture Sector to Climate Change

Family (household) size and ecosystem area (in terms of affected land area by climate change) are considered the most critical exposure factors. The study, having focused on smallholder farmers, reveals that most farmers in Bahati, Gilgil, Naivasha, Njoro, Rongai, and Subukia sub-counties own 0-2 acres of land. Kuresoi North, Molo, Naivasha, Nakuru Town, and Rongai sub-counties had a substantive number of farmers with 2-5 acres. Only Naivasha Sub-county had a few respondents with 5-10 acres (**Figure 3.15**).

Most households in Nakuru County have a household size of 2-5 members. Some households in Gilgil, Kuresoi North, Molo, Naivasha, Nakuru Town, Rongai, and Subukia sub-counties had 6 -9 members. Additionally, some households in Nakuru County, apart from Bahati, sub-county reported having only 1 member (**Figure 3.16**).

Generally, the aggregate exposure scores are a factor of land sizes and household numbers across sub-counties. There were no significant differences across the three sub-Counties. However, Subukia, Kuresoi North, and Gilgil have higher exposure scores, with Bahati Sub County having the lowest (**Figure 3.17**). At times, a low exposure value does not necessarily imply reduced vulnerability since farmers with larger farms can also undertake more adaptation practices, reducing their vulnerability.

3.2.1.5 Vulnerability of the Agricultural Sector

To ascertain the vulnerability of the agricultural system to climate change, the formulae Vulnerability=Sensitivity x Capacity was used. Sensitivity indicators included the suitability of the crops to the area, and on-farm diversification factors were used. Data shows all areas suitable for agricultural production with average figures of 80%. On diversification, most study sites showed an integrated cropping system to create farm resilience to climate change. Gilgil

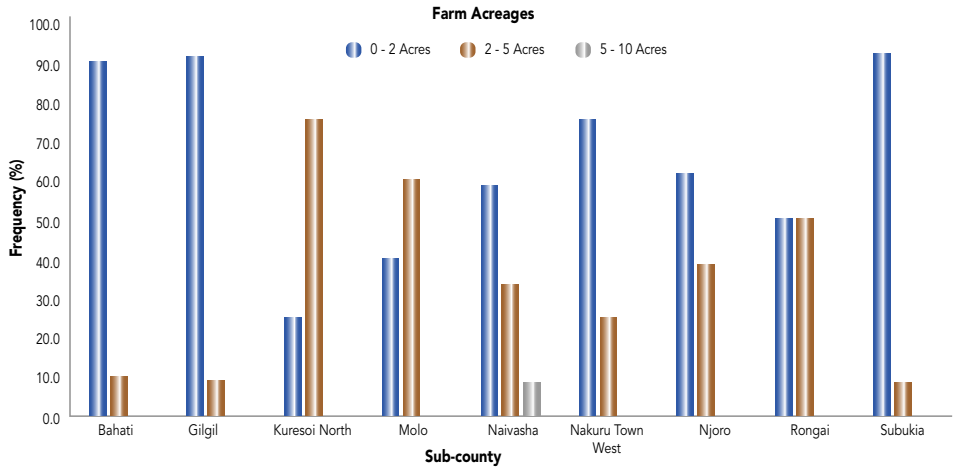


Figure 3.15. Farm acreages across the sub-counties

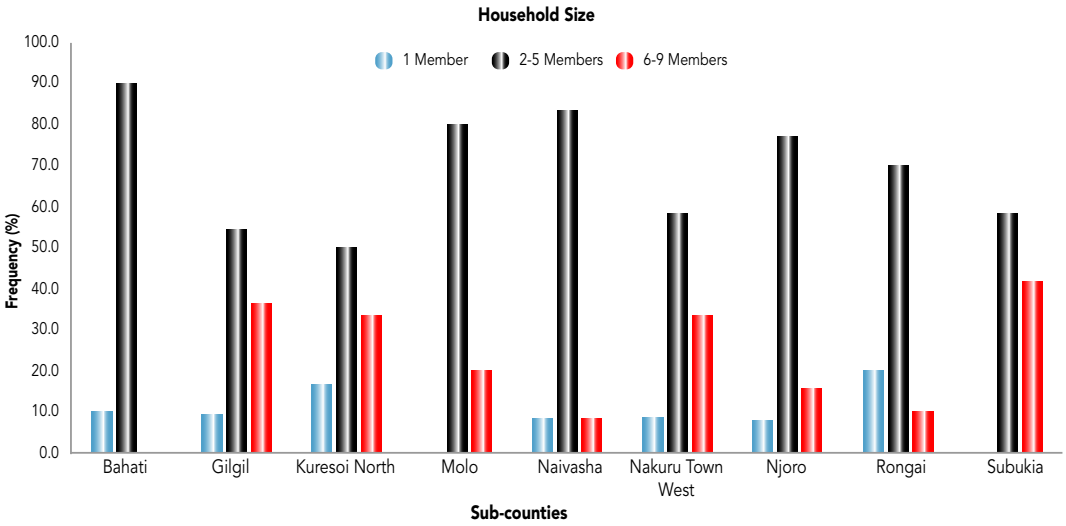


Figure 3.16. Household sizes across the sub-counties

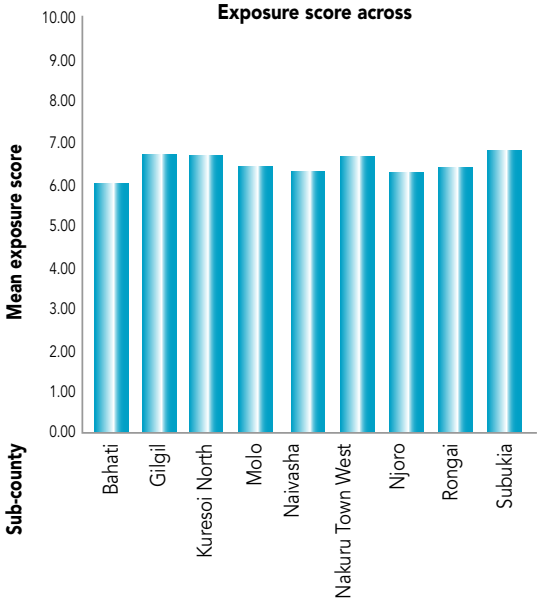


Figure 3.17. Exposure scores across the sub-counties

sub-county had the least number of farmers practising farm diversification (**Figure 3.18**).

Capacity level indicators included access to education, finance, extension, knowledge, and access to climate information (**Figure 3.19**). Kuresoi North shows the highest access to extension services, followed by Naivasha, Bahati, Molo, Njoro, and Rongai Sub-counties. Gilgil, Nakuru Town, and Subukia indicated no access to extension services. Farmers mainly depended on cooperatives, mass media, private companies, and to some extent, government extension and research institutions for extension information (**Figure 3.19a**).

Across all areas, farmers from Kuresoi North and Rongai showed more access to climate finance than other areas. At the same time, there was access to financial services reported in Gilgil and Subukia. Farmers accessed finance from Banks (in the Bahati sub-county) and cooperatives/Saccos (Bahati sub-county) self/family/friends, followed by table banking (Figure 3.19b).

On the education level, the majority of the farmers had secondary-level education. Some farmers in Kuresoi North, Molo, Naivasha, Nakuru, Njoro, Rongai, and Subukia sub-counties had tertiary-level education. Additionally, some farmers in Bahati, Gilgil, Molo, Naivasha Nakuru Town, and Njoro sub-counties had only primary-level; education (**Figure 3.19c**).

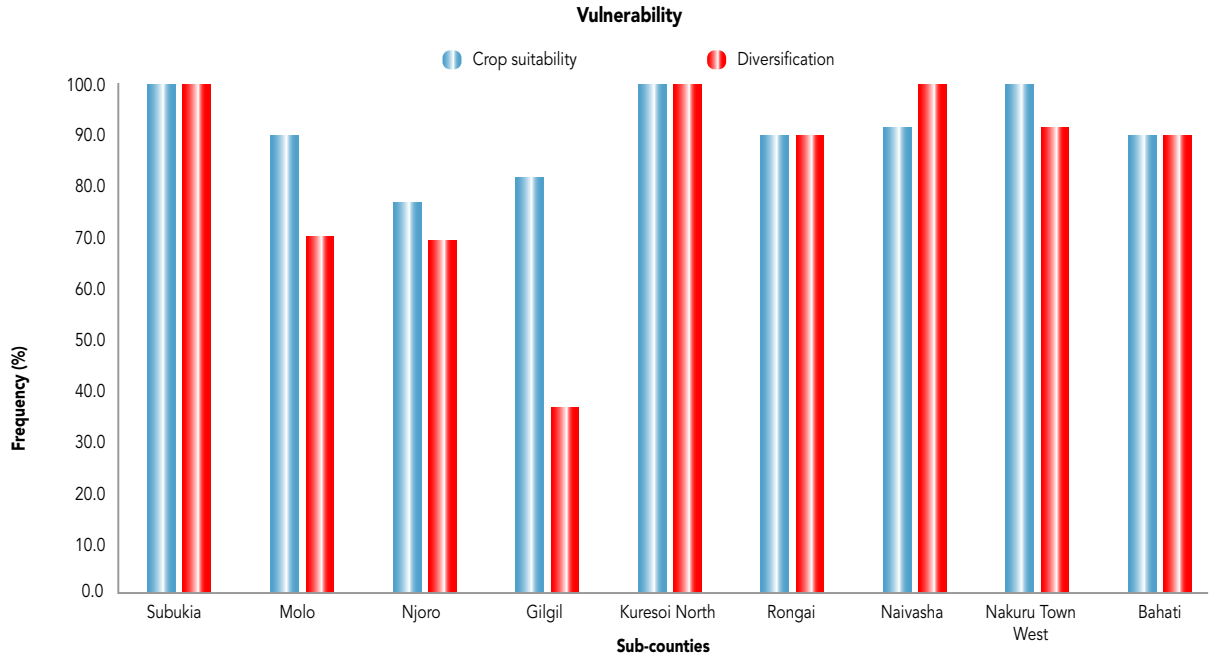


Figure 3.18. Suitability of crops and On-farm diversification across sub-counties

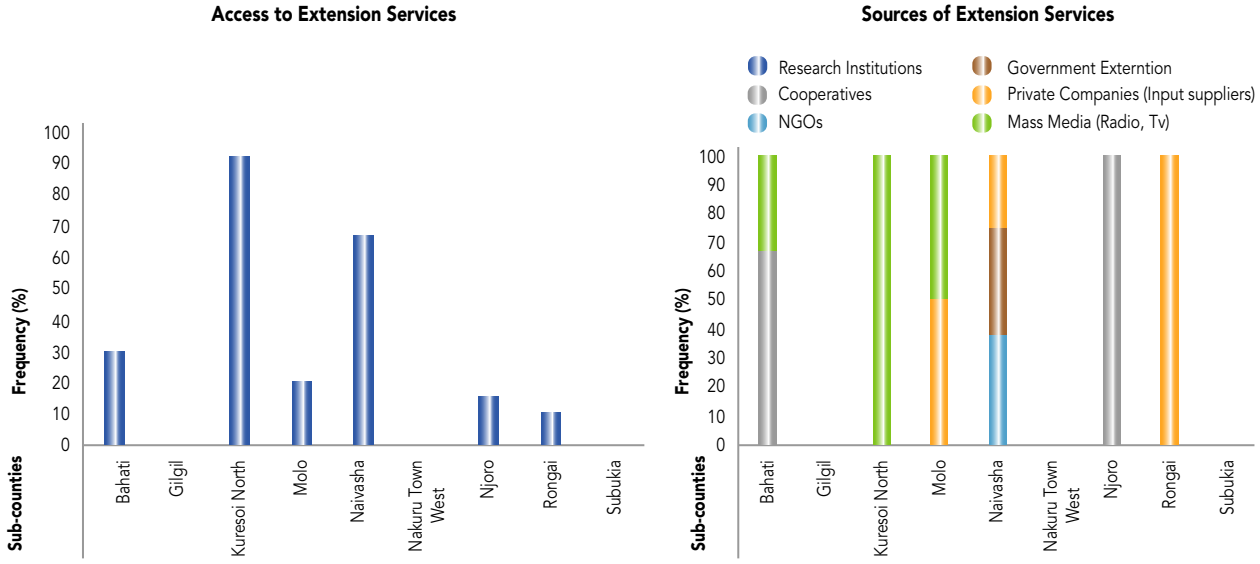


Figure 3.19a. Access to extension services across the sub-counties

Farmers in Kuresoi North, Molo, Nakuru Town, Rongai, and Subukia had the highest climate information access, while Naivasha had the least. Farmers mainly depended on radio and their neighbours to access climate information. The study also showed the dependence on indigenous information systems in understanding climate behaviour across the sub-counties in Nakuru County (**Figure 3.19d**).

The study shows very high vulnerability sensitivity scores across Nakuru County, especially in Gilgil, Njoro, Subukia, Nakuru Town, Bahati and Naivasha, Molo, Rongai, and Kuresoi North sub-counties, respectively (**Figure 3.20**). This could be associated with low education levels and limited access to extension services in the identified areas. The low vulnerability sensitivity scores in Kuresoi North and Molo sub-counties could also be associated with climate information since the two areas did receive climate information from various sources and had the highest access to weather and climate information.

3.2.1.6 Climate Risk

Climate risk is the interaction between hazard, exposure, and vulnerability. Climate Risk Score

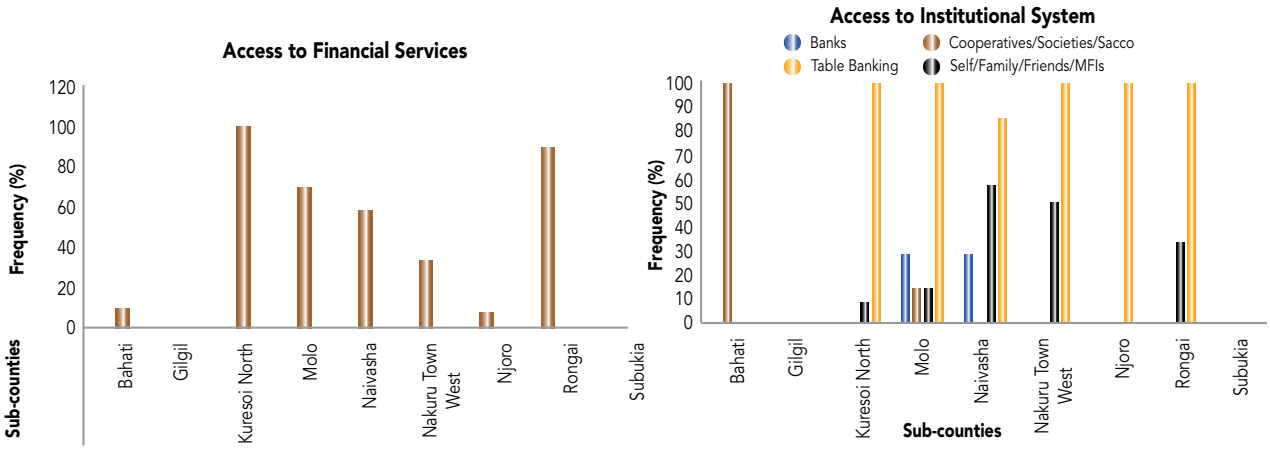


Figure 3.19b. Access to financial services across the sub-counties

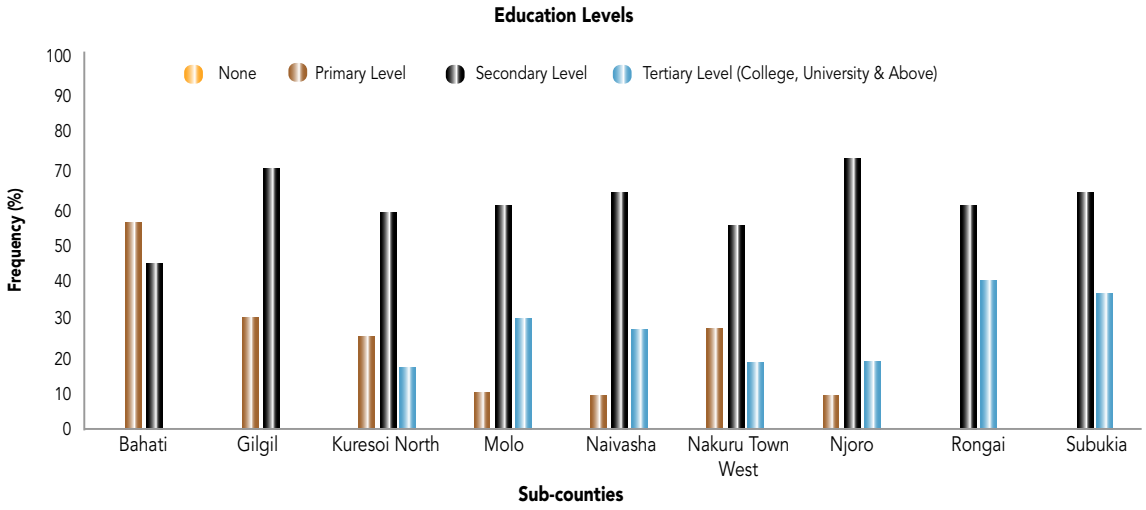


Figure 3.19c. Education level across the sub-counties

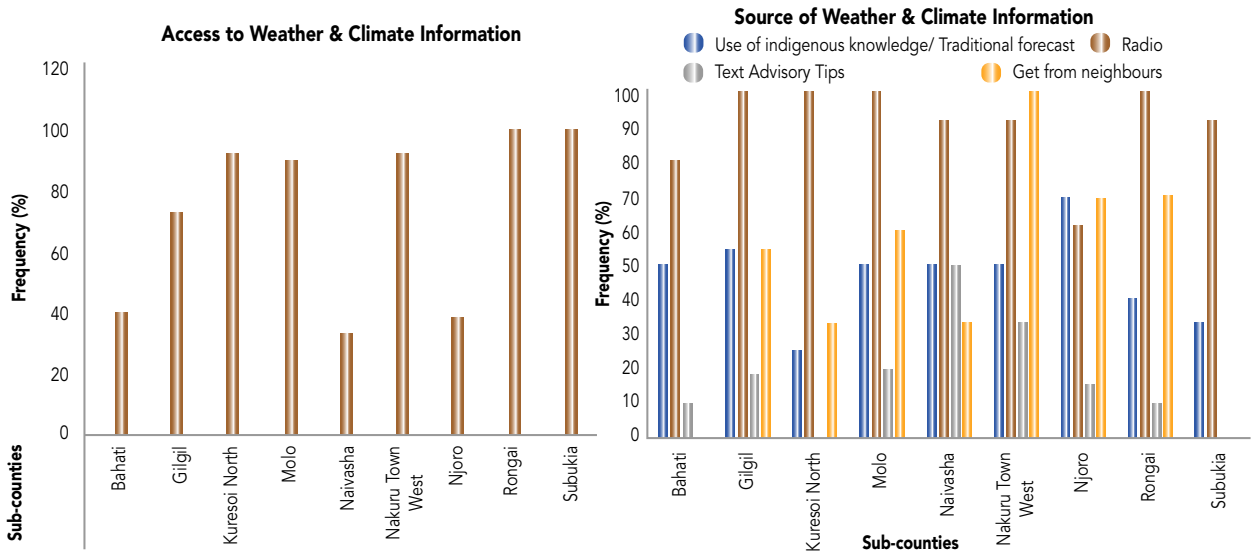


Figure 3.19d. Access to climate information across the sub-counties

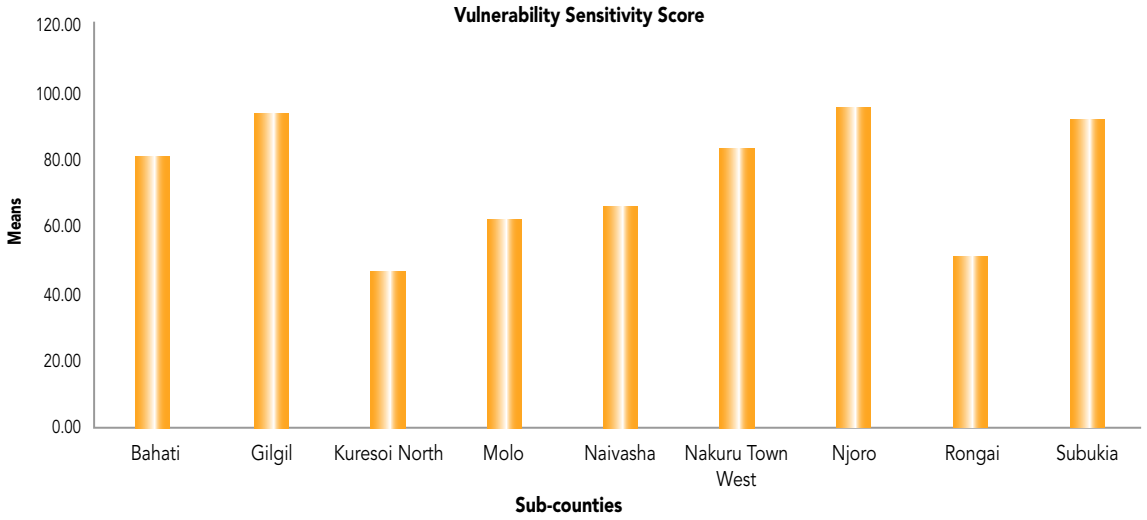


Figure 3.20. Vulnerability sensitivity scores across the sub-counties

= Climate hazard x Exposure x Vulnerability. The study shows that the Njoro sub-county has the highest risk score, followed by Nakuru Town, Subukia, and Gilgil sub-counties, while the Bahati sub-county has the least risk score (**Figure 3.21**). The highest climate risk in Njoro, Gilgil, Nakuru Town, and Subukia sub-counties is also supported by vulnerability sensitivity scores.

3.2.1.7 Adaptation

Several adaptation practices were considered in Nakuru count under the following classes; water management, soil water management, soil fertility management, crop management, diversification management, pest and disease management, natural resource management, post-harvest management, recycling of agricultural wastes, and adaptive markets. Generally, Molo, Naivasha, Nakuru Tow, and Rongai Sub-counties had the total adaptation scores, while Subukia and Bahati sub-counties had the least (**Figure 3.22**).

The study also shows differentiated uptake of

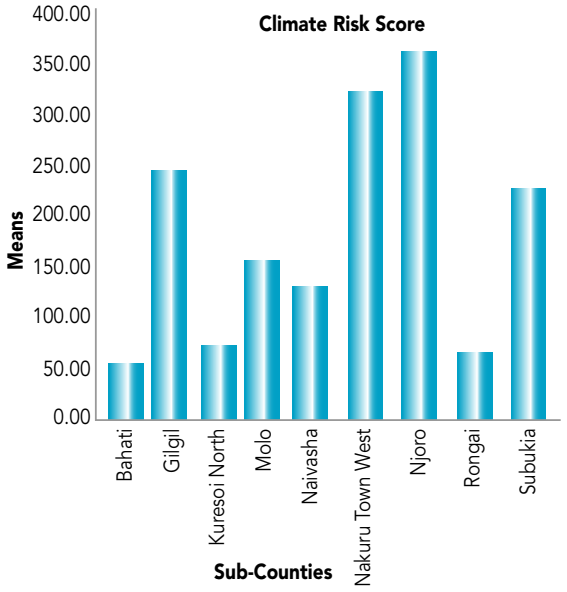


Figure 3.21. Climate risk scores across the sub-counties.

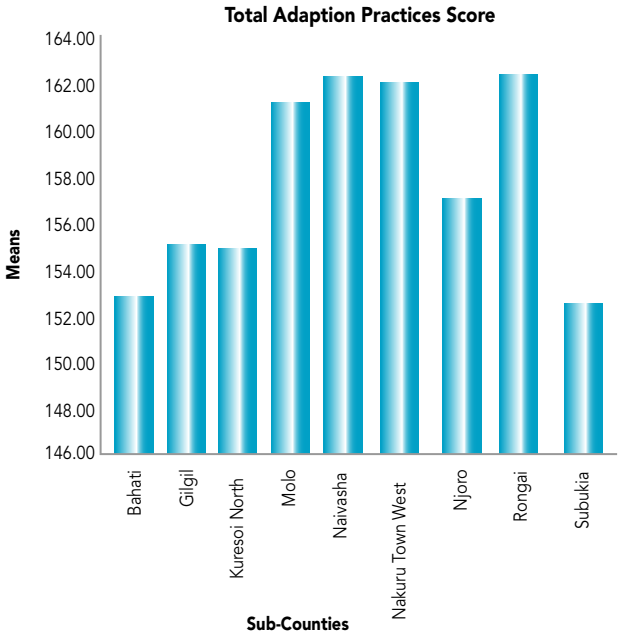


Figure 3.22. Total adaptation score across the sub-counties

adaptation practices across the sub-counties in Nakuru County. The uptake of soil fertility management practices was the highest, followed by diseases and pest management practices, post-harvest management, farm diversification, and water management. The uptake of natural resource management and recycling of agricultural waste was very low (**Figure 3.23**).

3.2.1.8 Climate Adaptation Index

The adaptation index indicates a set of practices that would optimize climate-risk-responsive agriculture management. It is anticipated that as the adaptation pathways intervene, farmer households will move towards a higher percentage level and adapt to the location-specific climate risks by adopting climate-responsive measures. Naivasha and Rongai Sub-counties show the highest climate adaptation index, followed by Nakuru Town and Molo sub-counties. At the same time, Bahati and Subukia sub-counties showed the least adaptation index compared to other sub-counties in Nakuru (**Figure 3.24**).

Determinants of the adaptation index entailed gender, education, finance, access to extension, and climate information. Farmers across Nakuru County are at different levels of implementing climate-responsive adaptation actions, with some farmers having very low values while others have higher values. The 40-70% level by most farmers could imply a medium level of adaptation.

In addition, the study also acknowledges the risk and vulnerability to climate change are socially differentiated and emerge from the intersection of inequalities and uneven power structures. Climate vulnerability is typically higher among social groups who experience multiple deprivations that inhibit them from managing daily risks and shocks, including but not limited to women, children, the elderly, people with disabilities, ethnic minorities, and indigenous peoples. These groups face deeper climate impacts and significant barriers to coping with and adapting to such impacts. Climate change-related risks in Nakuru County were found to have social impacts on women,

girls, the elderly and people living with disabilities in six main areas: water security, livelihoods, food and nutritional security, health, education and migration.

As a result, there is a need to provide school girls with access to education to support climate action and participation; Empower young women and girls towards leadership in climate action; Support young women and girls towards sustainable livelihoods that build resilience; Ensure social safety support nets for young mothers and girls affected by migration/ displacement, and Design interventions that ensure young women and girls can lead healthy lives in the face of climate change.

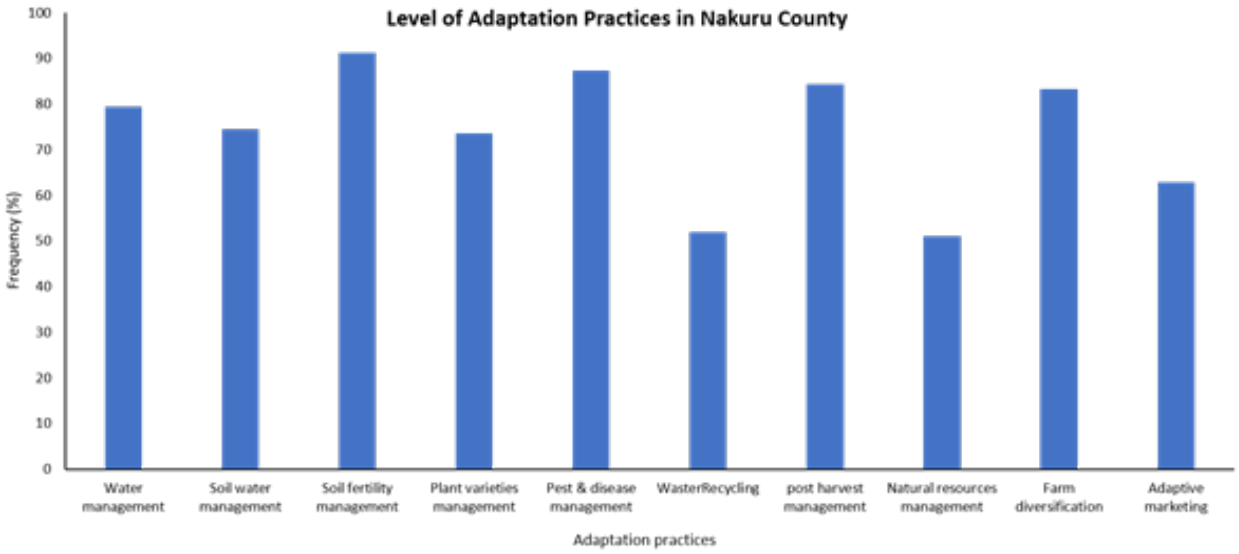


Figure 3.23. Level of implementation of adaptation practices across sub-counties

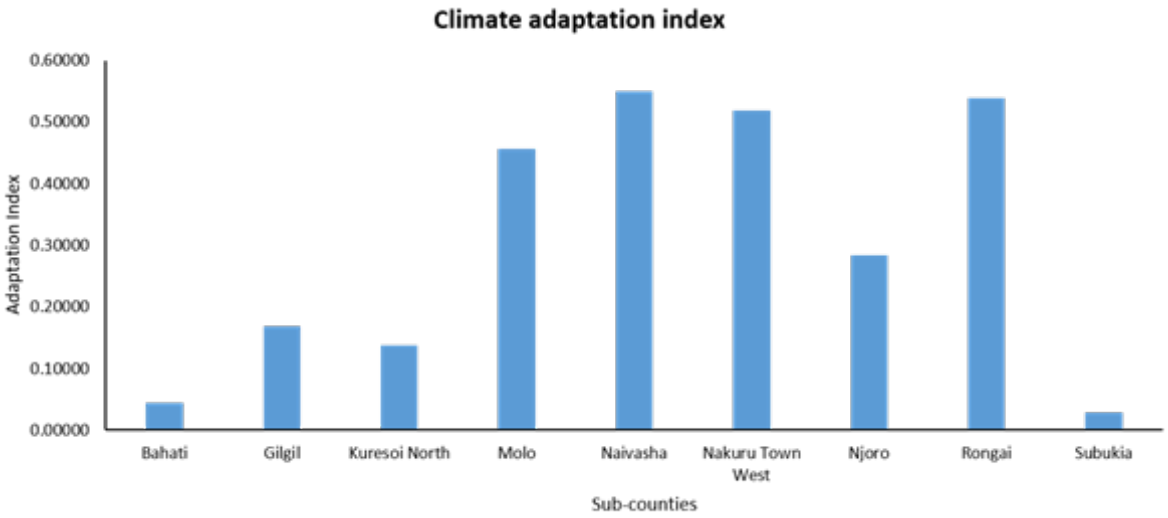


Figure 3.24. Adaptation index scores across sub-counties

3.2.2 Agroecology Dimension Analysis

Using the ten elements of FAO as the analysis lens, the study revealed that farmers' practices implemented adaptation that supported efficiency, recycling, regulation and balance, synergies, diversity, resilience, and co-creation of knowledge dimensions across all sub-counties. However, Subukia and Bahati sub-counties had the lowest integration of most agroecology elements (**Figure 3.25**).

The 10 FAO elements can be divided into 3. The first six elements relate to common agroecological systems, referred to as foundational practices and innovative approaches. These entail diversity, synergies, efficiency, resilience, recycling, co-creation, and knowledge sharing. The other two focus on contextual features and include; human and social values, culture, and food transitions. The remaining two refer to an enabling environment and include responsible governance and a solidarity economy (Fleippert, 2019), as illustrated in **Appendix IV**.

The study revealed that agroecology is quite a context and place-based. Assessing the ten elements helped identify key practices to be part of the climate and ecosystem-responsive practices for the agriculture sector in Nakuru County. Agroecology dimensions are critical when operationalizing agroecology-based projects to guarantee food systems transformation while protecting the environment. To a larger extent, agroecological elements overlap with adaptation and mitigation practices. Agroecology similarly promotes the connection of producers and consumers hence shortening supply chains, which point out key aspects of the trade. They allow for identifying important practices missing in a system to make the practices ecologically friendly.

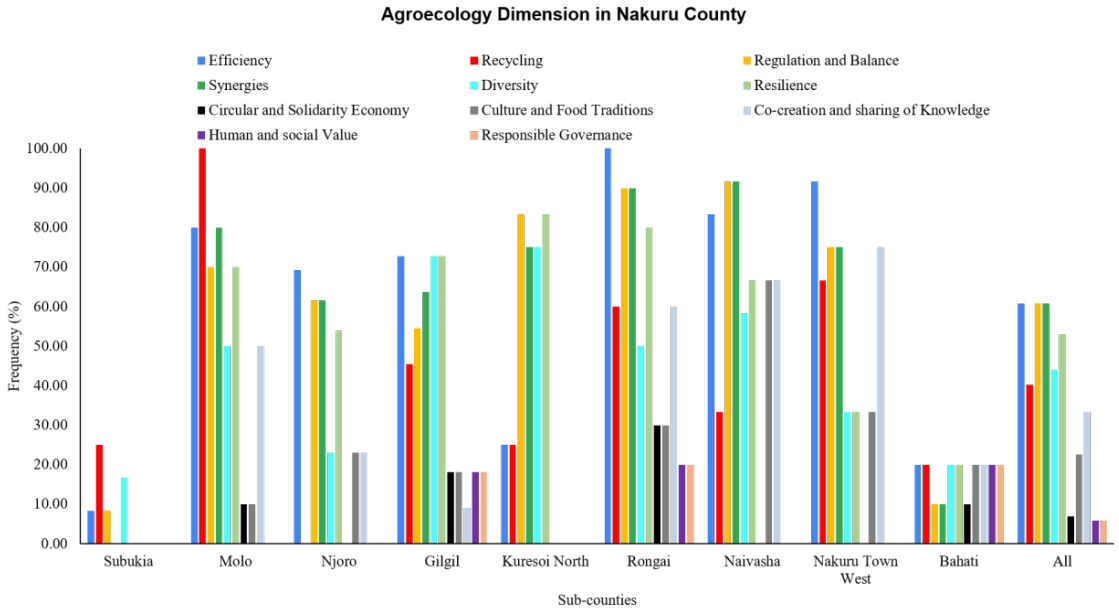


Figure 3.25. Agroecology Dimension across sub-counties

3.3 Pathways for Low carbon and resilient climate future for Nakuru County

Although it's not possible to eliminate the risks, it can reduce exposure and vulnerability while increasing resilience. The developed adaptation pathways entail site-specific recommendations based on identified climate hazards and ecosystem threats. These recommendations are constructed against the backdrop of an understanding that despite numerous national policies on environmental protection and biodiversity conservation, implementations of such policies have been devolved to the county governments. Yet, the impediments to implementing the national and county policies by the county governments are mainly the lack of enough funding and technical expertise. Recommended practices include technological, knowledge, institutional, and financial solutions, as explained below.

3.3.1 Pathway 1: Promotion and Adoption of Sustainable Soil and Land Management

a) *Status and Context*

Soil erosion risk mapping in Kenya shows that Nakuru County is at risk of land degradation. The causes of land degradation include biophysical (natural) factors related to climatic conditions and extreme weather events such as droughts and floods and catchment factors such as steep slopes and highly erodible soils. The changes in temperature regimes and precipitation patterns have led to the shifting of agroecological zones, thereby changing the geographical suitability of crop enterprises and the cropping seasons. There is a shift in the seasonal rainfall patterns, distribution, and reliability, and there is increased encroachment of water catchments leading to land degradation. Across Nakuru County, the availability of quality irrigation water is often the most constraining factor to agricultural production, with climate change making water supplies increasingly unreliable.

In addition, human activities pose the greatest threat, including unsustainable land management practices (anthropogenic) factors such as the destruction of natural vegetation, over-cultivation, overuse of external inputs, overgrazing, poor land farming, and excessive forest conversion. This has reduced production per unit area and increased post-harvest losses and crop production costs.

Sustainable Soil and Landscape Management (SSLM) practices that increase fertility and water use efficiency will need to be promoted at the farm level across all sub-counties in Nakuru County. SSLM is important in managing climate change threats in agricultural systems. Practices under SSLM have the advantage of protecting the soil, water, and energy. An analysis of the

...human activities pose the greatest threat, including unsustainable land management practices (anthropogenic) factors such as the destruction of natural vegetation, over-cultivation, overuse of external inputs, overgrazing, poor land farming, and excessive forest conversion.

legal, regulatory policy and socio-economic issues impacting land degradation suggests that many laws, policies, strategies, development plans, and institutional frameworks exist that mention land degradation and SSLM either directly or indirectly. A number of the policies address soil erosion, protection of catchment areas, soil and water conservation, rainwater harvesting, tree planting, and pollution control. However, Nakuru County has not put resources into SSLM implementation. Key gaps also exist in addressing SSLM, especially in agricultural systems.

b) *Challenges and emerging issues*

i. Increased extreme weather and climate change events such as droughts/dry spells, changing rain patterns, increasing temperature, extreme cold, and floods.

ii. Increased pollution by farm chemicals in the various ecosystems, especially agro and terrestrial ecosystems.

iii. Increased encroachment of water catchments leads to land degradation.

iv. Increased contamination of farm inputs pollutants in food chains.

v. Lack of Nakuru County-specific Strategic Investment Framework (CSIF) for SSLM

The proposed package of SSLM practices in Nakuru County focuses on soil health by promoting water management, soil water conservation, soil fertility management, recycling agricultural waste to energy and farm inputs, farm diversification, and management of natural resources (Appendix II). The following interventions are proposed to address the soil and water management issues.

Table 3. 3. Sustainable Soil and Land Management indicators

S/no	Interventions to be implemented with Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Strengthen the capacity of farmers to adopt sustainable water/soil-water/soil fertility management practices and good agricultural practices (GAP).	The number of farmers practising sustainable water/ soil-water/ soil-fertility management practices and good agricultural (GAP).
2	Strengthen the capacity of the Water Resource Users Association (WRUAs) and community groups on sustainable soil and land management practices.	Number of WRUAs and community groups practising sustainable soil and land management practices.
3	Support/provide incentives for increased water use efficiency (4Rs of water management). Right Source, Right Rate, Right Place, Right Timing.	Nature and type of incentives provided.
4	Work with stakeholders to establish a Nakuru County-specific Strategic Investment Framework (CSIF) for SSLM.	CSIF for SSLM established within the Nakuru County Climate Change Action Plan (2023-2027) cycle.
5	Support farmers to conduct soil testing to support soil nutrition practices	Numbers of farmers accessing soil testing analysis services and management services.

3.2.2 Pathway 2: Create an enabling environment for promotion and adoption of agroecology and agrobiodiversity conservation

a) *Status and Context*

Harnessing the potential of agroecology to transform agriculture and food systems requires an enabling policy, legal and regulatory framework for coordinated action and collaboration among a range of actors. However, agroecology has not been sufficiently mainstreamed into existing Nakuru County policies and strategies[10]. Nakuru County has no policy or legal framework that is explicit on agroecology. Consequently, there is no policy, law, strategy, or regulatory framework upon which efforts seeking to promote the adoption and scale-up of agroecology can be anchored. Further, cross-cutting issues such as inadequate financing of agricultural activities and the limited capacity of women, youth, and vulnerable groups (WY&VG) can lead to poor implementation of activities seeking to promote agroecology. The duplication of action, given that various institutions and stakeholders can play roles in agroecology and related issues are also a potential barrier.

b) *Challenges and emerging issues*

i. Limited mainstreaming of agroecology and other innovative-sustainable practices into existing national and county policies and strategies.

ii. Lack of specific Nakuru County government policies or strategies for supporting the promotion and scale-up of agroecology.

iii. Limited funding for agroecological initiatives and innovations, including the limited capacity of the county (farmers and community groups) to tap into existing funding opportunities. Such as climate financing).

iv. Absence of certification or standards to reflect the use of agroecological practices in Nakuru County.

Consequently, Nakuru County needs a sound and enabling environment to promote the adoption scaling up of agroecology. This requires laying or strengthening (as appropriate) the policy foundations for agroecology and other innovative approaches to contribute to sustainable agriculture and food systems that enhance food security and nutrition. The following actions are proposed.

Table 3.4. Indicators for promotion and adoption of agroecology and agrobiodiversity conservation

S/no	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Work with stakeholders to review and mainstream agroecology and other related innovations into existing county policies, legislations, and regulations.	The number of policies reviewed and revised within the Nakuru County Climate Change Action Plan (2023-2027) cycle.
2	Work with stakeholders to develop a County Policy, Strategy, or Legislation to support the promotion of agroecology and other related innovations (draw lessons from Murang'a and Kiambu that have draft policies on agroecology).	Policy, strategy, or law developed within the Nakuru County Climate Change Action Plan (2023-2027) cycle.
2	Develop mechanisms for funding agroecology initiatives and innovations, including building the capacity of the county to tap into existing funding opportunities. For example, climate finance and carbon credits.	The number of staff and community groups trained on proposal writing and fundraising. Creating a County Agroecology Fund – drawing lessons from existing funds such as the Nairobi Water Fund.
3	Work with stakeholders to sensitize the county on principles of agroecology.	The number of training on agroecology and agro-biodiversity conducted.

3.3.3 Pathway 3: Strengthen multi-stakeholder engagements/innovation platforms to support agroecology and sustainable agriculture

a) *Status and context*

Strategies and planning for implementing agroecological and other innovative approaches at different scales (farm/local/county) can help achieve this fundamental transformation of food systems by setting long-term goals, ensuring policy coherence across sectors (agriculture, trade, health, gender, education, energy, and environment), and involving all relevant actors through consultative multi-stakeholder processes. In line with this, there is evidence that locally-generated innovation can be scaled up through multi-stakeholder processes.

Multi-stakeholder platforms can take the form of food producers' and consumers' associations, organizations, and cooperatives that build capacities and create and exchange knowledge to facilitate the adoption of agroecological and other innovative approaches. They can also involve coordination mechanisms such as Nakuru County Agriculture Sector Steering Committee (CASSCOM). These platforms allow for experiential learning and knowledge-sharing among practitioners, and the co-production of knowledge among multi-stakeholder networks enhances its legitimacy and generates innovation adapted to the local context. Despite the importance of MSPs, few of these platforms (stakeholder or innovation) support agroecology and sustainable food systems. In addition, while Nakuru CASSCOM brings together various county government departments, it lacks legal and funding backing. Thus, innovations and dissemination depend on multi-stakeholder collaboration in the agrifood value chain to achieve a competitive advantage for better environmental, business, and societal outcomes.

b) *Challenges and emerging issues*

i. Lack of innovation platform for agroecology brings together women and other vulnerable groups.

ii. Weak legal framework and funding for Nakuru CASSCOM.

iii. Weak linkages between innovation platforms and existing multi-stakeholder platforms.

iv. Weak linkages between rural producer communities and urban markets or consumer communities.

v. Weak food producer associations and cooperatives.

To establish voluntary commitments, stakeholders, especially farmers involved in large-scale or agro-industry farming, the main economic activity in Nakuru County, will be most effective. Nakuru County has high biodiversity; hence small-scale farmers, who make up the majority of the residents, should be represented by their leaders in the County Climate Change and Biodiversity committees. The county should also utilize the existing NGOs, depending on their core activities, to support initiatives at the village level. Such multi-stakeholder engagement may be critical in establishing voluntary commitments on aquatic ecosystem biodiversity around the lakes in the county and forest ecosystems where farming takes place. With such engagements, the county can control access to the areas holding bio-species, improve data collection on land use, and improve governance of agroecological zones. The following interventions are suggested.

Table 3.5. Indicators for multi-stakeholder engagements

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Developing strong, inclusive innovation platforms for agroecology and agrobiodiversity conservation (with a focus on youth, women, and the vulnerable) at sub-county/ward levels.	Number of platforms for agroecology, including women, youth, and other vulnerable groups formed.
2	Provide legal and coordination support and funding for Nakuru CASSCOM to help promote agricultural co-creation.	Number of policies/strategies/bills for CASSCOMs to help promote agricultural co-creation.
3	Linkages between Multi-Stakeholder Platforms (MSPs) and Innovation platforms to support the uptake of already existing technologies.	Link at least 5 agroecological innovations to relevant stakeholders per year.
4	Strengthen linkages between urban communities and food production systems to favour transitions towards sustainable food systems.	Link 3 agroecology producers to urban markets. Include at least one urban stakeholder/ consumer group/market actor in MSP.
5	Strengthen food producers' associations and cooperatives that build capacities and create and exchange knowledge to facilitate the adoption of agroecological and other innovative approaches.	Map all the food producer associates Build capacity of at least 5 farmer groups/cooperatives per ward/year.
6	Capacity building through multi-stakeholder processes, with a strong focus on innovations emerging from the grassroots.	1 training per year for CASSCOM members. 1 Training for at least 10 innovators per year.
7	Recognizing and supporting participatory guarantee systems (PGS) as a valid means to certify organic, ecological, and agroecological producers.	1 PGS at the county level. Link County PGS with national/ international certification agency.

3.3.4 Pathway 4: Strengthen the Adoption of Ecosystem-Based Adaptation

a) *Status and context*

Shifting weather patterns due to climate change, affecting rainfall and temperature, are likely to impact the ecosystem goods and services such as clean water and food on which people rely. Ecosystem-Based Adaptation (EBA) is a strategy for adapting to climate change that harnesses nature-based solutions and ecosystem services. EBA involving the conservation, sustainable management, and restoration of ecosystems, can help people adapt to the impacts of climate change. Taking the EBA pathway will need to emphasize integrating nature-based methods in addressing climate change and ecosystem restoration. Practices must focus on conserving natural ecosystems, including forest, land, and water-based systems.

b) *Challenges and emerging issues*

i. Farming practices are not focused on conserving natural ecosystems, including forest, land, and water-based systems.

ii. No policy that the relevant authorities should take up species monitoring periodically through conducting site surveys and monitoring species populations.

iii. There is no minimum climate change mitigation and biodiversity conservation budge

iv. Biodiversity is not integrated into mining and quarrying life cycles

It has been established that the highest species richness and remaining indigenous forests are found in areas with intensive crop farming. The county government should consider

establishing voluntary commitments that focus on intensive crop farming in these since they create a high potential to conserve biodiversity. Likewise, mapping out Key Biodiversity Areas (KBA) and setting regulations that promote avoidance of such areas when implementing development projects may contribute to biodiversity conservation. Mapping such areas will lead to identifying high-priority sites for habitat monitoring. Besides mapping, distinguishing key habitat areas to protect endangered biodiversity should be an annual or periodic procedure. A mandatory periodic review of protected areas and buffer zones for stationary species and corridors for migratory species should be implemented.

It should be in policy that the relevant authorities should take up species monitoring periodically through conducting site surveys and monitoring species populations as would be stated to underscore species composition and size and also establish the human activities and water resource protection levels with a view of establishing the value of restored habitats to biodiversity, agriculture, and other activities. Therefore, the lost species can be reintroduced if possible. The ecological value and likely permanence of such introduced species and habitats should be ascertained to incorporate them into biodiversity planning programs.

The county government should allocate a minimum financial allocation (as a percentage of the county revenue or through any other formula) to the relevant bodies tasked with climate change mitigation and biodiversity conservation. This will ensure that the plans and measures undertaken are not impaired due to financial constraints. Additionally, it will allow for the recruitment or hiring of technical expertise to drive the implementation of the available policies.

A task force should be formed, or one of the existing bodies should identify synergies

The ecological value and likely permanence of such introduced species and habitats should be ascertained to incorporate them into biodiversity planning programs.

between other economic sectors, such as agriculture and forestry, and identify how linking such sectors can work in biodiversity conservation. For instance, the links between logging, charcoal production, and forest clearing for agricultural expansion or industrial activities leading to effluent discharges into the water systems should be identified, and voluntary commitments should be sought. This would only work through enhanced coordination (which can be created by the task force or the relevant body) between sectors to facilitate integrated biodiversity mainstreaming and the development of biodiversity management plans. All sectors should have their plans enriched by conservation ideas from the selected body before such plans are used. The authorization from NEMA and policies therein are more biased toward environmental management than biodiversity conservation.

Farmers who take up adaptive measures to counter climate change should be rewarded to encourage more farmers to engage in such measures. Such adaptive measures may include tree planting, harvesting, and increasing water and soil conservation. Also, staggering cropping should be encouraged for resilient but staple crops such as Irish potatoes because such help reduces climate change impacts. In addition, agricultural technologies that conserve the ecosystems

should be encouraged and checked before use within the county. Animal farming should focus on feed conservation, water harvesting and conservation, and fodder production rather than grazing. More adapted cattle breeds should be made to replace the high-feeding common breeds. Generally, the agriculture department and the ministry of environment in the county should liaise for mainstreaming agricultural practices.

Mining and quarrying activities are economic activities that offer employment to a large number of residents. The mining and quarrying companies should endeavor to integrate biodiversity into their life cycles and submit reports (including GIS framework) periodically about their performance in that aspect to the relevant authorities. Through these reports and monitoring, the county government should offer valid compliance certifications at each cycle to mark the end and the beginning of another cycle. Finally, the quarrying and mining companies should be compelled by law to undertake restoration procedures. The following interventions are proposed.

Table 3.6. Indicators for Strengthening Ecosystem-Based Adaptation

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Key Biodiversity Areas avoidance and Spatial Prioritization of KBAs.	Key biodiversity priority areas avoided.
2	Regular monitoring of mapped-out species.	The number of species mapped and monitored regularly.
3	Formulation of a minimum climate change mitigation and biodiversity conservation budget.	Minimum climate change mitigation and biodiversity conservation budget formulated
4	Sectoral Linkages	The number of sectors linked.
5	Rewarding measures	The number of farmers rewarded to take up adaptive measures.
6	Integrating Biodiversity into mining and quarrying life cycles.	Biodiversity integrated into mining and quarrying life cycles

3.3.5 Pathway 5: Support promotion, uptake, and scale-up of agroforestry

a) *Status and context*

Agriculture and forestry are among the six sectors for which Nationally Appropriate Mitigation Actions (NAMAs) pathways have been developed in the National Climate Change Action Plan. Selected actions for mitigation include agroforestry and increasing tree cover to 10% of the total land area. Agroforestry is acknowledged in several international policy fora and conventions for its relevance in advancing climate change adaptation and mitigation actions, climate-smart agriculture, restoration of degraded landscapes, controlling desertification, and provisioning multiple ecosystem services. The NCCAP 2018 to 2022 promises to have increased the total area under agroforestry at the farm level by 200,000 acres (80,000 hectares). Other NCCAP results within the CSA framework that agroforestry can contribute to include: (i) support the reclamation of 60,000 hectares of degraded land; (ii) increase area under integrated soil nutrient management

by 250,000 acres (100,000 ha); and (iii) increase area under conservation agriculture to 250,000 acres (100,000 ha) incorporating minimum/ no-tillage with trees to provide adequate soil cover (GOK 2018b). However, the benefits of agroforestry practices have not been demonstrated well enough to guarantee adoption countrywide, including in Nakuru County, implying that other drivers of adoption need to be pursued.

b) *Challenges and emerging issues*

i. Limited formalization of agroforestry into the mainstream agricultural and forestry knowledge systems and policy, legal, and institutional framework

ii. Limited access to quality planting materials (seeds, seedlings, cuttings)

iii. Limited human, infrastructural, and institutional (innovation) capacities for scaling agroforestry practices

Despite growing recognition of agroforestry's positive (and potential) impact on livelihoods and landscapes, formalization of the practice in the mainstream agricultural and forestry knowledge systems and policy, legal, and institutional framework has lagged. This has been attributed to, among others, the diverse pathways and difficult-to-measure characteristics of impacts of agroforestry practices -especially ecological benefits - (Dawson et al. 2013; FAO 2013) and the fragmented, sector-specific approach that has dominated agricultural and forestry policies in many countries. As a system interacting with multiple sectors, agroforestry often experiences policy and institutional conflicts and omissions. As a result, human, infrastructural, and institutional (innovation) capacities for scaling agroforestry practices are underdeveloped in most developing countries, especially in Africa and Kenya. In light of the challenges, the following actions are proposed.

Table 3.7. Indicators for support promotion, uptake, and scale-up of agroforestry

S/ No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Promote/support community tree nurseries (provide idle public land for tree seedling business).	Establish at least 1 community tree nursery per year for agroforestry trees.
2	Enhance access to indigenous tree planting material (seeds, seedlings, cuttings, etc.)	Build the capacity of farmers to propagate agroforestry trees (e.g., training on grafting and tissue culture).
3	Enhance awareness creation on the utility of trees and tree products, e.g., on medicinal, pesticide properties, and cultural value) using existing and emerging knowledge and resources.	Number of training conducted
4	Have different stakeholder and innovation fairs and support early learning in schools by introducing fairs to encourage Nakuru County to support agroforestry work.	Number of innovation fairs held per year
5	Mainstream agroforestry more coherently into Nakuru County policies, legal, and institutional frameworks.	Number of policies where agroforestry is mainstreamed

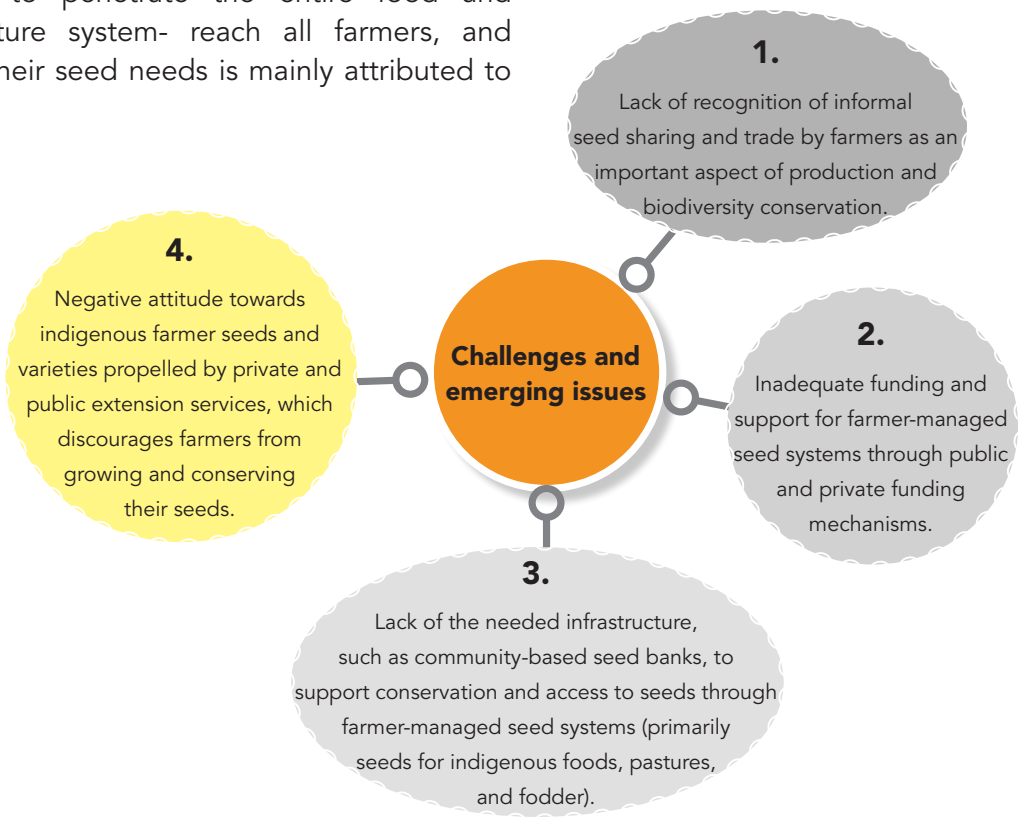
3.3.6 Pathway 6: Promotion and Adoption of Community-based seed banks

a) *Status and context*

Seed is the basis of life and all forms of agricultural production, i.e., food, feeds, and fiber. Seed refers to grains or ripened ovules of plants used for sowing or the fertilized ripened ovule of a flowering plant containing an embryo and capable of germination to produce a new plant broadly or a propagative plant structure (such as a spore, cutting, sucker, or small dry fruit). Both crop and animal production systems rely on the availability of seed and other planting materials, either existing or self-propagating in the natural environment or in the hands of producers who plant and tend to them.

While in many instances, the commercial seed selection process has helped improve production and consistency in production and productivity levels, this process has only provided for 20% of seed and plant material needs. The inability of the commercial seed sector to penetrate the entire food and agriculture system- reach all farmers, and meet their seed needs is mainly attributed to two main factors. One is the impracticality of the conventional seed multiplication process in some of the crops/important plants and the inability of the commercial seed sector to provide seeds at a cost that is accessible to all farmers, regardless of their social or economic status.

While meeting this gap over the years, the informal seed sector has also thrived globally, providing a strong alternative source of viable seeds- with richer diversity and better resilience to global shocks than the formal/ commercial seed sector. However, in Kenya, there is a strong push for the adoption of genetically modified seeds (GMOs), which have several associated challenges, including safety concerns, environmental impacts such as harming beneficial insects, economic impacts, ethical concerns, regulatory challenges and lack of public understanding about GM technology and how it's used in food production which contributes to misinformation and mistrust.



b) *Challenges and emerging issues*

i. The government of Kenya has lifted the ban on the cultivation and importation of genetically modified foods.

ii. Lack of recognition of informal seed sharing and trade by farmers as an important aspect of production and biodiversity conservation.

iii. Inadequate funding and support for farmer-managed seed systems through public and private funding mechanisms.

iv. Lack of the needed infrastructure, such as community-based seed banks, to support conservation and access to seeds through farmer-managed seed systems (primarily seeds for indigenous foods, pastures, and fodder).

v. Negative attitude towards indigenous farmer seeds and varieties propelled by private and public extension services, which discourages farmers from growing and conserving their seeds.

As a result, there is a need for agricultural counties like Nakuru to recognize the place and enhance the competitiveness of the informal seed sector. Community-based seed banks aim to preserve and disseminate locally adapted and diverse varieties of crops within a community. These seed banks can help to promote low carbon and resilient climate futures in several ways:

i. Promoting the use of locally adapted and diverse crop varieties can increase agricultural systems' resilience to climate change's impacts, such as extreme weather events and changing temperature and precipitation patterns. These varieties are better suited to local growing conditions and are more likely to thrive in the face of climate-related stresses.

ii. Community-based seed banks can help reduce agriculture's carbon footprint by reducing the need to transport seeds over long distances. Local seeds are more likely to be produced and distributed within the community, reducing the need for fossil fuel transport.

iii. By promoting locally adapted seeds, community-based seed banks can help preserve crops' genetic diversity, which is important for building resilience in the face of climate change. A diverse gene pool allows plants to adapt and evolve in response to changing conditions, increasing the chances that some individuals will be able to survive and reproduce in the face of stresses such as drought, pests, and disease.

iv. Community-based seed banks can also help to promote sustainable agriculture practices that have lower carbon emissions and are more resilient to the impacts of climate change. For example, they may encourage agroecological practices that rely on natural fertilizers and pest management techniques rather than synthetic inputs that contribute to greenhouse gas emissions.

v. By promoting the use of local seeds and supporting the development of seed production and distribution networks within communities, community-based seed banks can help to empower local people and increase their capacity to adapt to a changing climate.

Promoting and adopting community-based seed banks in Nakuru County can help support the development of more sustainable and resilient local food systems, which is essential for adapting to a changing climate and thus contributes to a low-carbon and climate-resilient future. The following actions are proposed to be implemented in the Nakuru County Climate Change Action Plan (2023-2027).

Table 3.8. Indicators for promotion and adoption of Community-based seed banks

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Build community seed banking facilities in Nakuru county (preferably aligning with groups/cooperatives practising seed saving and sharing).	Establish at least 1 community seed banking facility per county
2	Promote the use and conservation of farmer seeds and varieties through extension services and other awareness-creation and knowledge-transfer platforms.	Training and capacity building of extension staff on farmer-managed seed systems
3	Conduct regular analysis and monitoring of indigenous foods and seed availability in the county.	Regular status update on county seed status
4	Create platforms for public sharing and knowledge transfer on the county's different local varieties, e.g., through annual seed fairs.	One seed fair per year
5	Support the development and institutional framework for Nakuru County-based quality declared seed systems (QDS) which will facilitate better market engagement in the county.	County-based QDS system developed
6	Support access through subsidies and vouchers to indigenous plant varieties for food, feed, fiber, or other important ecosystem services.	At least 5 varieties identified and supported by the county

3.3.7 Pathway 7: Support Agricultural Training Centers or model farms approach

a) ***Status and context***

With emerging issues affecting agricultural production, generating and disseminating knowledge is important in ensuring that we are up-to-date and prepared to produce enough to sustain ourselves. The role of demand-driven research that is primarily focused on furthering understanding of the trends and impacts of emerging issues of climate change, invasive species, pest and disease attacks, and designing solutions through practical, participatory research methods cannot be overstated. The Agriculture Training Centers (ATCs) model is one of the most viable, tested approaches to meet this need.

ATCs focus on training practical skills and innovative approaches to sustainable food production while protecting the environment. The ATCs model also fosters the connection between the holders of the knowledge (academicians) and those who apply the knowledge generated through research and are on the frontline in identifying knowledge/ research needs and innovations (the producers). This nexus is critical for sustainable agriculture development. This transformation considers lived experiences, indigenous knowledge of producers, and new technologies and practices identified through research and technology development processes.

b) *Challenges and emerging issues*

i. Inadequate funding for the ATC model.

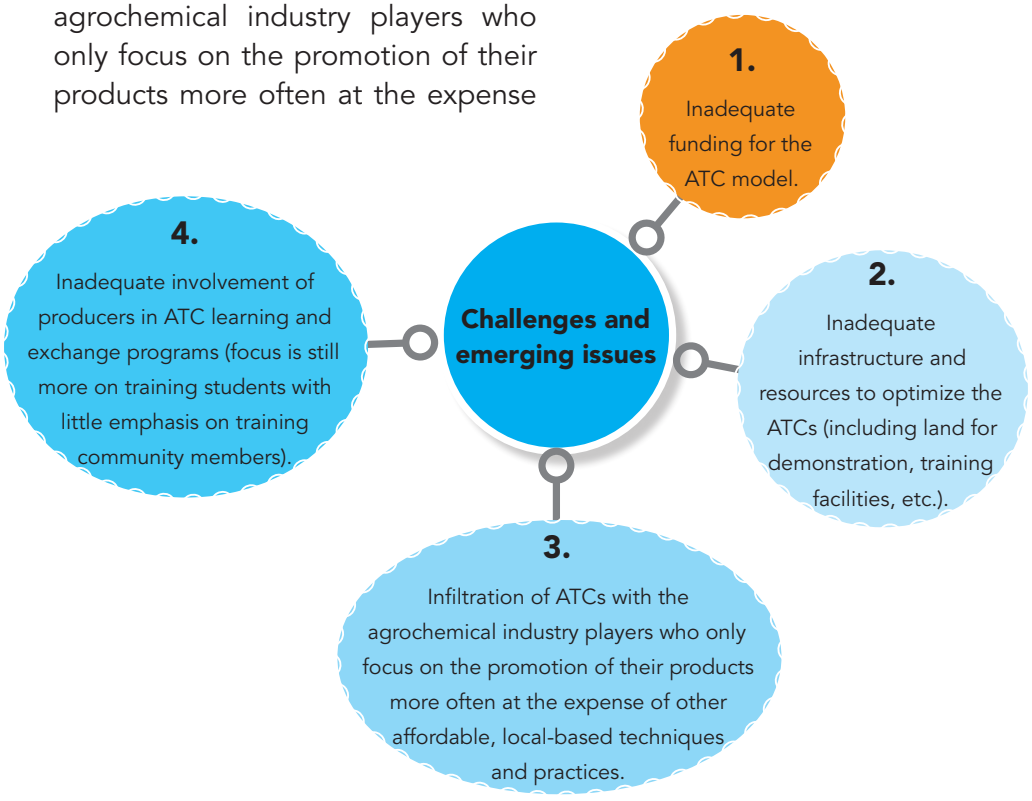
ii. Inadequate infrastructure and resources to optimize the ATCs (including land for demonstration, training facilities, etc.).

iii. Infiltration of ATCs with the agrochemical industry players who only focus on the promotion of their products more often at the expense of other affordable, local-based techniques and practices.

iv. Inadequate involvement of producers in ATC learning and exchange programs (focus is still more on training students with little emphasis on training community members).

Agricultural training centres and model farms can significantly contribute to a low-carbon and resilient climate future in Nakuru County by providing farmers with the knowledge and skills they need to adopt sustainable and climate-friendly farming practices. These practices can include using low-carbon technologies and practices such as precision agriculture, conservation agriculture, and agroforestry, as well as adopting climate-resilient crop varieties and integrating animals into crop production systems.

By adopting these practices, farmers can reduce their greenhouse gas emissions, increase the carbon sequestration potential of their land, and build resilience to the impacts of climate



change. This can help mitigate the negative impacts of climate change on agriculture and food security and contribute to the goal of achieving a low-carbon and resilient future in Nakuru County.

In addition to providing training, agricultural training centres and model farms can also serve as demonstration sites. Farmers can see these practices and learn how to implement them on their farms. This can effectively promote adopting sustainable and climate-friendly farming practices on a larger scale.

Overall, Promoting and adopting agricultural training centres or model farms can contribute to a low-carbon and resilient climate in Nakuru County by promoting sustainable agriculture practices, building capacity for adaptation, facilitating the adoption of new technologies, and strengthening networks and communities of farmers. The following interventions are proposed.

Table 3.9. Indicators for Support for Agricultural Training Centers or model farms approach

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Develop a Nakuru County strategy for the revitalization of ATCs.	1 County Strategy developed.
2	Provide resources for building, finalizing, or renovating/equipment of ATCs in Nakuru County.	Ensure at least 1 functioning ATC in the county.
3	Develop and implement guidelines for the demonstration farms within ATCs to ensure that the technologies promoted are economically sound, environmentally viable, socially inclusive, and sustainable.	Development of county ATC model farm approach guideline.
4	Develop strong linkage between ATCs and extension services, farmer groups, and cooperatives.	Training, joint activities
5	Institutional support and promotion of Nakuru County ATCs.	One county activity in the ATCs per quarter
6	Linking ATCs to the TVET system and other County and national training institutions.	At least 3 exchange programs/linkages established

3.3.8 Pathway 8: Promote access to organic farm inputs

a) *Status and context*

Agricultural inputs continue to be a major debate in Kenya, with increasing awareness of the impact of some agricultural inputs on soil health and productivity, local biodiversity, water quality and safety, and human health. Chemical inputs continue to take root in most parts of the country with the promises of rapid action on pests and diseases to protect crops and safeguard the harvest. Chemical fertilizers have also been marketed as more effective in boosting soil fertility and ensuring high productivity, especially in major grain crops and horticulture production. However, over time, the negative impacts of heavy, non-judicious use of these products have been witnessed in most parts of the country- the impacts on aquatic life, quality of soil, i.e., acidification in the sugar belt and maize growing regions, impact on important biodiversity among other issues have been noted through multiple research initiatives.

b) *Challenges and emerging trends*

i. One of the major challenges is the preference for inorganic inputs only in government-sponsored farmer-support programs. This creates an imbalanced market that works against organic input providers.

ii. Lack of awareness of some of the long-term, environmental, and productivity gains of organic farming.

iii. Inadequate support of local innovations that produce/provide organic solutions for farmers to scale up and build the competitiveness needed to sustain their businesses.

iv. The awareness of the negative impacts of chemical inputs has increased farmers' demand for organic, environmentally friendly farming inputs. While the input production side gradually adjusts to meet this demand, various policy and technical barriers make it difficult for these products and technologies to penetrate the market.

The following interventions are proposed:

Table 3.10. Indicators for Promoting access to organic farm inputs

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Include and, where possible, prioritize organic inputs in county farmer support programs.	At least one-third (1/3) of all county subsidy and farmer support programs should go into organic inputs.
2	Promote the use of locally available resources, farmer knowledge, and practices in sustainable food production.	Training and capacity building of extension staff on organic farming techniques.
3	Support local producers of organic farm inputs.	At least one organic input provider per ward is identified and capacity-built.

3.3.9 Pathway 9: Support Local markets for farmers

a) *Status and Context*

The current agricultural market system in Kenya suffers from several inefficiencies and blockages, such as the presence of cartels and brokers in markets; information asymmetry among market players, which reduces producer margins and blocks entry of new market players while increasing the wide gap between the farm gate and market price; failure to honor contractual obligations between buyers and producers; conflicting markets' management and regulatory roles by government agencies; substandard hygiene and quality arising from lack of enforcement of standards, and poor consumer awareness.

While county governments in Kenya have developed initiatives to build fresh produce markets and are aware of the need to invest in larger fresh produce markets with cooling and storage, the facilities remain inadequate. As a result, farmers, traders, and consumers in market locations are faced with the problem of inadequate physical market infrastructure. Where infrastructure exists, such markets are inappropriately constructed, underutilized, in disuse, congested, disorganized, and have poor sanitary conditions. In addition, the market facilities do not have designated sections/zones for products produced through regenerative practices.

b) *Challenges and emerging issues*

i. Limited understanding of whether and how products from agroecological production systems are being valued in markets.

ii. Lack of specific market incentives to encourage the adoption of agroecological production systems.

iii. Inefficient supply chains and inadequate market infrastructure for fresh produce with cooling and storage facilities.

iv. Absence of designated zones for trading products using agroecological or regenerative practices.

v. Absence of certification or standards to reflect the use of agroecological practices.

In light of these challenges, there is a need to promote diverse market arrangements with greater flexibility in the face of disruptions and capable of supporting the market and social innovations that strengthen linkages between consumers and food producers, particularly small-scale farmers. Supporting local markets for farmers can contribute to a low-carbon and resilient climate future in several ways:

i. Reducing transportation emissions: By purchasing from local farmers, consumers can reduce the distance that food has to travel from farm to market, which can reduce greenhouse gas emissions from transportation.

ii. Supporting small-scale farmers: Local markets provide an important source of income for small-scale farmers, who may not have the resources to compete with larger, more industrial operations. Local markets can help preserve diverse and sustainable farming practices by supporting these farmers.

iii. Promoting sustainable farming practices: Local markets can incentivize farmers to adopt sustainable practices, as consumers are often willing to pay a premium for locally-grown, environmentally-friendly products.

iv. Building resilience in the food system: Local markets can help to

build resilience in the food system by providing a more direct connection between producers and consumers. This can reduce the food system's vulnerability to disruptions caused by extreme weather events and other climate-related challenges.

v. Promoting food security: Local markets can help to ensure that communities have access to a diverse range of fresh, nutritious foods, even during times of supply chain disruption or extreme weather events.

Supporting local markets for farmers can contribute to a low-carbon and resilient future in Nakuru County by reducing greenhouse gas emissions, supporting sustainable farming practices, and building resilience in the food system. The following actions are proposed.

Table 3.11. Indicators for Supporting Local markets for farmers

S/no	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Work with stakeholders to support collective action in marketing, quality management, certification, and value addition	Number of farmer groups linked to markets within the Nakuru County Climate Change Action Plan (2023-2027) cycle
2	Strengthen the capacity of farmers to realize the full potential of digitalization for sustainable agriculture and food systems through capacity building and cooperation with ICT providers and technology transfer	Number of farmers accessing market-related ICT platforms
3	Support the establishment of special zones/ sections in urban markets for products produced using regenerative or sustainable practices for organic/agroecology-practising farmers	Number of markets having designated trading zones for food products produced through agroecological practices
4	Sensitizing people on the importance of agroecology.	Number of training on agroecology and agro-biodiversity conducted
5	Promote awareness and implementation of the food traceability standards such as the KS1758 code of practice [11] and develop and enhance capacity for food safety checks in local markets and publish the results.	Number of awareness sessions The capacity of food safety checks Frequency of safety checks.
6	Work with partners to improve market infrastructure, including sanitation and waste management.	The number of markets supported

3.3.10 Pathway 10: Strengthen agricultural extension systems to deliver increased productivity, resilience to climate change, and wealth creation

a) *Status and context*

The attainment of the government's target of ensuring food security and reducing poverty for all requires improvements in agricultural productivity. Agricultural extension services play an important role in ensuring information flow across the chain, thereby reducing uncertainty and enhancing the performance of the whole agricultural supply chain system. Studies by the International Food Policy Research Institute have shown that increasing extension visits reduces poverty and child malnutrition. The country's Vision 2030 and the Agricultural Growth Transformation Strategy (ASTGS) recognize the need to strengthen extension systems. Despite the importance of extension, access to extension services continues to be limited. The need for a strong extension system is important in light of low agricultural productivity, rising poverty and food insecurity, and conditions that have been made worse by the impacts of climate change.

Following the devolution of the agriculture functions, County governments are the main implementers of public extension services. Together with National Government and other organizations supporting rural livelihoods, agricultural intensification and commercialization have been promoted, resulting in enhanced productivity in some value chains and improved incomes for smallholder farmers. However, increased intensification, associated with increased use of external inputs over time, coupled with climate change's effects, have resulted in declining productivity in many value chains and the risk of losing gains already achieved. Improving the access of small food producers (including small farmers, pastoralists, fisher folk, and forest-dependent people), in particular women, youth and persons with disabilities, to extension services is critical to fill the gaps in information, knowledge and technology and may contribute to wider and accelerated transitions towards food and nutrition security and reduced poverty.

b) *Challenges and emerging issues*

i. The extension staff's capacity to offer training on agricultural approaches is limited.

ii. A lack of coordination of these efforts while implementing decentralized and pluralistic policies in providing extension services has led to increased availability of actors providing extension services to farmers.

Therefore, there is a need to strengthen extension systems to address the challenges of unsustainable food systems that threaten to reverse gains already made. The following actions are proposed.

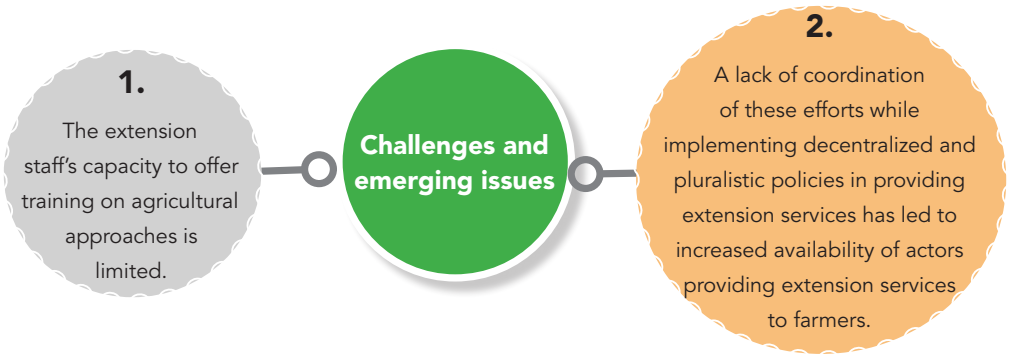


Table 3.12. Indicators for Strengthening agricultural extension systems to deliver increased productivity, resilience to climate change, and wealth creation

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Capacity building for extension officers on agroecology and sustainable agriculture.	Training manual for agroecology developed in collaboration with other stakeholders.
2	Increase extension officer-to-farmer ratio from an estimated 1:10,000 to 1:1,000 for improved implementation of agroecological practices.	Hire extension officers per ward gradually to attain a ratio of 1:1000 in 5 years.
3	Enhancing coordination and collaboration among extension agents from the public, private sector, and NGOs.	Policy on extension coordination at the county level developed.
4	Promote Community-based learning systems, such as farmer field schools (FFS) or farmer learning centers, where a group of farmers addresses a problem together in the field, volunteer farmer trainers, and farmer-to-farmer extension services.	Set up 5 FFS groups per ward. Train 10 volunteer farmer trainers to offer extensions per ward/year.
5	Promote Digital and other ICT computer-based advanced technologies for communicating and managing information to improve youth involvement in agriculture.	All extension officers are trained on digital extension. 1 ICT-based extension system set up at the County level.
6	Promote delivery of shared knowledge on agroecology and sustainable agriculture.	Agroecology content is included in the number of field days and; Number of exhibitions where agroecological information is shared.
7	Bringing research and extension closer and better linking international and national research and extension systems with local knowledge and farmer-to-farmer knowledge exchange.	A framework for extension/research/farmer linkages was developed. The number of linkage meetings/events held.
	Promote co-production, validation, and communication of knowledge through extension officer-research-farmer exchanges on agroecology.	The number of co-production of agroecology knowledge events.

3.3.11 Pathway 11: Support integrated pest management (IPM) and other alternative approaches to pest and disease management

a) *Status and context*

There is a clear indication that pesticide use in Kenya is increasing rapidly. Some evidence suggests that a good share of this results from increased crop and livestock intensification and industrial agriculture. An alternative approach to pesticide use known as integrated pest management (IPM) has been promoted in Kenya for over three decades. Ecological pest control works by restoring the balance between pests and their natural enemies and barriers to movement through cultural techniques, promoting on-farm diversity, choosing appropriate varieties, and introducing natural enemies. Different tactics are used in developing site-specific management systems that capitalize on natural biological factors that serve to maintain the pests at levels below those causing economic loss ('injury'). Chemicals are used only as a last resort, but their dosages and application are carefully adjusted to minimise deleterious effects on health and the environment.

b) *Challenges and emerging issues*

i. Limited availability of alternatives to pesticide use

ii. The personnel available for crop protection and IPM are too few and often inadequately educated and trained/ There are too few personnel available for crop protection activities, and most are not adequately trained for their jobs

iii. Limited funding by the County government on IPM. Most work on IPM in Counties is carried out in projects funded by international donors.

iv. Lack of basic technical studies on pests and their natural enemies; effective and economic means of production of natural enemies

v. Scouting services are not organized as is frequently

vi. Inadequate laws referring to the production, registration, and use of commercially produced natural enemies

Despite the promotion of IPM, its adoption continues to be low. While many factors explain low use of IPM, the status is further complicated because pesticides are often supplied by cooperatives, agrochemical companies, government projects, etc., and are often applied as prophylactic calendar treatments. In such cases, one frequently observes a spillover effect of pesticide application on food. There is, therefore, a need to promote IPM practices in agricultural production systems to enhance productivity, environmental conservation, and human health. The following are the suggested interventions.

While many factors explain low use of IPM, the status is further complicated because pesticides are often supplied by cooperatives, agrochemical companies, government projects, etc.

Table 3.13. Indicators for Supporting integrated pest management (IPM) and other alternative approaches to pest and disease management

S.No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Training extension officers on IPM and alternative approaches to pest and disease control.	Training manual for IPM developed in collaboration with other stakeholders All extension officers trained on IPM management.
2	Training farmers on IPM through two-way communication between extension workers and farmers and short training courses and farmer—scientist communication.	Develop a course/training module on IPM targeting 3 key value chains Train at least three farmer groups per ward on IPM practices.
3	Support local innovations and production of alternative pest control products.	Incubate at least 3 innovations per ward. Provide subsidies for their IPM products in three key value chains.
4	Prioritize environmentally friendly/ organic pest control products in government farmer support programs.	3 IPM products promoted in each of the county agriculture-supported projects.
5	Promote IPM and sustainable farming practices through shows and exhibitions.	Showcase IPM practices in; One agricultural show /exhibition a year. 1 Field day per county/year.
6	Provide incentives for farmers to adopt IPM practices.	Number of farmers provided with incentives to adopt IPM practices.
7	Link IPM-produced products with markets.	3 IPM-produced crop products linked to markets
8	Promote pest-resistant varieties of crops	One variety promoted in each of the 3 priority value chains
9	Support pilot trials on IPM practices in collaboration with other stakeholders (NGOs, private sector, etc.).	Trials for three IPM innovations in each ATC.
10	Implementation of routine scouting services will lead to early detection of pest outbreaks.	Monthly scouting of pests and diseases in each ward.

3.3.12 Pathway 12: Promotion and Adoption of Renewable (Clean & Green) Energy

a) *Status and context*

Nakuru County hosts the nation's complexes of geothermal power production. Olkaria complex has made Kenya one of the world's leading geothermal power producers. This aspect has also made Naivasha be earmarked for the establishment of an industrial park by the National Government due to its proximity to the Olkaria geothermal complex, which will make power cheaper and facilitate other uses of direct steam from the wells.

A mix of appropriate energy technologies is necessary to make a shift to food chains that are climate smart. Energy plays an important role in almost every stage of the agri-food system; pre-production, production, post-harvest, storage and processing, transport and distribution. A large chunk of the greenhouse gases that blanket the Earth and trap the sun's heat is generated through energy production by burning fossil fuels to generate electricity and heat. Fossil fuels, such as coal, oil and gas, are the largest contributor to global climate change, accounting for over 75 per cent of global greenhouse gas emissions and nearly 90 per cent of all carbon dioxide emissions.

Energy plays an important role in almost every stage of the agri-food system; pre-production, production, post-harvest, storage and processing, transport and distribution.

Emissions need to be reduced by almost half by 2030 and reach net zero by 2050. To be able to avoid the worst impacts of climate change. This can be achieved by ending reliance on fossil fuels and investing in alternative energy sources that are clean, accessible, affordable, sustainable, and reliable. Renewable energy sources provided by the sun, wind, water, waste, and heat from the Earth are replenished by nature and emit little to no greenhouse gases or pollutants into the air.

b) *Challenges and emerging issues*

i. A huge population in Nakuru County still uses charcoal or firewood as their main source of cooking fuel.

ii. There is a need to safely supply clean fuels, electricity and water to meet the growing energy demand worldwide despite declining resources.

iii. There is a real need to drastically increase energy efficiency by developing new, more efficient and cleaner energy systems rather than incrementally improving existing systems.

iv. Reducing pollution and stabilizing greenhouse gas emissions from energy utilization are necessary.

v. There is a long-term need to make more active use of renewable sources of energy (e.g., solar energy, biomass, wind, geothermal, and wave) and design better conversion systems without negative impacts on the environment.

Table 3.13. Indicators for renewable energy

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Training farmers on renewable (clean & green) energy sources.	• Training manual for renewable energy options developed in collaboration with other stakeholders • All farmers trained and adapted to renewable energy options.
2	Support local innovations and production of renewable energy products.	• Incubate at least 3 innovations per ward. • Provide subsidies for their renewable energy products
	Provide incentives for farmers to adopt renewable energy	• Number of farmers provided with incentives to adopt renewable energy
	Promote awareness and implementation of renewable energy practices, including waste-to-energy training.	• Number of awareness sessions

Using renewable energy sources and opening up access to energy through efficient and affordable small-scale systems is important for increased productivity and enhanced resilience to climate change extremities. Nakuru County should invest more in clean and green energy sources to reduce its escalating electricity bill. Examples of renewable energy that Nakuru County can tap include Solar, biogas, improved cook stoves, briquettes, and Zero Energy Cooling Chamber.

Accelerating the transition to clean energy is the pathway to a healthy, livable planet today and for generations to come because of the following reasons:

1. Renewable energy sources are available in all countries, and their potential is yet to be fully harnessed[12].
2. Renewable energy prices are dropping rapidly, making it the cheapest power option in most parts of the world today[13].
3. Switching to clean energy sources, such as wind and solar, thus helps address not only climate change, air pollution, and health[14].
4. Investment in renewables creates three times more jobs than in the fossil fuel industry[15]; Ensuring a just transition, and placing the needs and rights of people at the heart of the energy transition, will be paramount to ensure no one is left behind.
5. Renewable energy makes economic sense because its efficient, reliable renewable technologies can create a system less prone to market shocks and improve resilience and energy security by diversifying power supply options.

3.3.13 Pathway 13: Promotion and Adoption of Sustainable Waste management

a) *Status and context*

Waste management remains one of the critical development challenges nationally and at the county level. Waste is inevitable due to ordinary human activities such as industrial production, consumption at the household level, and construction and commercial processes, among others. However, its accumulation has environmental, health, social and economic implications in the long term.

Nakuru has a county waste management policy (2019) which provides the guiding framework for Waste Management in Nakuru County. It consists of the constitution of Kenya and various statutes, sessional papers and sectoral plans, among others. The national and county departments involved in waste management included the National Environment Management Authority (NEMA), and county departments in charge of public health, public works and trade were consulted. In addition, the process involved private actors in waste management, such as waste collectors and transporters, resident associations, waste sorters and recyclers.

Nakuru County should adopt an integrated approach to waste management and principles of sustainable waste management that form a healthy environment. Landfill sites are considerable sources of greenhouse gas emissions. Thus the primary objective in developing waste management must be to reduce emissions throughout the whole chain. Coping with changing climatic conditions is particularly an issue when managing old landfill sites and contaminated land. For instance, increased precipitation increases the leaching of nutrients and contaminants from landfill sites. Also, waste management, including plants that store and treat dangerous substances and landfill sites, should naturally not be located in areas that are liable to floods. On the other hand, agricultural waste may be utilized for livestock, and poultry feeding, converted to mulch or biochar for use on farms as fertilisers or recycled for reuse on the farm, e.g. waste water from the kitchen.

b) *Challenges and emerging issues*

i. Nakuru has limited financial resources and inadequate personnel for effective waste management.

ii. Whereas plastic wastes and food wastes are the major components of the solid wastes generated, there were no effective technologies for the collection, storage, transfer and disposal of these wastes.

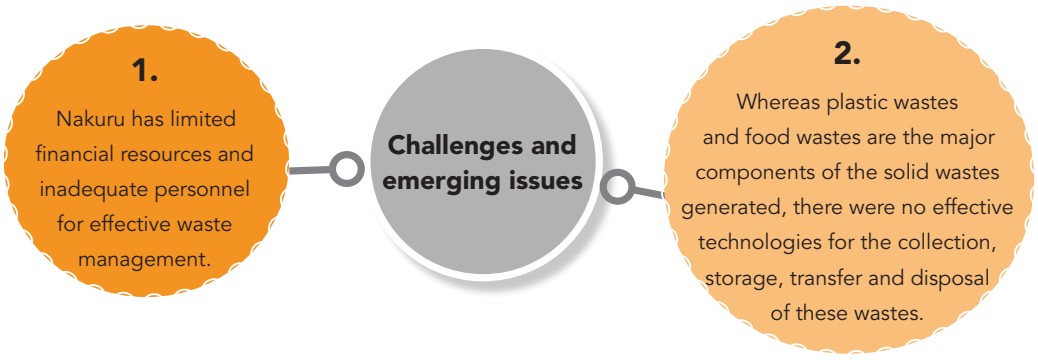


Table 3.14. Indicators for waste management

S/No	Interventions to be implemented with the Nakuru County Climate Change Action Plan (2023-2027)	Indicators
1	Coordinate the provision of waste management services.	Number of waste management services providers.
2	Provide a platform for dialogue, consultation, collaboration and participation in waste management.	Number of platforms provided
3	Facilitating mobilization and sensitization of county residents on waste management.	Number of mobilization and sensitization meetings on waste management.
4	Ensure harmonization of public and private sector strategies and programs on waste management in the county	public and private sector strategies and programs on waste management in the county
5	provide incentives to promote community and private sector participation in sustainable waste management	Number of community members and private actors receiving incentives.
6	Enforce laws and guidelines related to waste management.	Waste management laws enforced
	Mobilize and facilitate the formation of local community or neighbourhood initiatives or programmes for waste management.	Number of community or neighbourhood initiatives or programmes for waste management.

The County Government of Nakuru, through the Ministry of Environment, should spearhead policy reforms for solid waste management in the country and also aim at promoting more collaboration with corporate bodies to help build the capacity of service providers. In addition, public members should be educated on the importance of minimizing waste through reducing, reusing, recovering and recycling certain products.

3.4 Nakuru County Climate Story Map

The **Nakuru County Climate Vulnerability and Ecosystem Story Map** (https://arcg.is/1mmL9q2) is an interactive online platform using climate information maps, figures, and an expert tool to support the story, which provides insight into the climate change situation in agriculture in Nakuru County. Storylines guide navigation within the story map with informative maps and figures, providing further information. The story section and the key Agroclimatic indicators are based on the investigated farmer's needs (**Figure 3.26**).

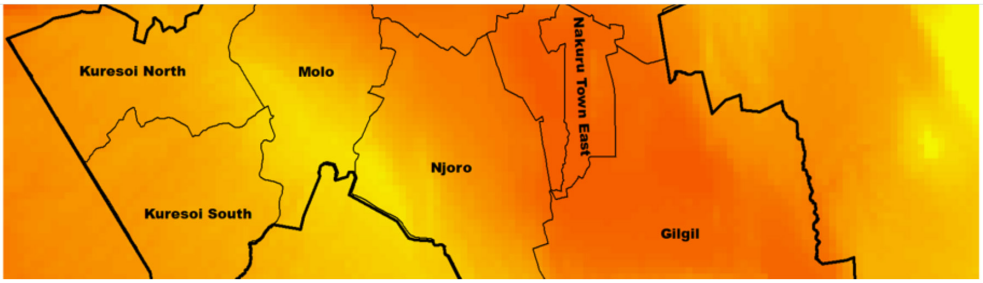


Figure 3.26. Snapshot of the interactive story climate map for Nakuru County

4. CONCLUSION AND RECOMMENDATIONS

The agricultural sector entails cash crop production such as wheat, coffee, pyrethrum, tea, floriculture, ranching, and apiculture, while main tourist attractions and activities include National parks, forests, and lakes.

4.1 Conclusion

Nakuru County is driven mainly by agriculture, manufacturing, tourism, and the service sector. The agricultural sector entails cash crop production such as wheat, coffee, pyrethrum, tea, floriculture, ranching, and apiculture, while main tourist attractions and activities include National parks, forests, and lakes. 70% of the total land in Nakuru County is highly agriculturally productive. Most households depend on agriculture, and a significant number of farmers have an average land holding of 0.77 hectares; however, 49% are poor, while 36% of the county's population are food poor. Half of the county's population does not have access to healthy and nutritious food. Smallholder agricultural production is mainly under rain-fed conditions, with weather fluctuations impacting productivity. Significant changes in the climate are expected between now and the end of the century, while many smallholder farmers are ill-equipped to cope with climate-related risks. Therefore, it is evident that Nakuru County's agriculture systems are highly vulnerable to the impacts of climate change. Accumulating evidence of climate change threatens to adversely affect agricultural production and endanger the County from achieving food security and nutrition.

The elevation of the area primarily controls the climatic conditions for Nakuru County. Climate vulnerability assessment confirmed that climate change-related hazards and the associated risks for agricultural production across sub-counties in Nakuru County are a particularly high and increasing trend. The strong link between adaptation scores and the adaptation index implies that the identified practices are responsive to identified risks. However, the low values across farmers call for enhanced farmer support to ensure implementation.

Agroecology is an important driver for enhancing sustainable food systems- and the progressive realization of the right to adequate and safe food in the context of the constitution of Kenya 2010. However, its potential and integration into research, policy, and practice are limited. Farmers mainly implemented practices that supported efficiency, recycling, regulation, synergies, diversity, and resilience, while practices that supported the co-creation of knowledge, human and social value, and responsible governance dimensions were the least integrated across the sub-Counties.

Adaptation to climate change will require cross-disciplinary solutions that include developing feasible narrative scenarios that describe possible mitigation and adaptation paths for a just transition to low carbon and resilient climate future for Nakuru County were developed based on management practices implemented by farmers. Based on the described results, the site-specific utilization of agroecological-based climate and landscape smart practices (CLSPs) profiles offers promising options for designing more resilient agricultural systems in Nakuru County. The key to adaptation is to make complex climate information accessible in a relevant, simple, and actionable way through the development of climate story maps.

Although there are still uncertainties about the impacts of climate change on the specific wards and value chains, the information facilitates a discussion on the agricultural sector's future development across sub-counties in Nakuru County.

4.2 Recommendations

1. Farmers are at different levels of uptake of adaptation practices and hence need continuous support in building capacities for farmers to increasingly implement adaptation practices.
2. Nakuru County should develop an evidence-based and context-specific policy approach to climate change as part of its County Climate Change Action Plan (2023-2027).
3. Stakeholders should adopt a process of making climate projections and scenarios fit for purpose for end-users at the ward and farm level.
4. There is also a need to include policymakers and the financial sector in Nakuru County's climate adaptation planning.
5. Policymakers must address climate change and ensure that farmers can access finance and benefit from other support programs to apply adaptation measures.
6. Ward/local/landscape-level multi-stakeholder approach is required to facilitate the implementation of identified practices.
7. Landscape/farm-level and agroecological-based climate and landscape smart practices (CLSPs) need to be implemented to enhance agricultural systems' resilience in Nakuru County.
8. The change agents and end users need to downscale and simplify the climate information for use.
9. Capacity building through extension services needs to be scaled up. However, it was reported during validation that the Nakuru county extension services department had launched a call centre to diversify the delivery of extension services to the farmers.
10. There is a need for the inclusion of climate change champions in Nakuru County.
11. There is a need to work with all groups of people, including indigenous communities, women, youths, people living with disabilities and the elderly, to help conserve natural resources.
12. Different stakeholders and partners should avail adequate financing for research work on climate.

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6. APPENDICES

6.1 Appendix I: Spatial distribution of Historical Bioclimatic variables for Nakuru County

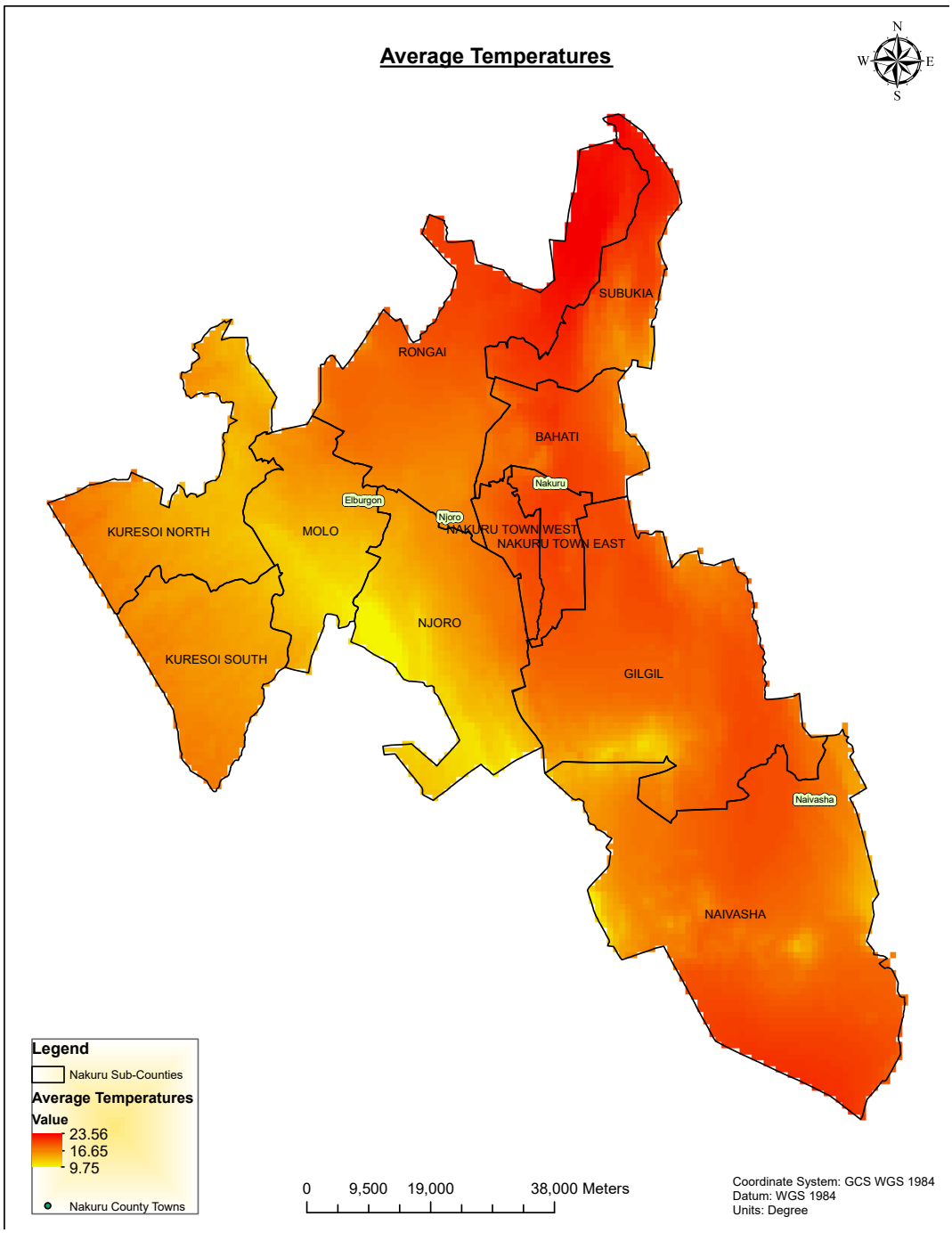


Figure 6.2.1. BIO1 = Annual Mean Temperature

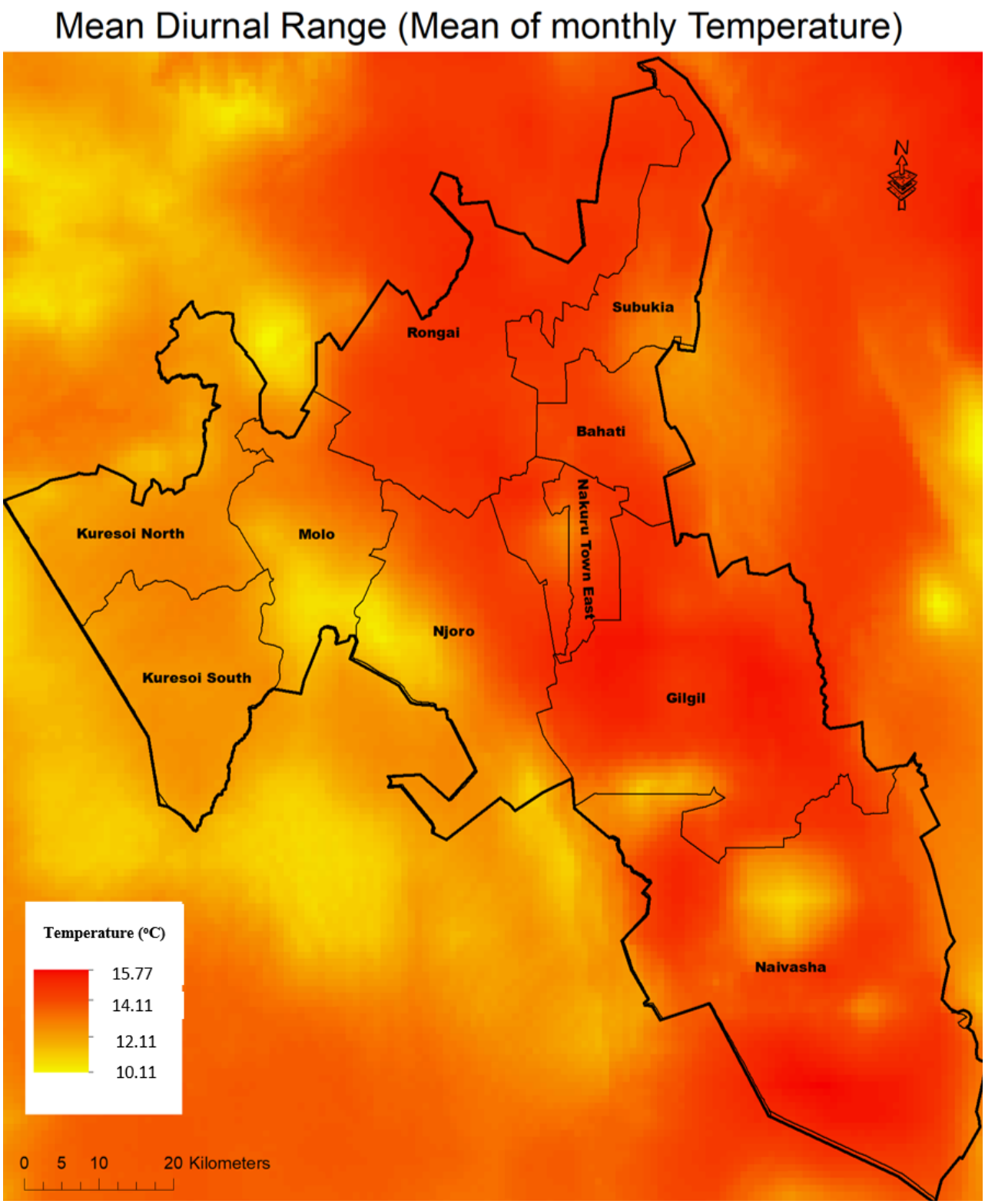


Figure 6.2.2. BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))

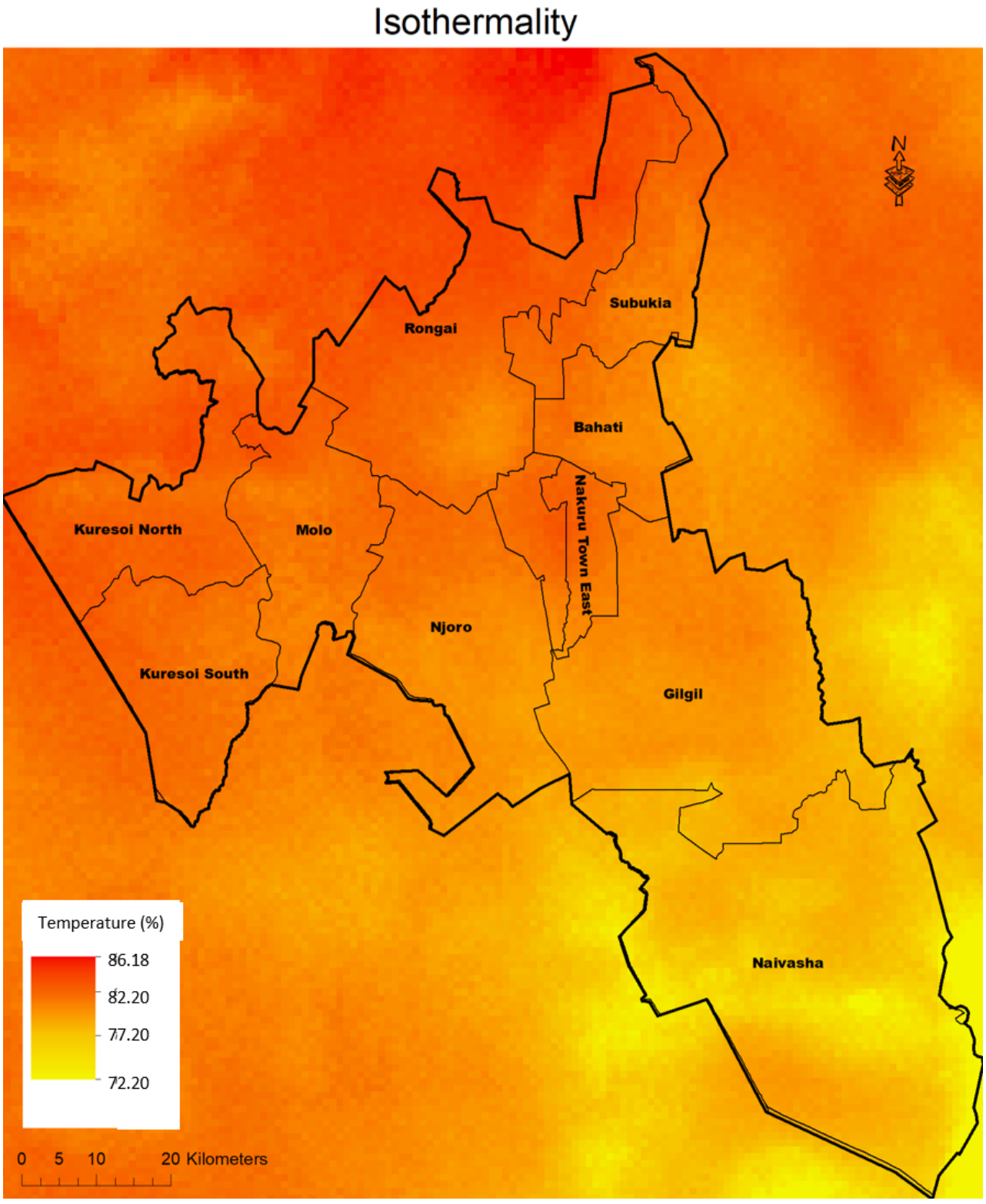


Figure 6.2.3. BIO3 = Isothermality (BIO2/BIO7) (×100)

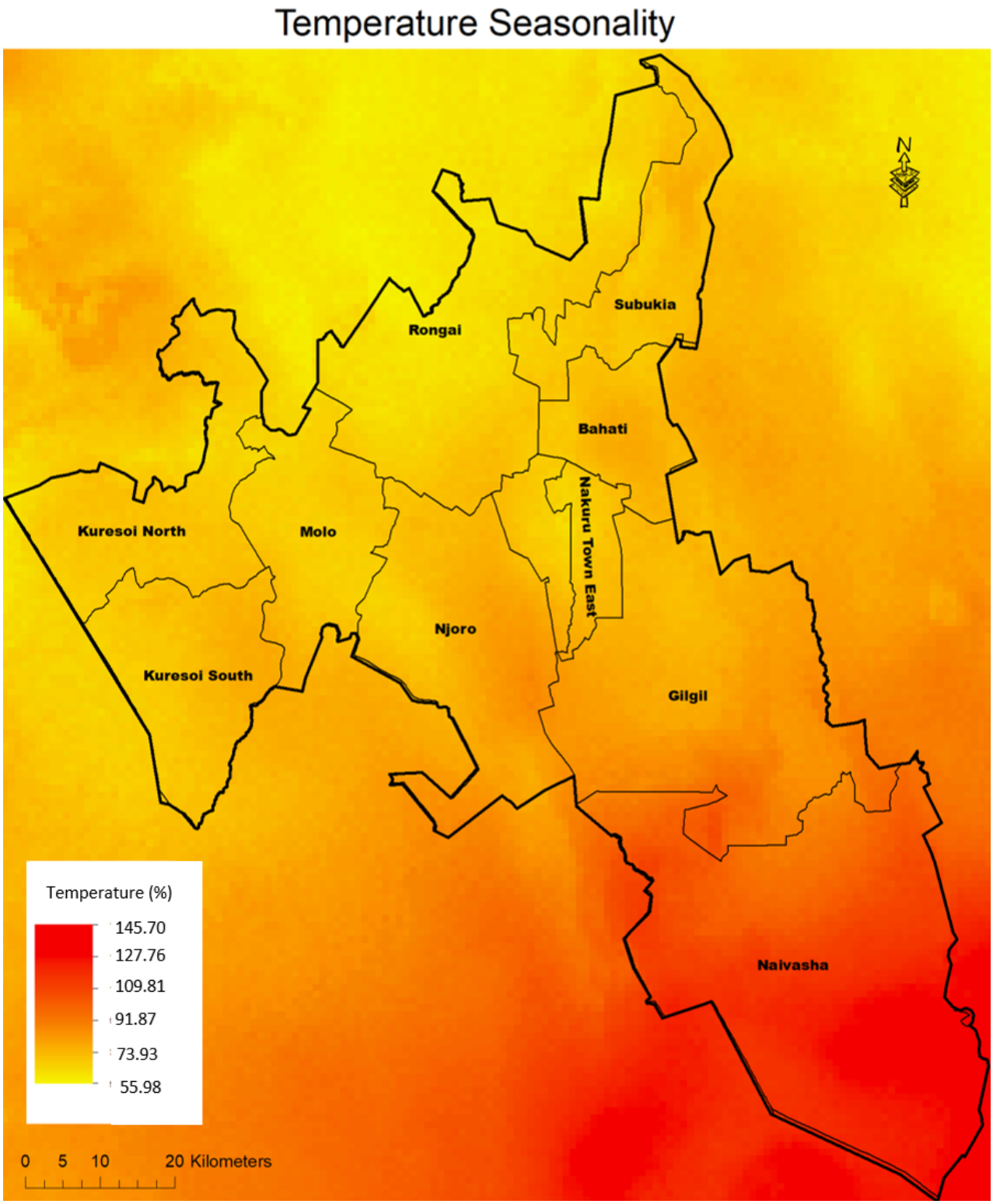


Figure 6.2.4. BIO4 = Temperature Seasonality (standard deviation ×100)

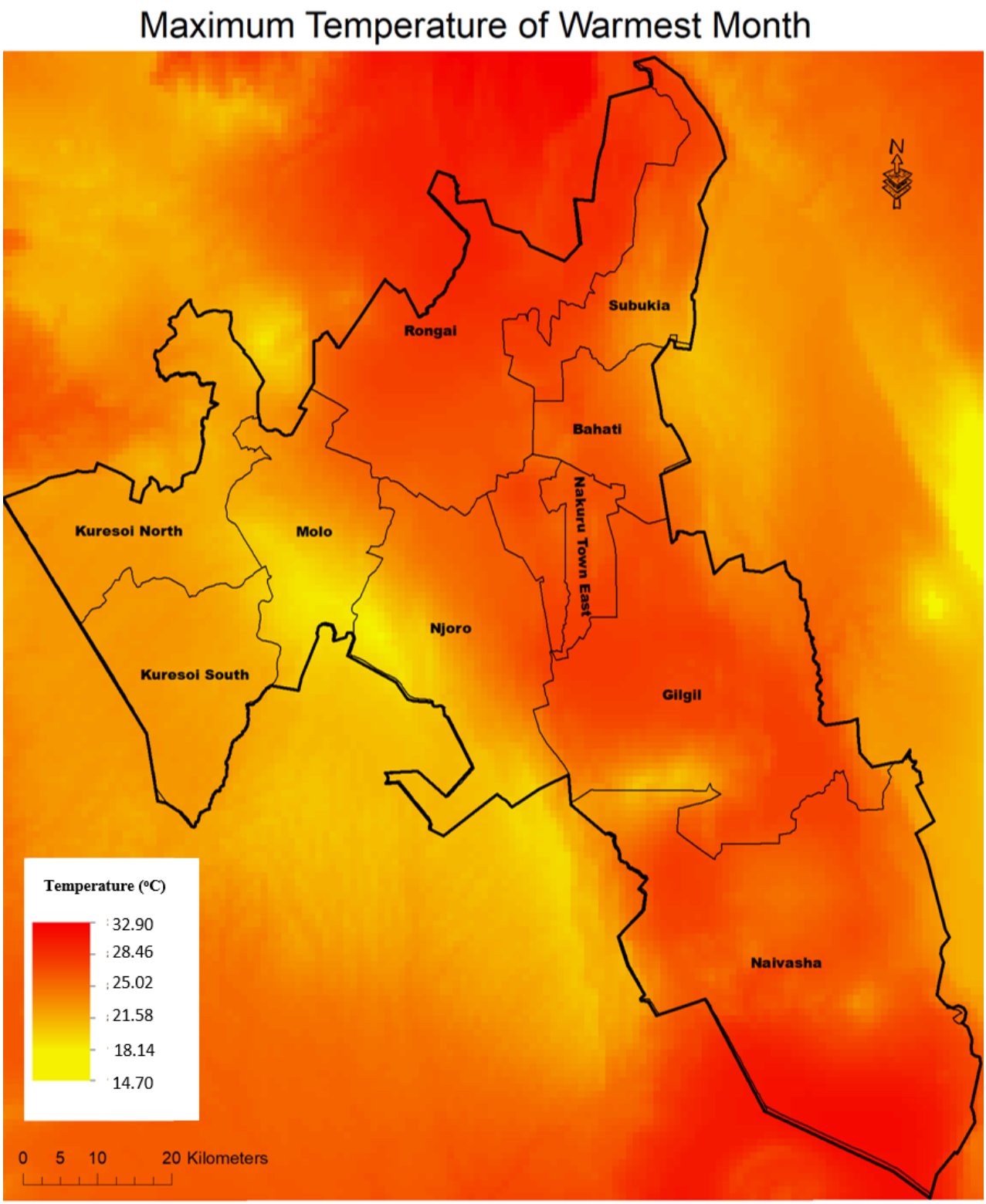


Figure 6.2.5. BIO5 = Max Temperature of Warmest Month

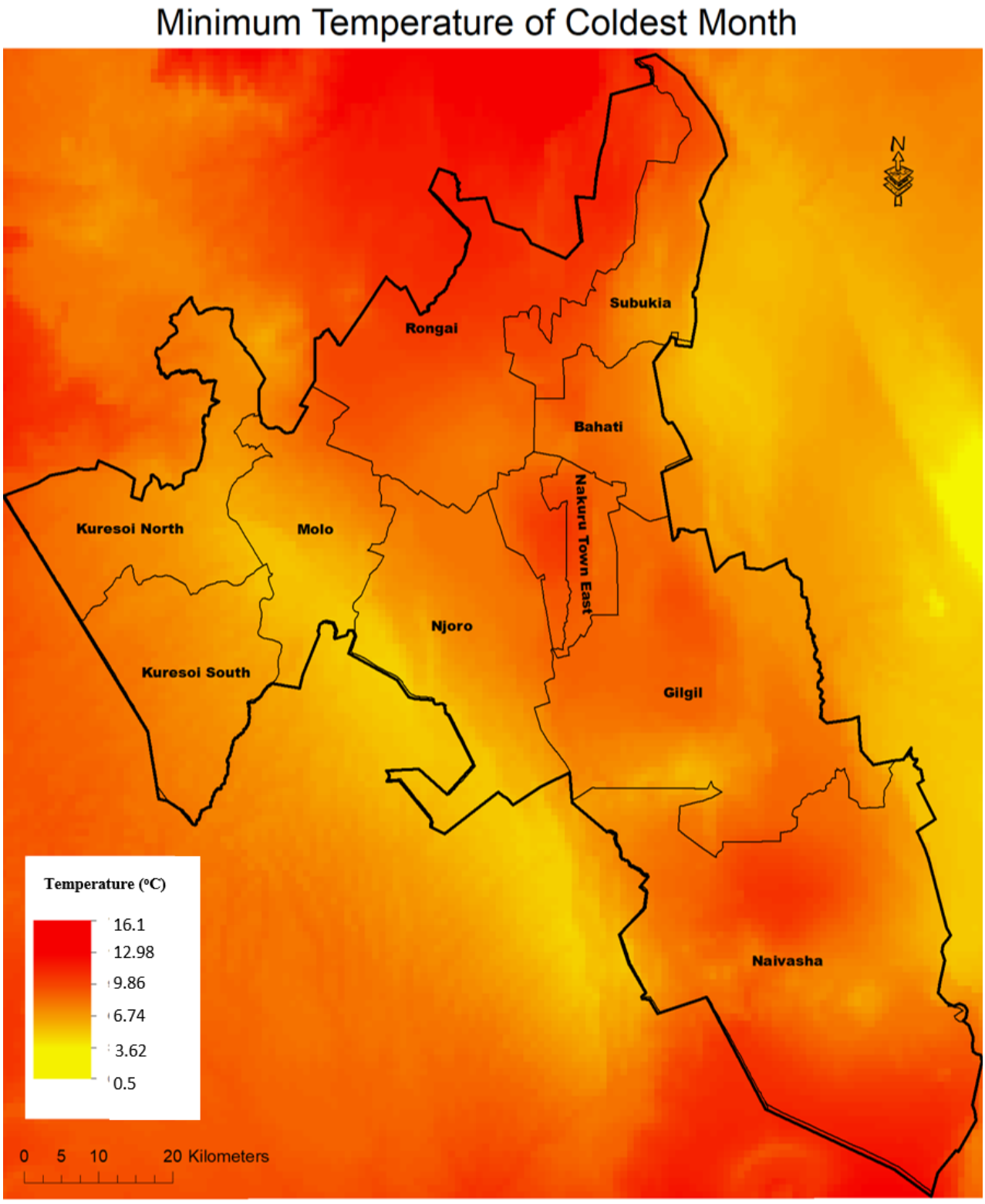


Figure 6.2.6. BIO6 = Min Temperature of Coldest Month

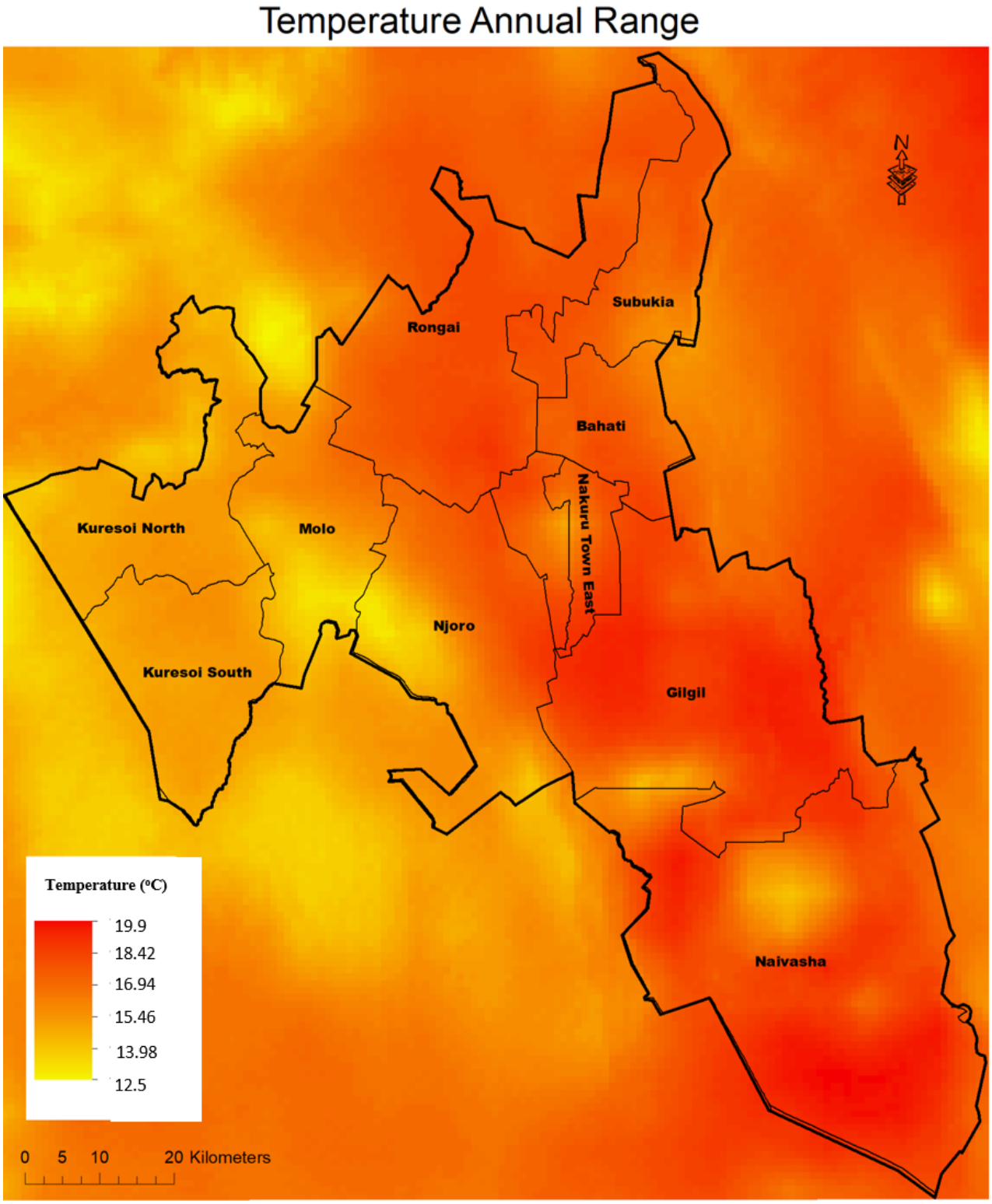


Figure 6.2.7. BIO7 = Temperature Annual Range (BIO5-BIO6)

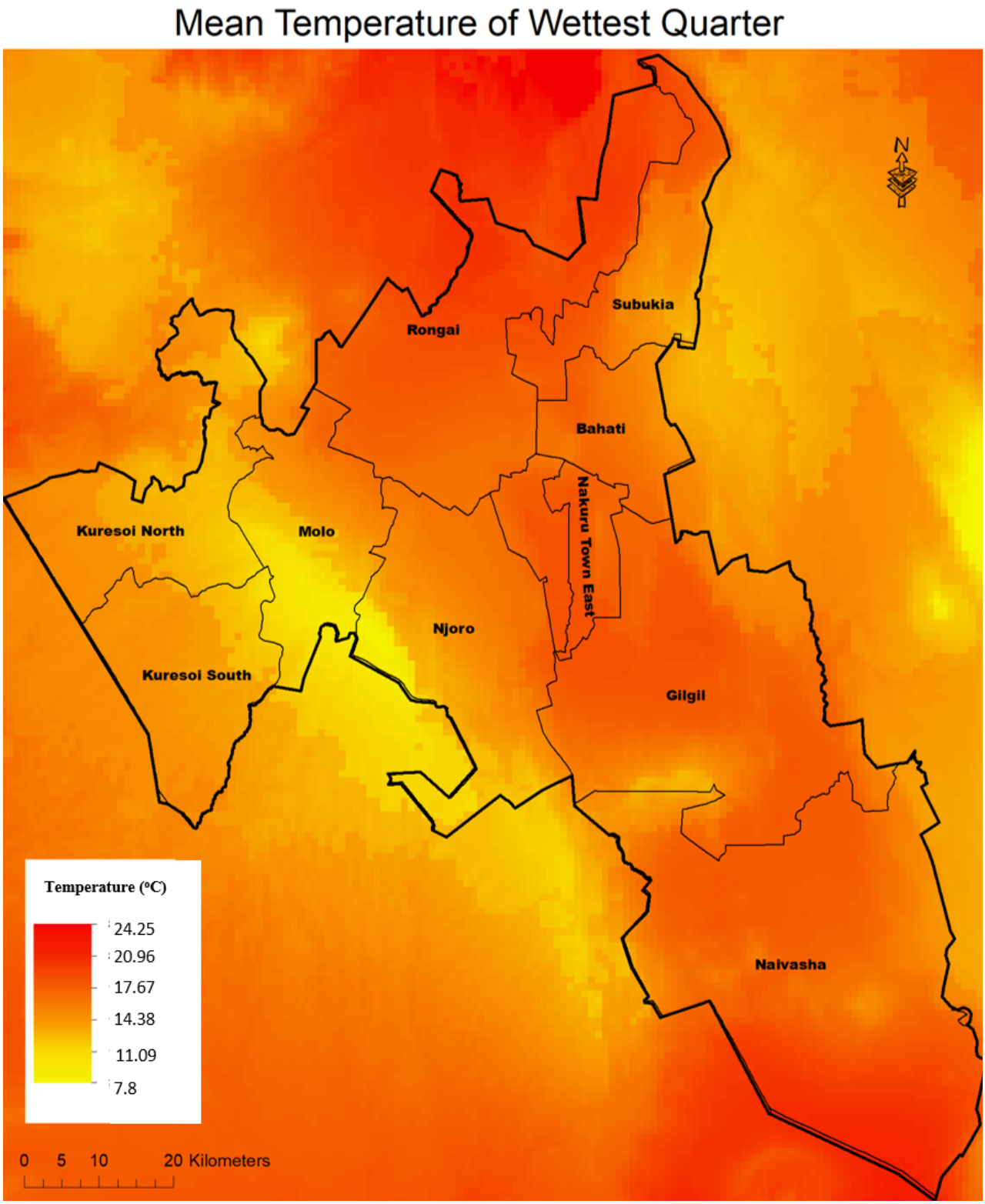


Figure 6.2.8. BIO8 = Mean Temperature of Wettest Quarter

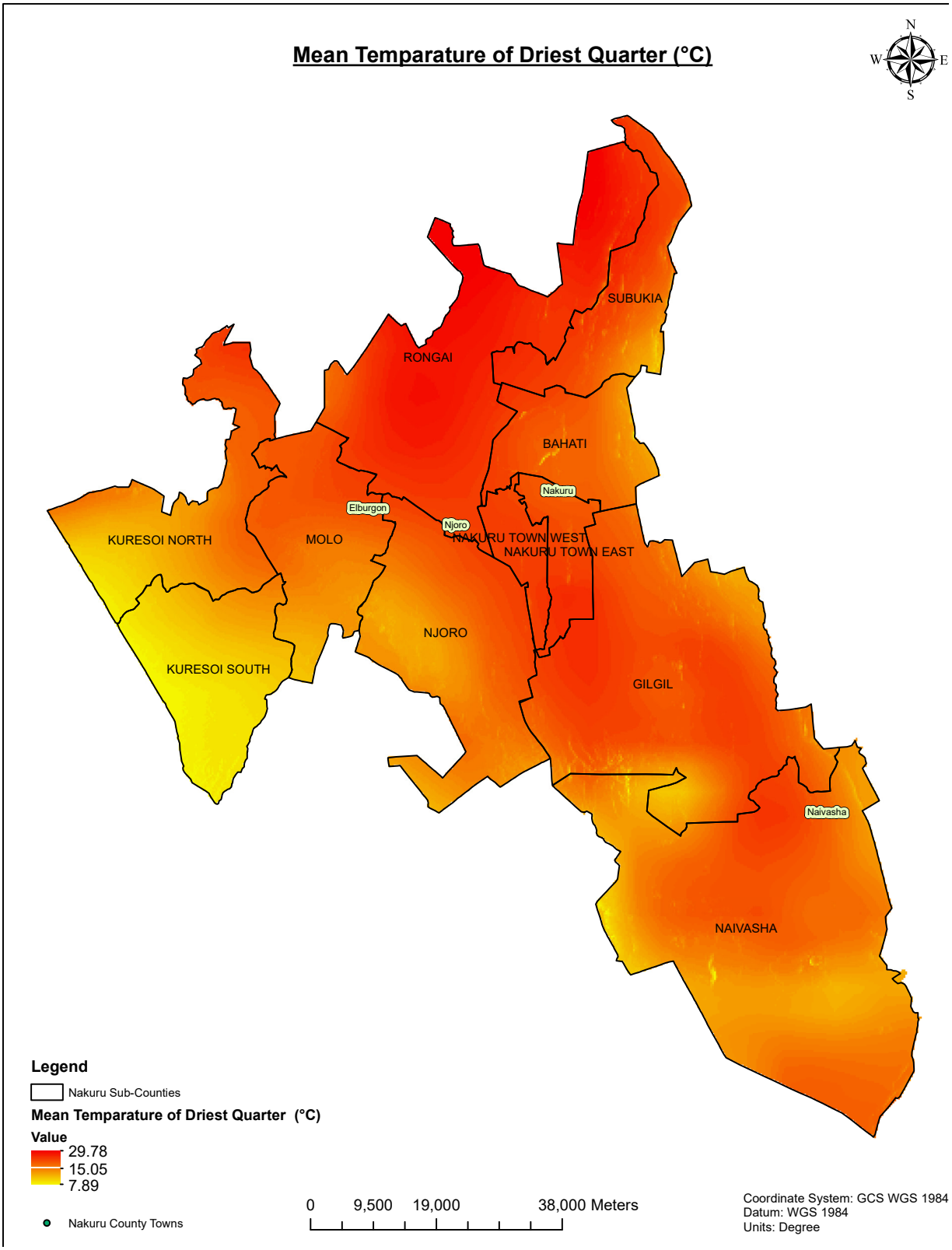


Figure 6.2.9. BIO9 = Mean Temperature of Driest Quarter

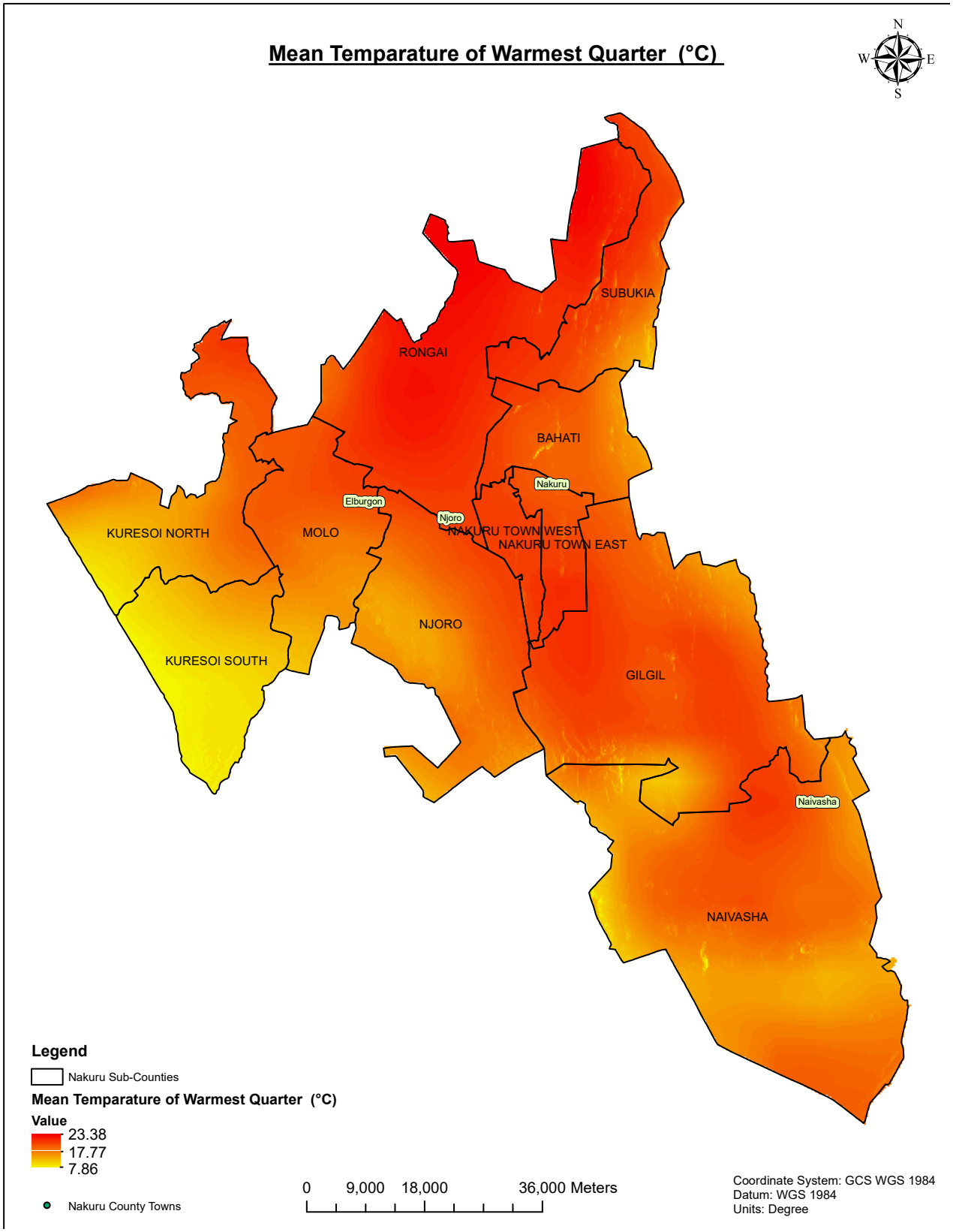


Figure 6.2.10. BIO10 = Mean Temperature of Warmest Quarter

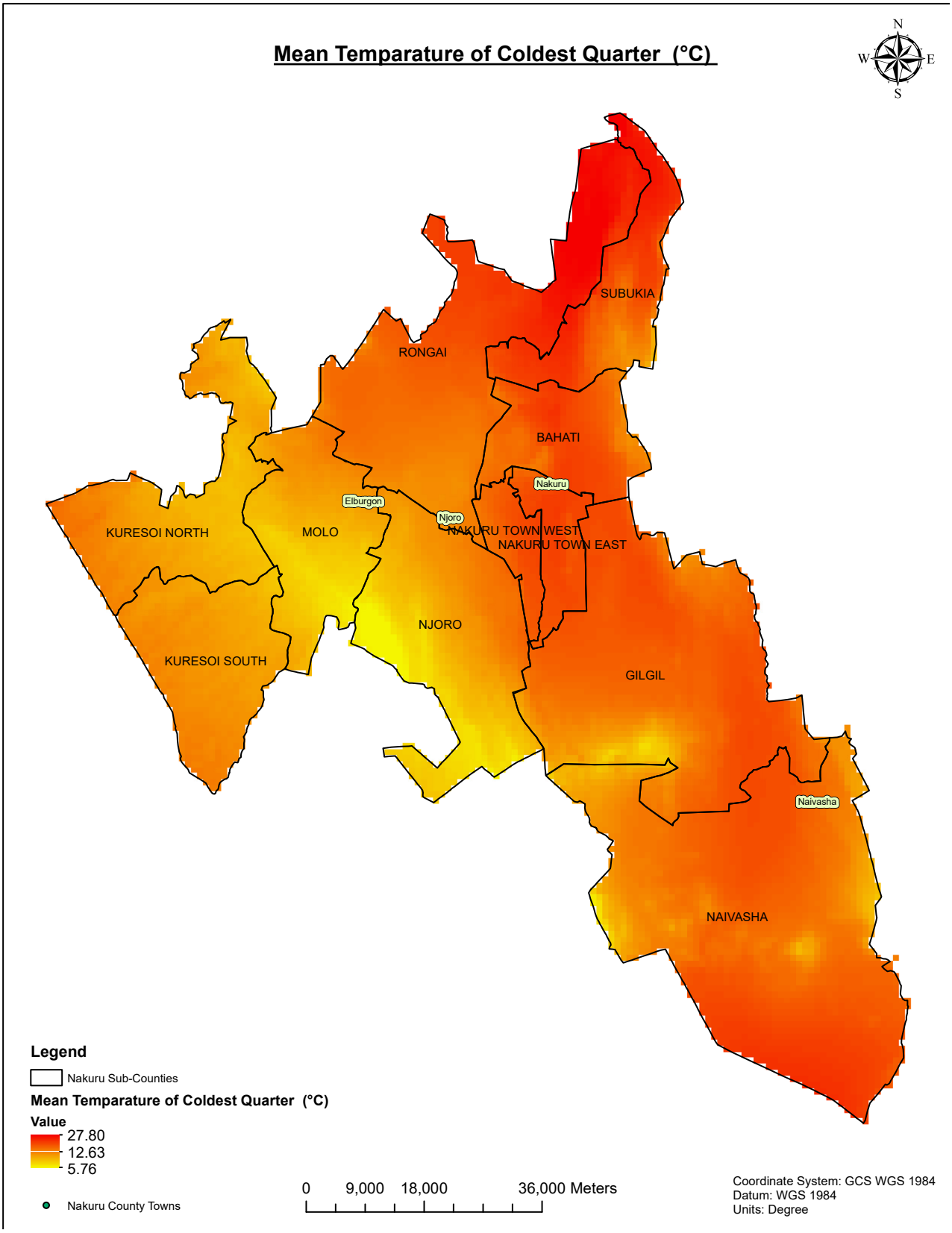


Figure 6.2.11. BIO11 = Mean Temperature of Coldest Quarter

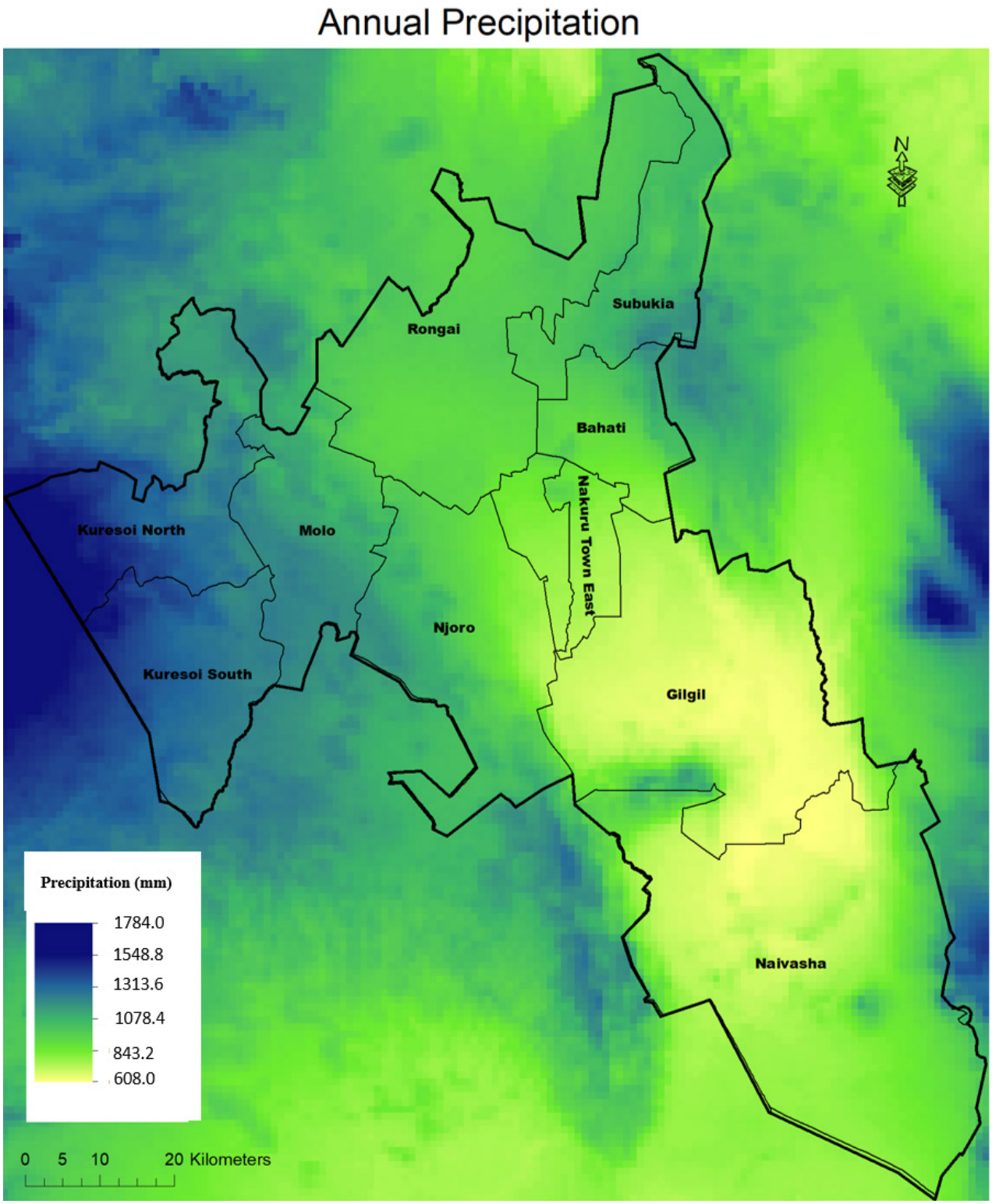


Figure 6.2.12. BIO12 = Annual Precipitation

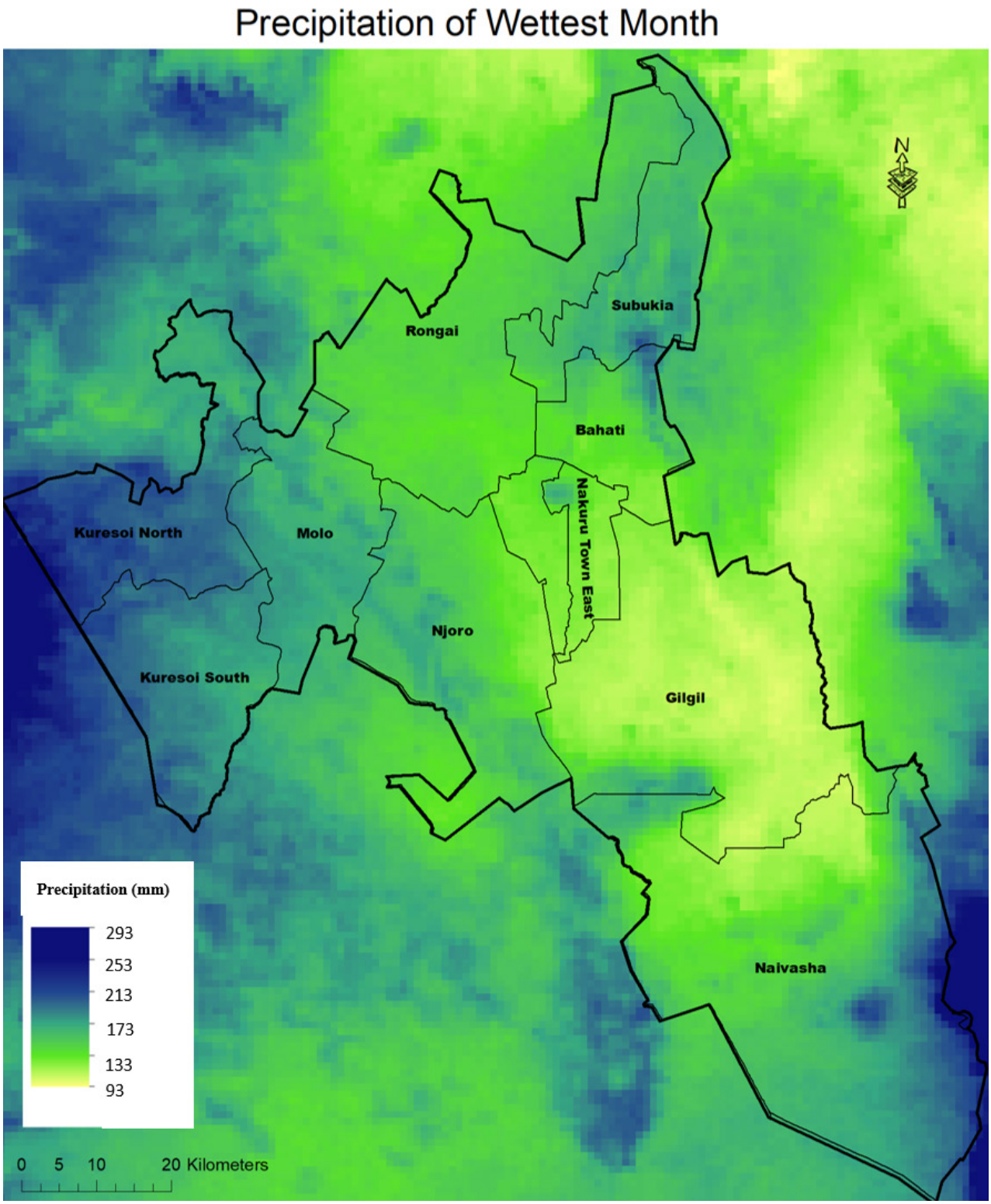


Figure 6.2.13. BIO13 = Precipitation of Wettest Month

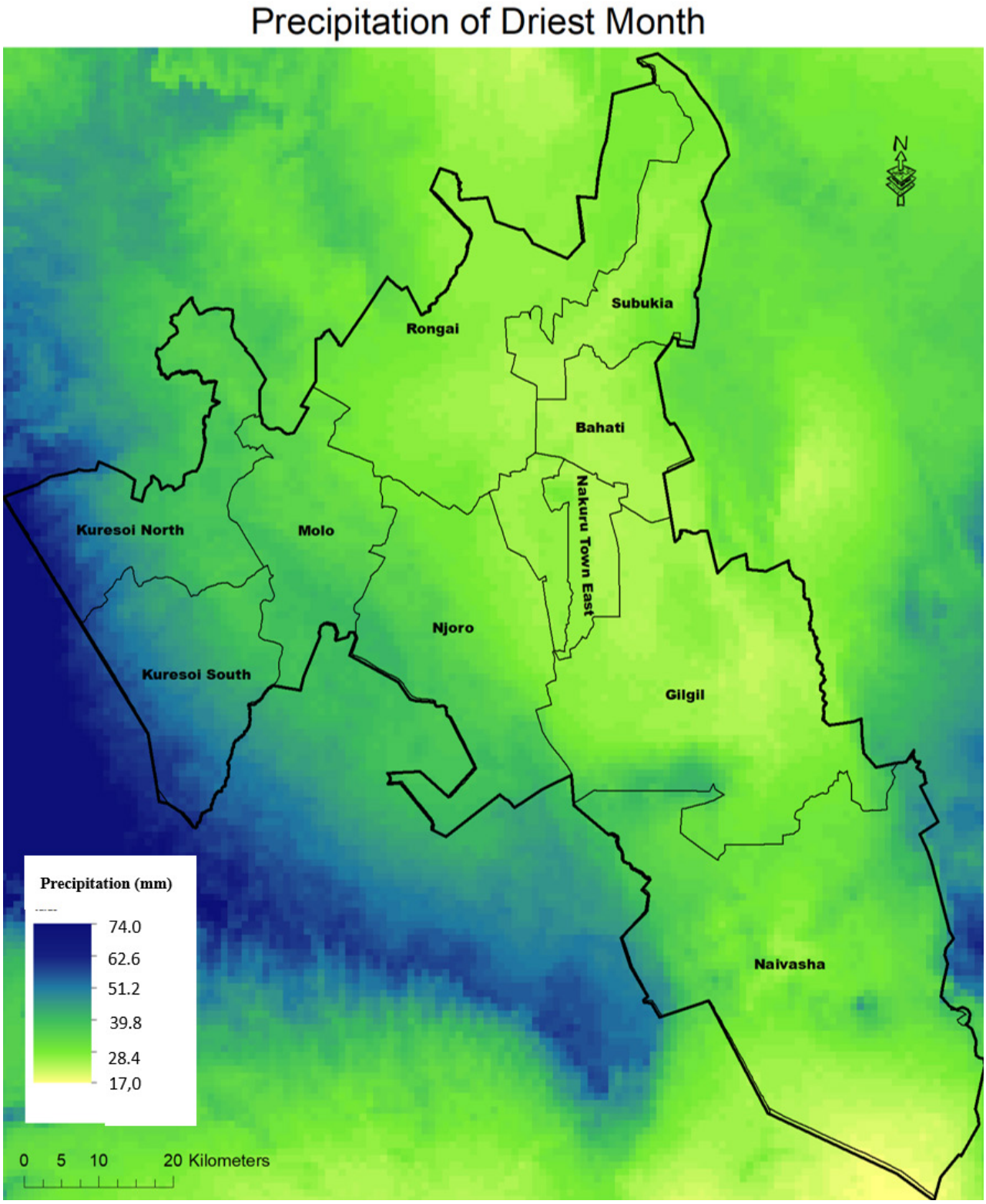


Figure 6.2.14. BIO14 = Precipitation of Driest Month

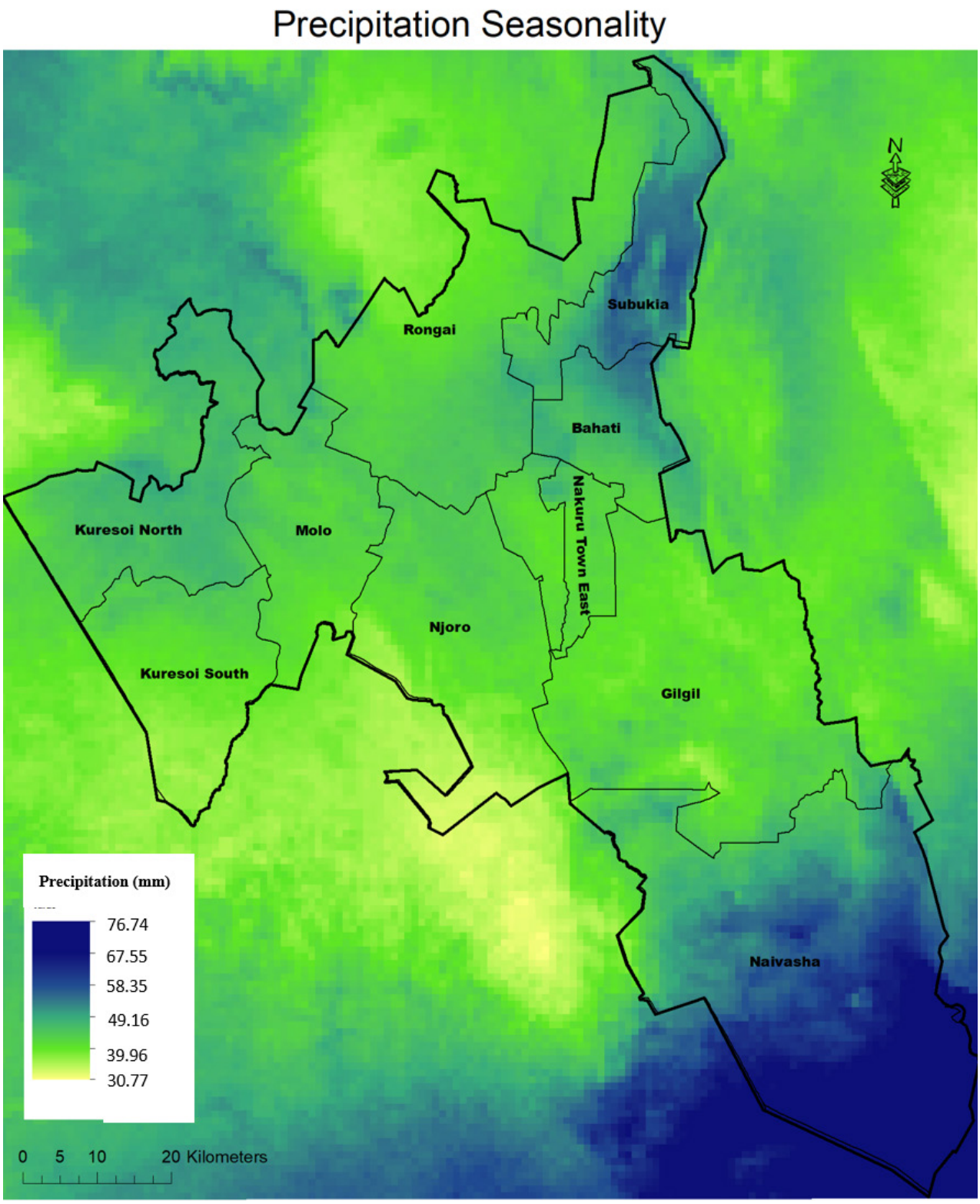


Figure 6.2.15. BIO15 = Precipitation Seasonality (Coefficient of Variation)

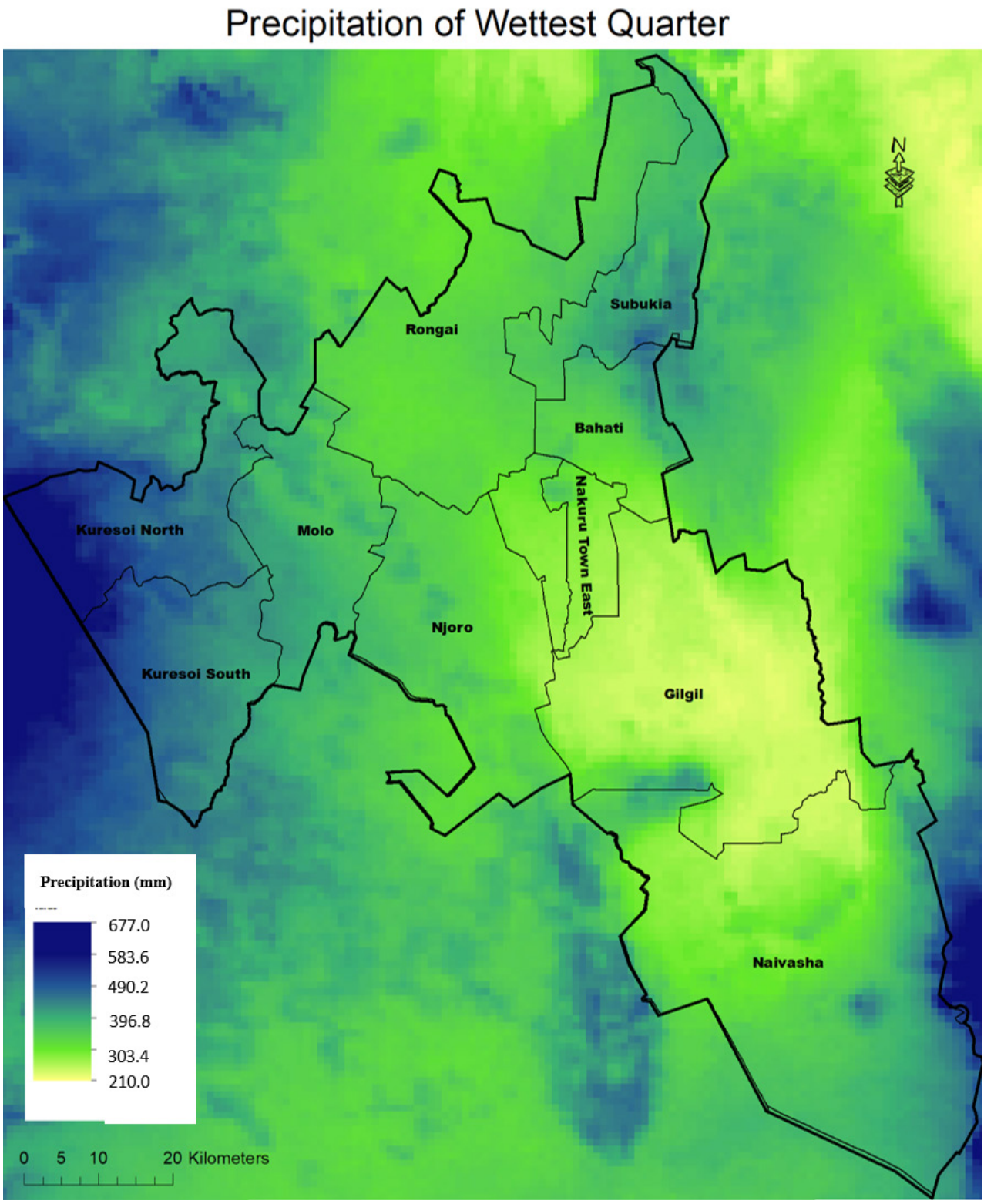


Figure 6.2.16. BIO16 = Precipitation of Wettest Quarter

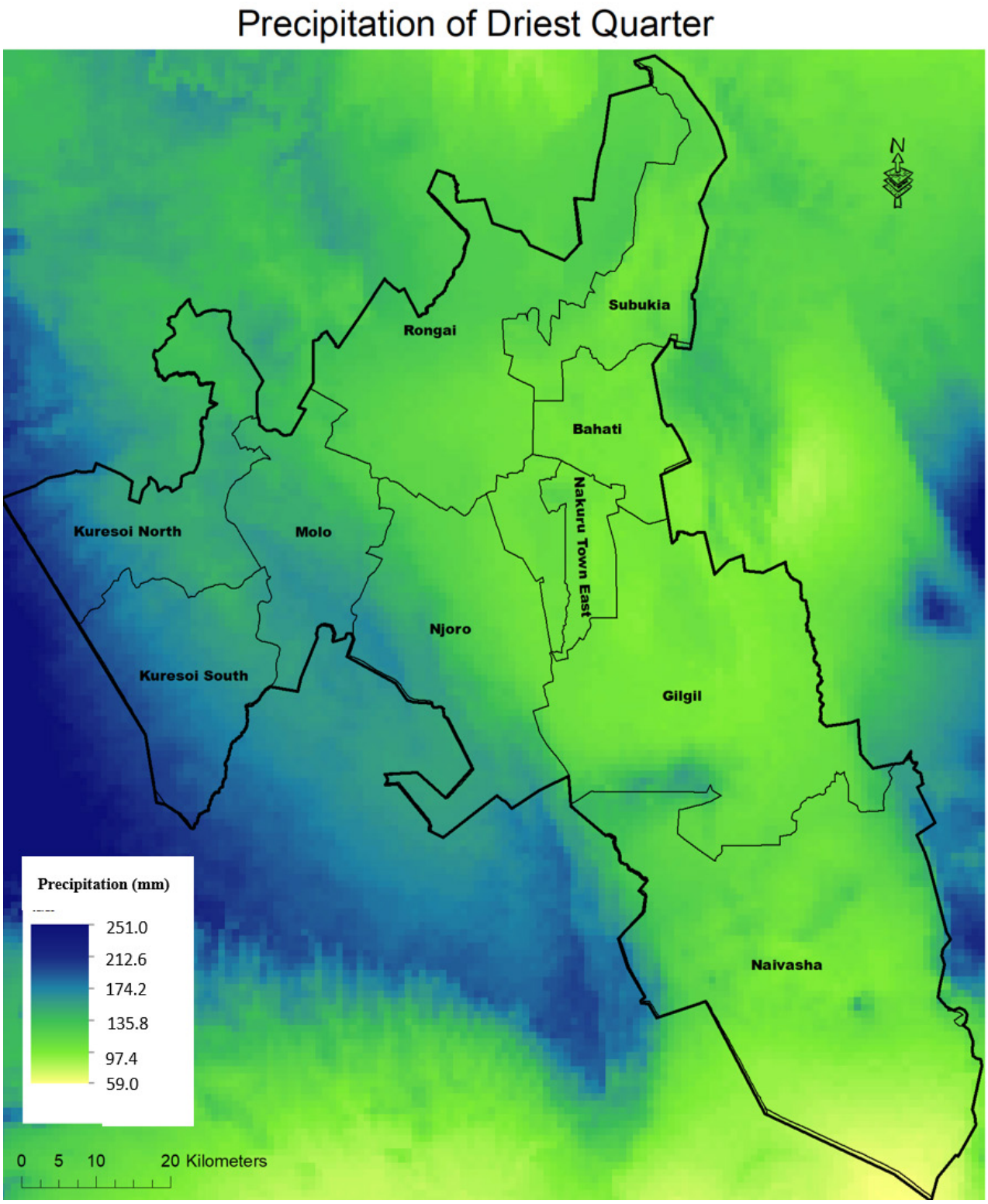


Figure 6.2.17. BIO17 = Precipitation of Driest Quarter

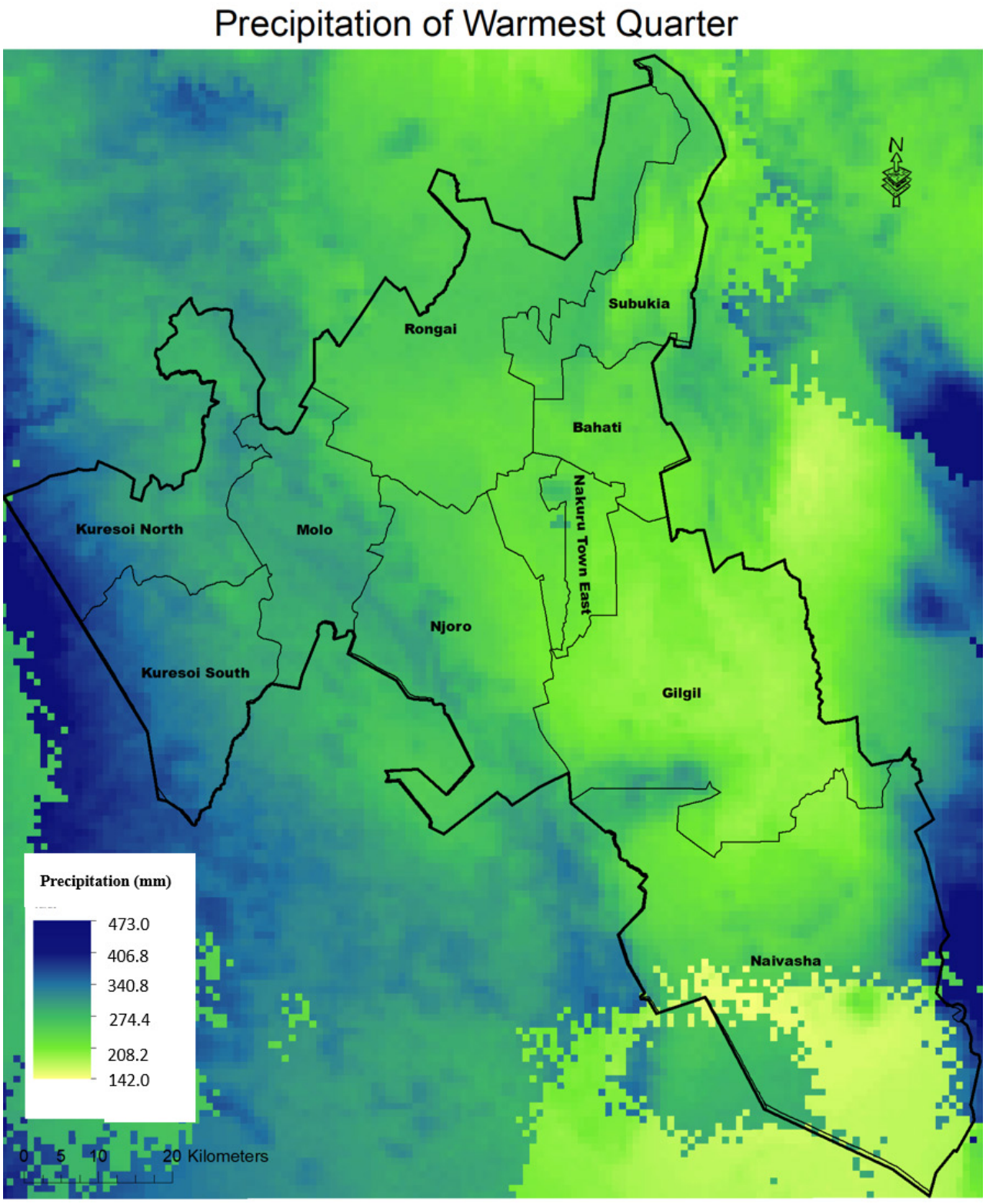


Figure 6.2.18. BIO18 = Precipitation of Warmest Quarter

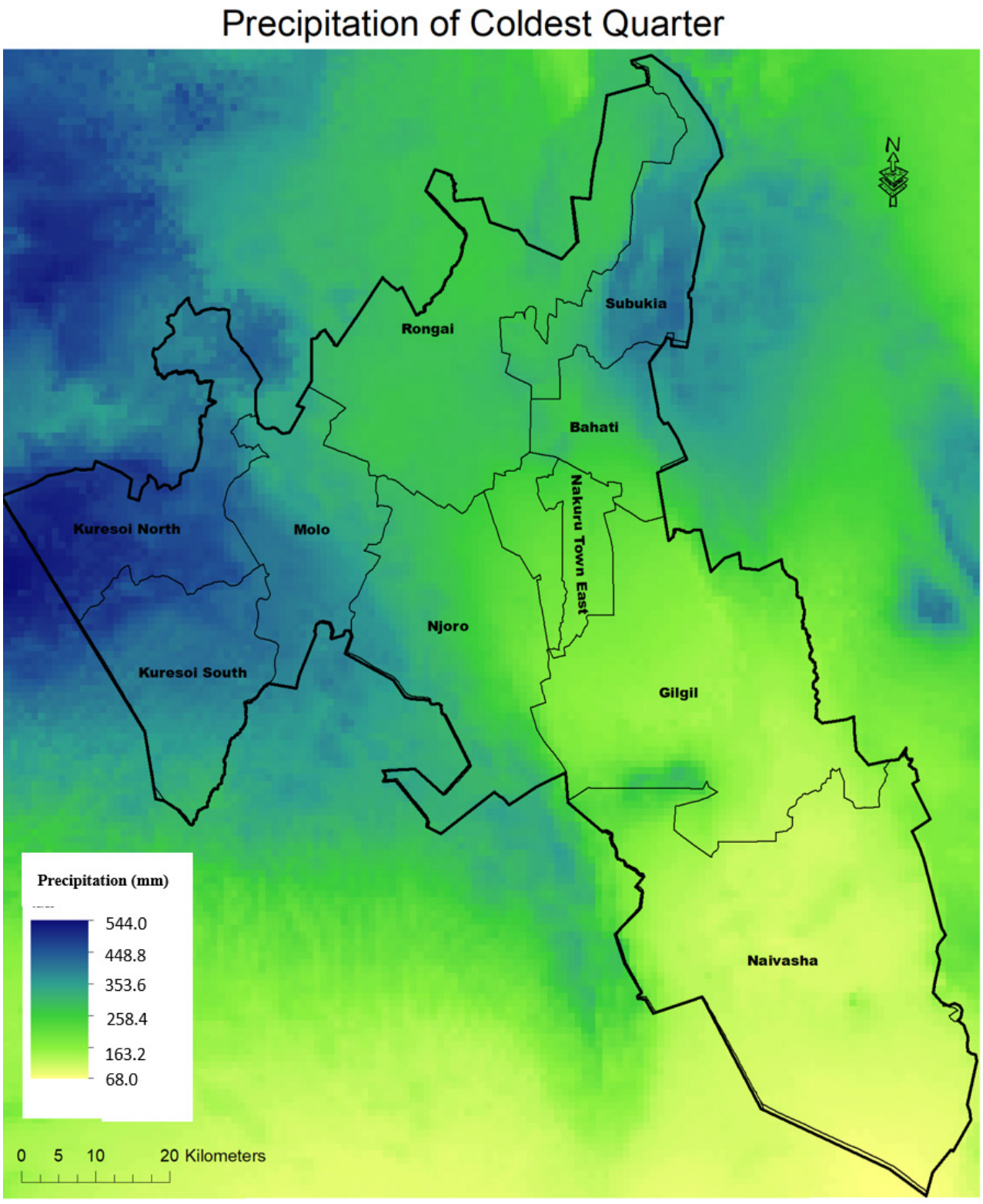


Figure 6.2.19. BIO19 = Precipitation of Coldest Quarter

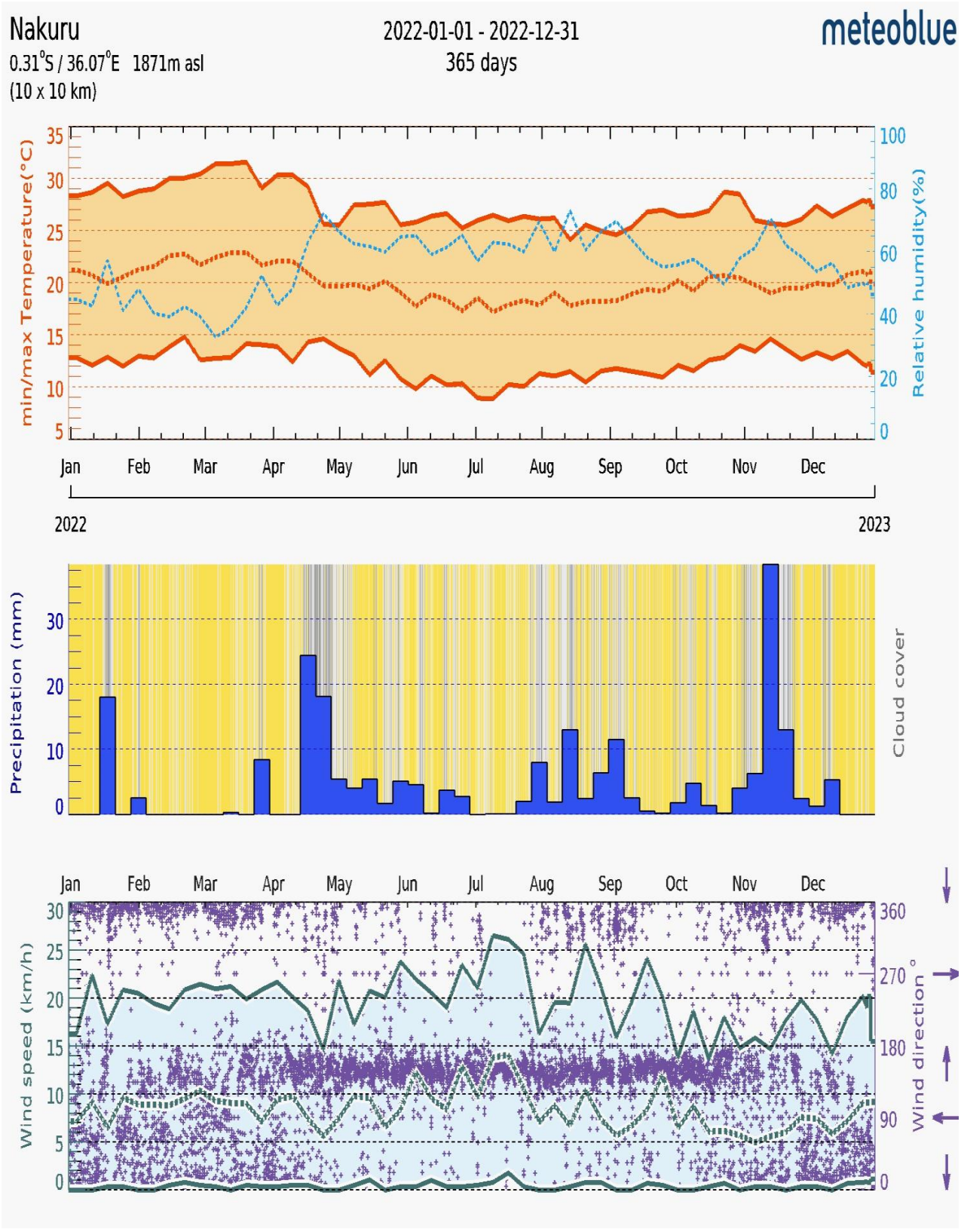


Figure 6.2.20: Temperature, Precipitation and Wind Speed 2022

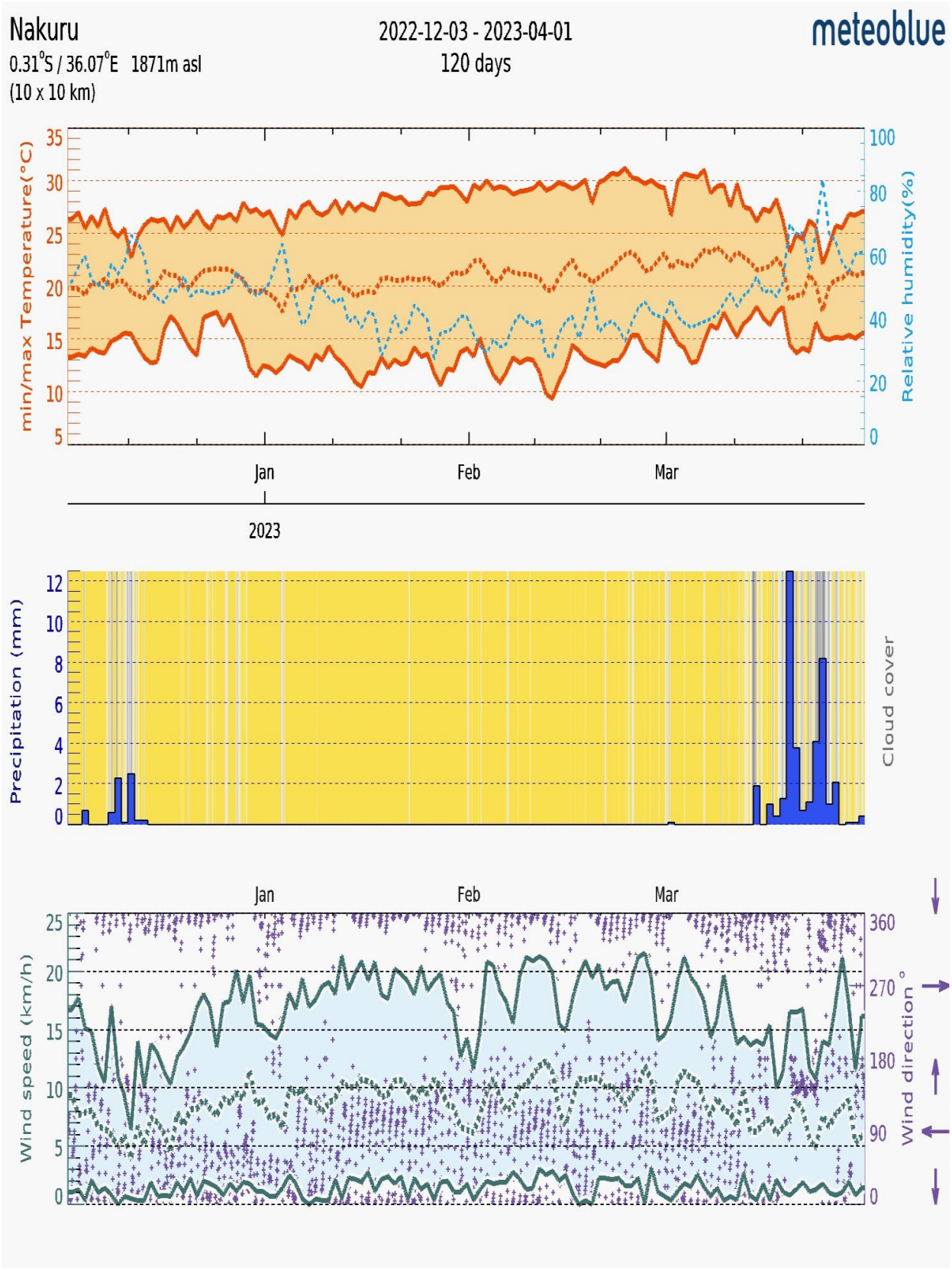
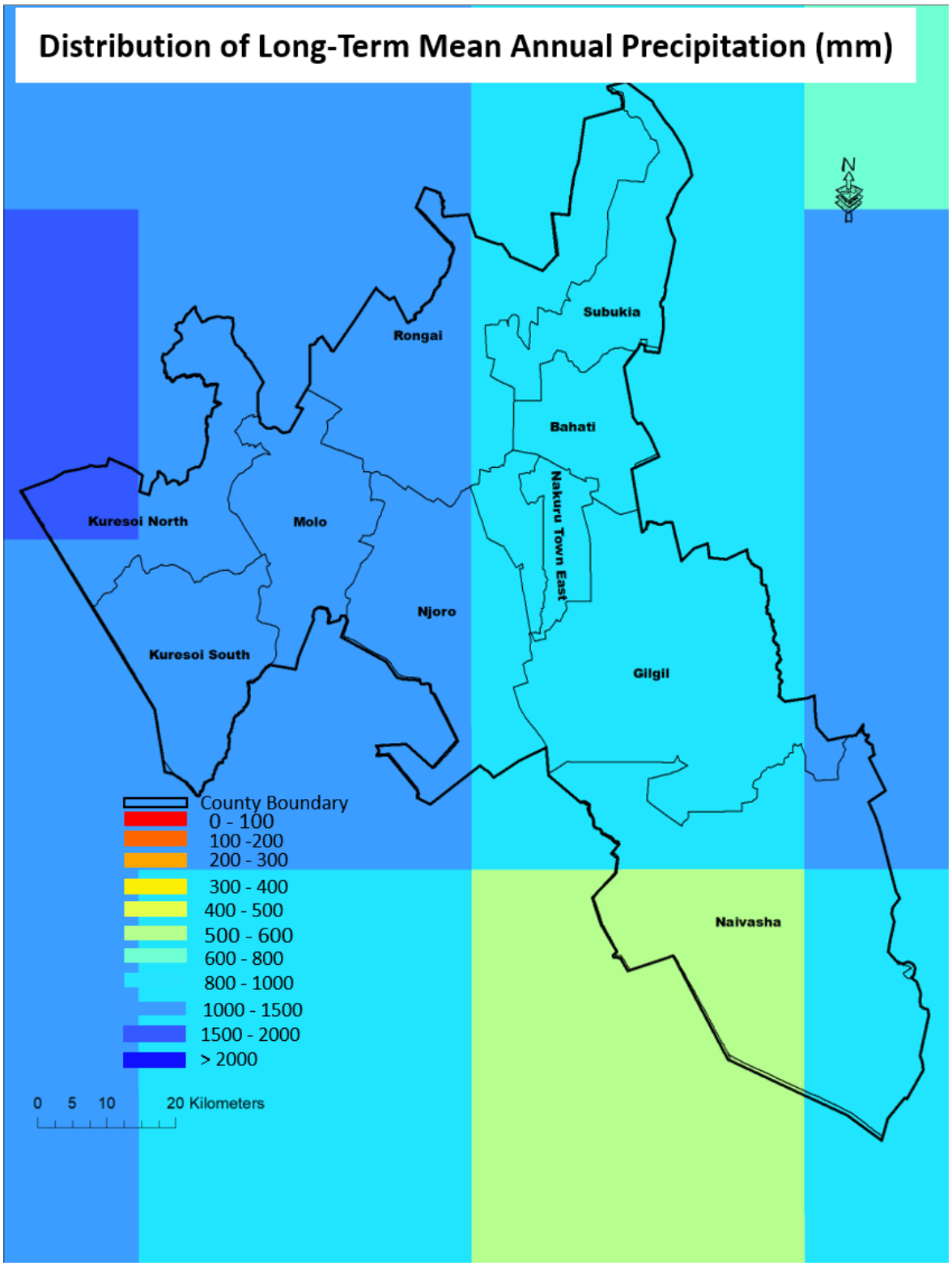
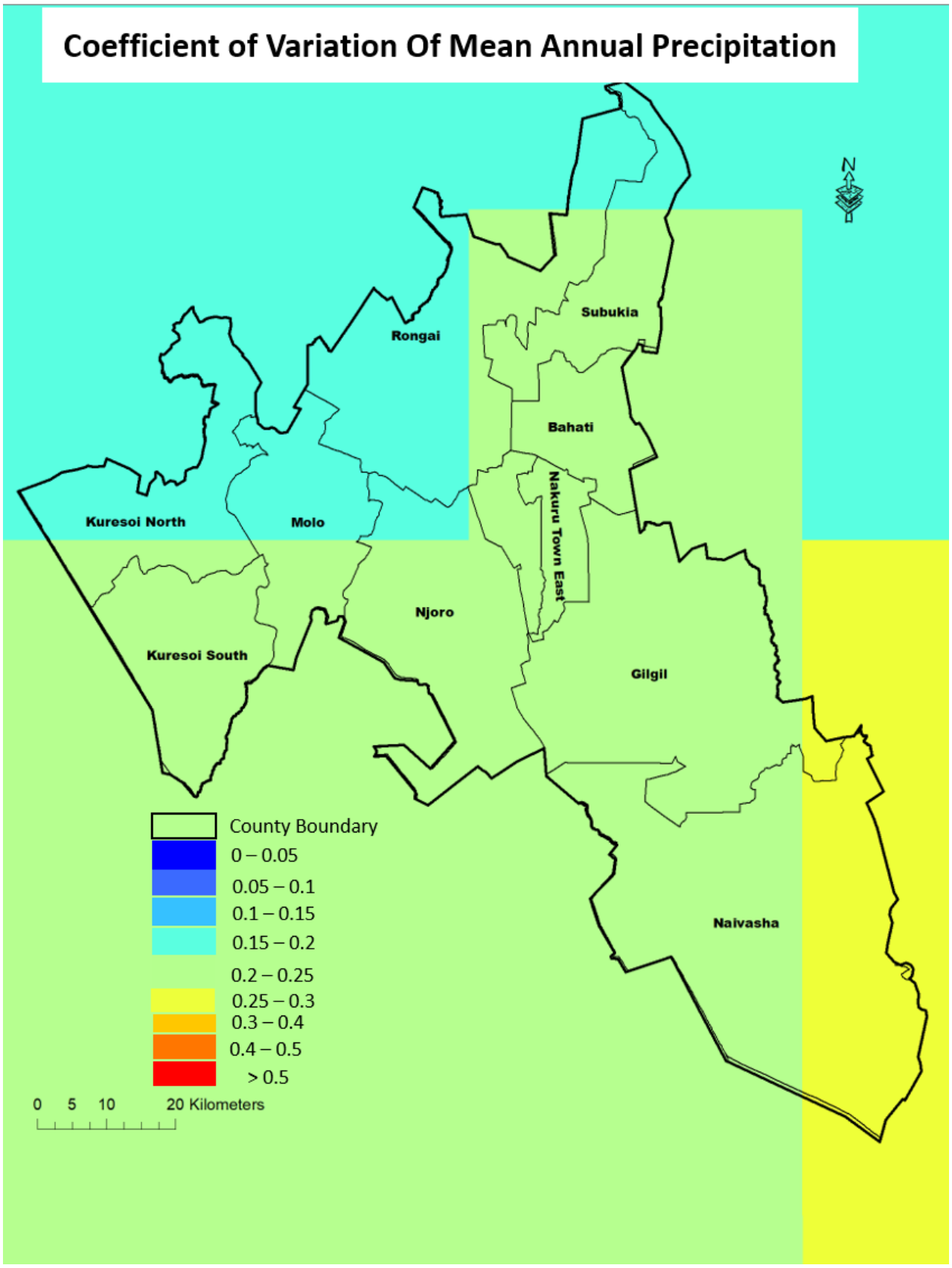
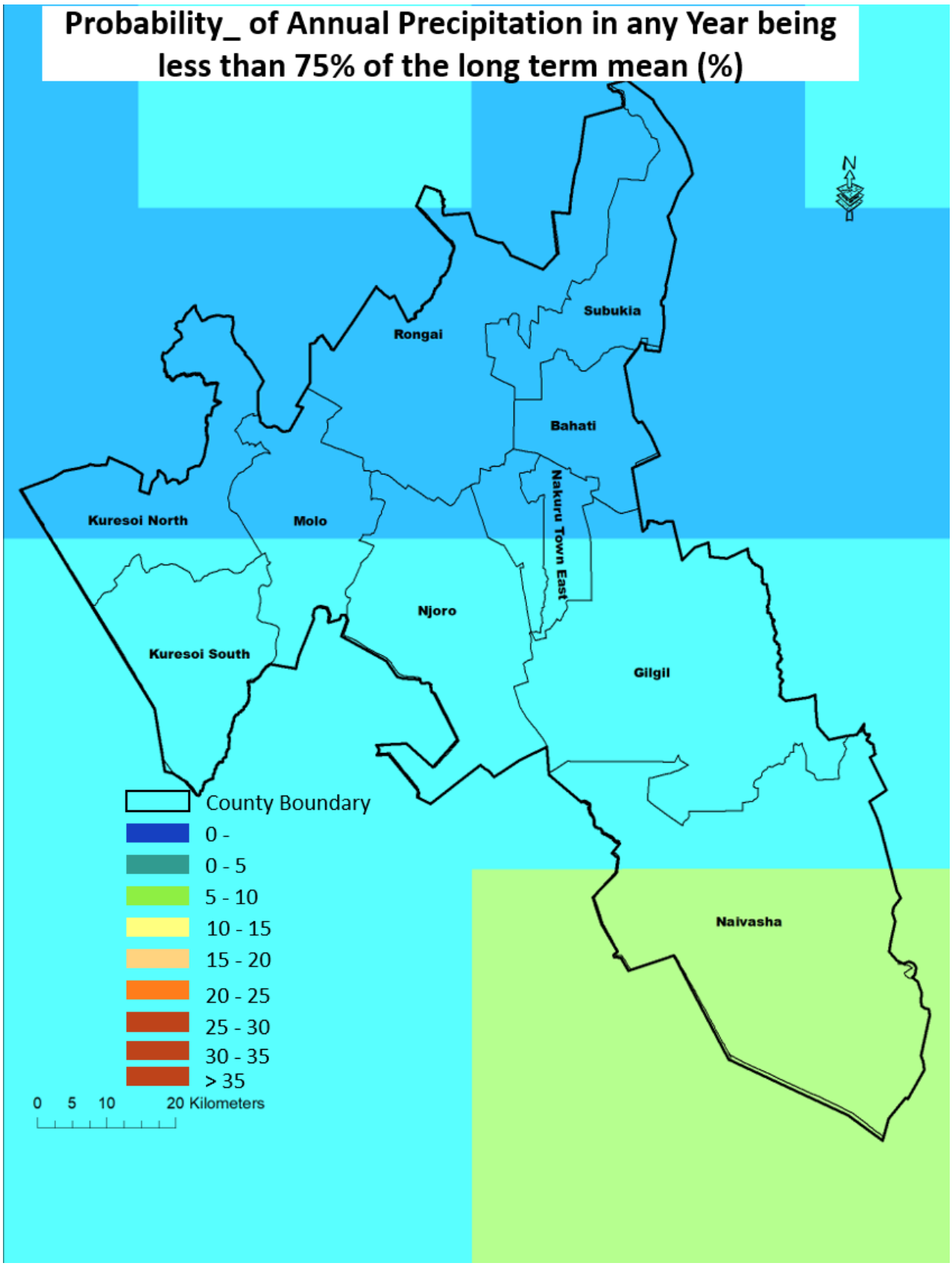


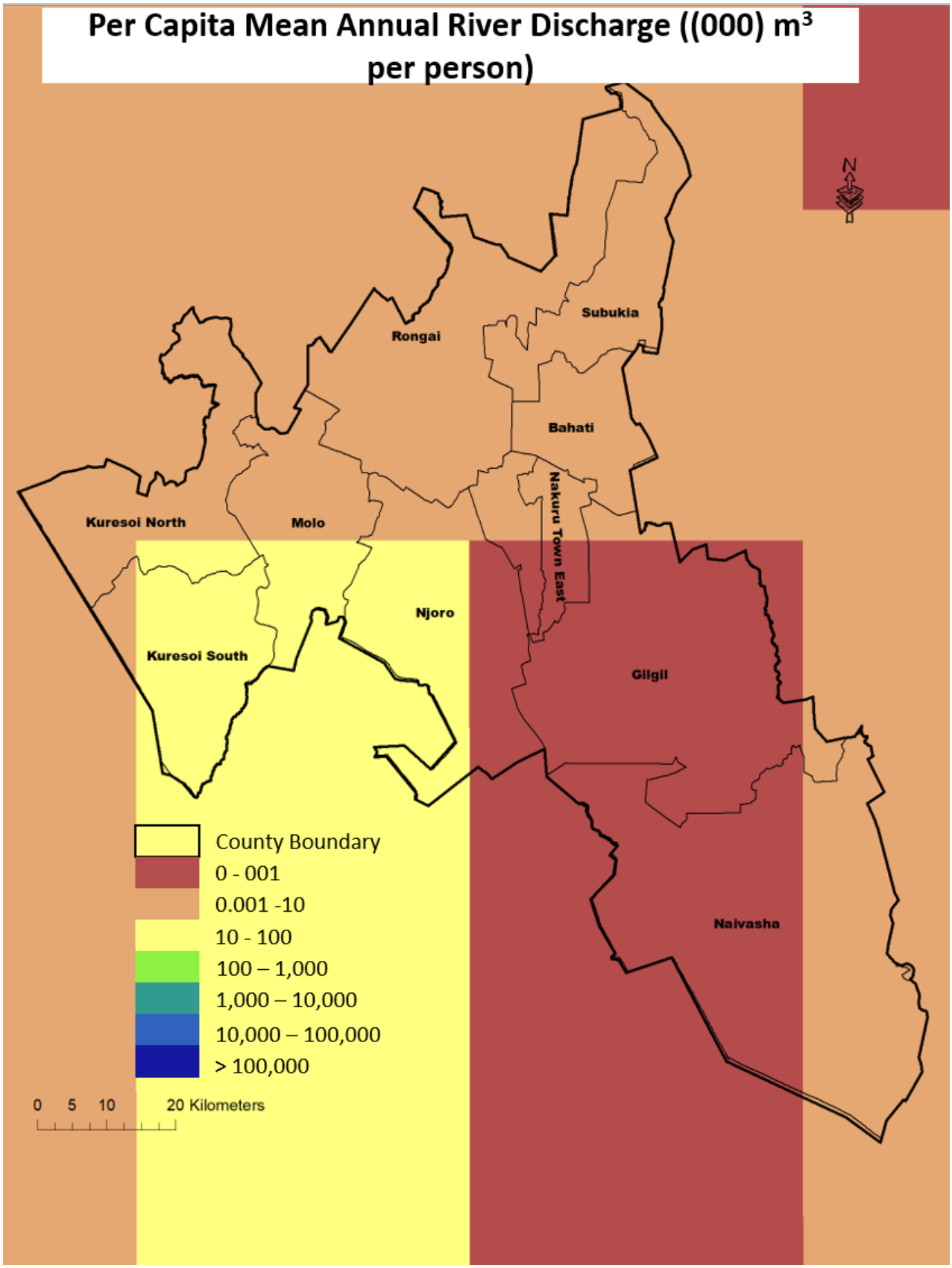
Figure 6.2.21: Temperature, Precipitation and Wind Speed 2023

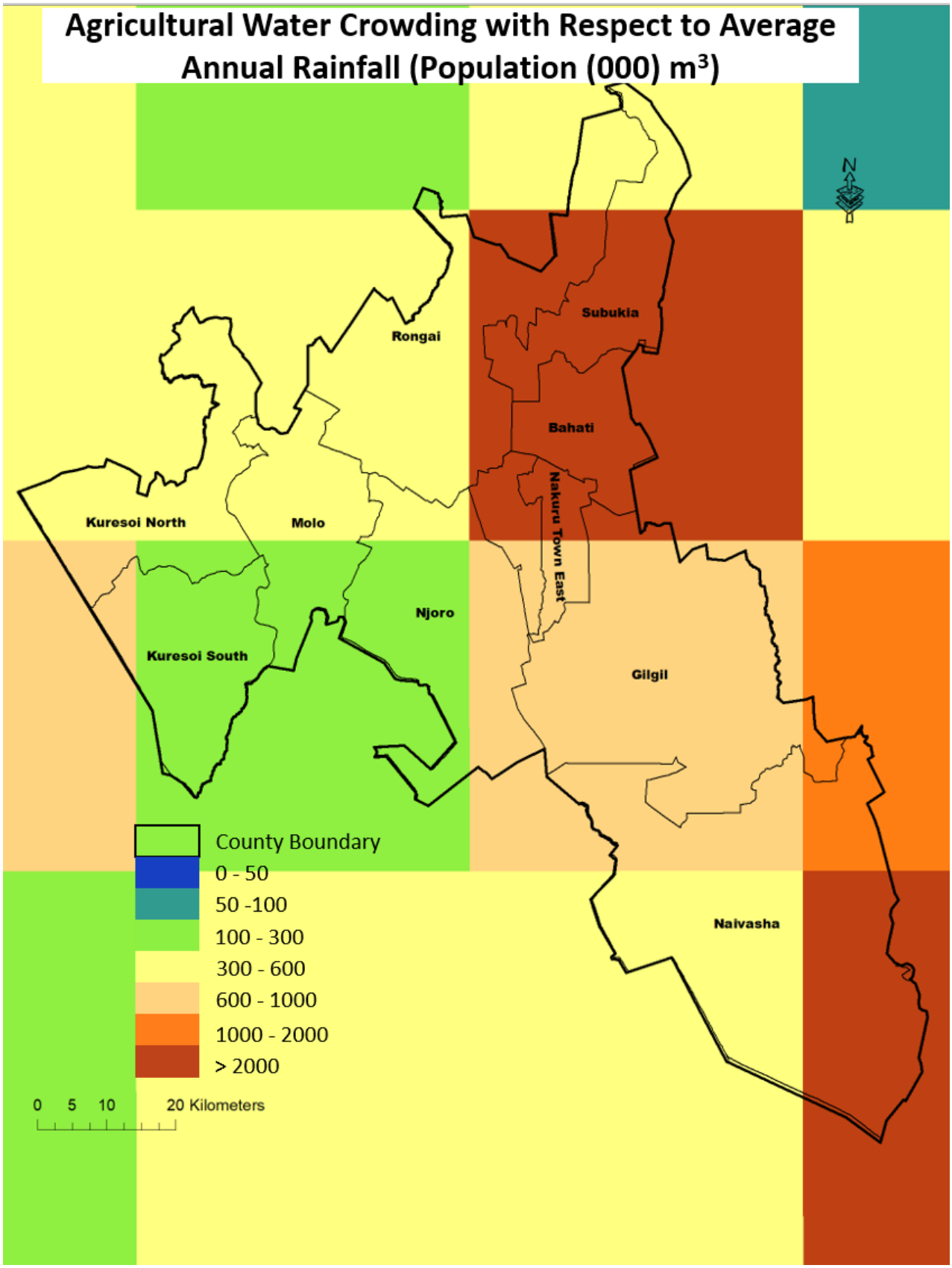
6.2 Appendix II: Patterns and impacts of droughts in Nakuru County

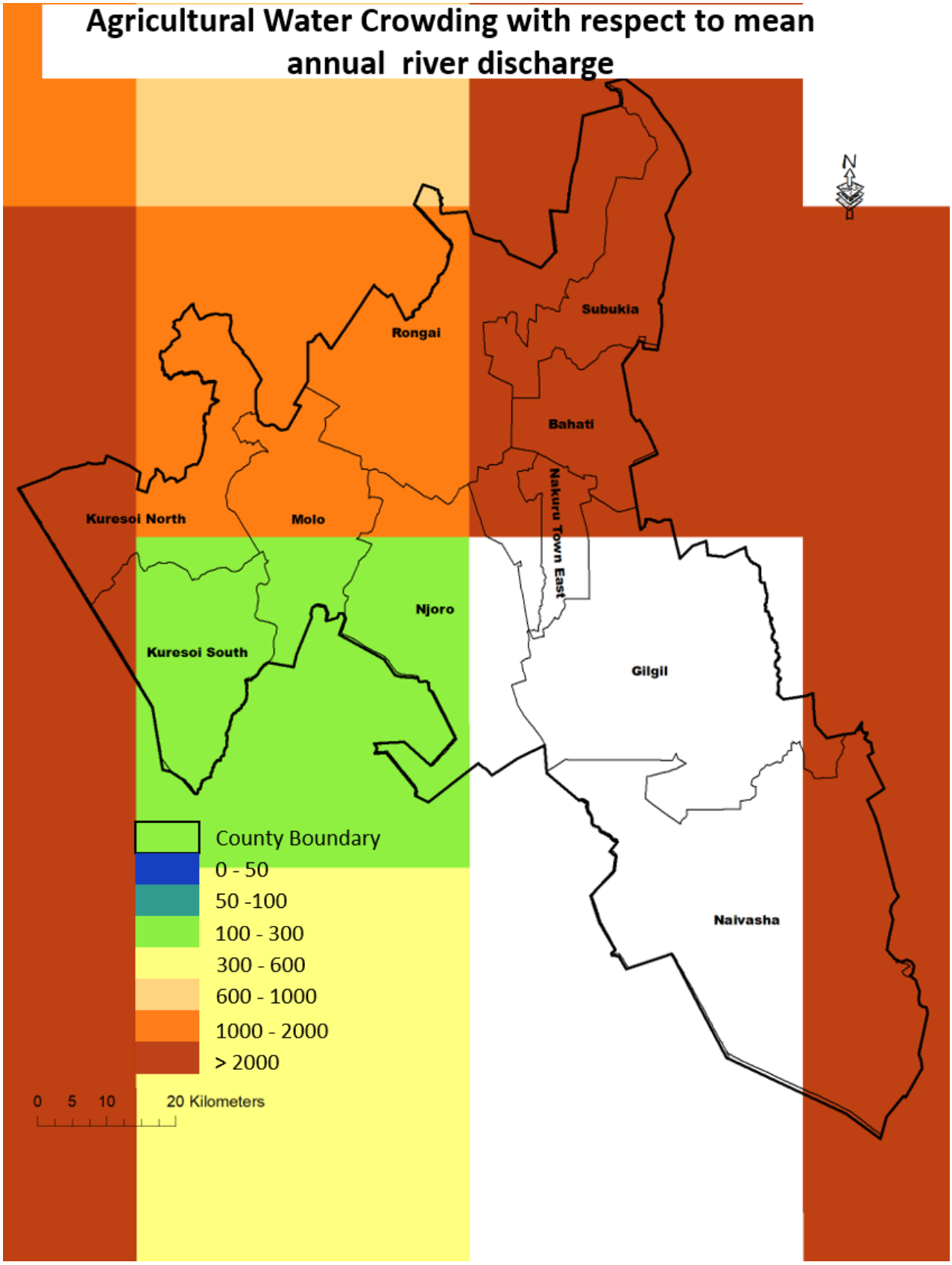


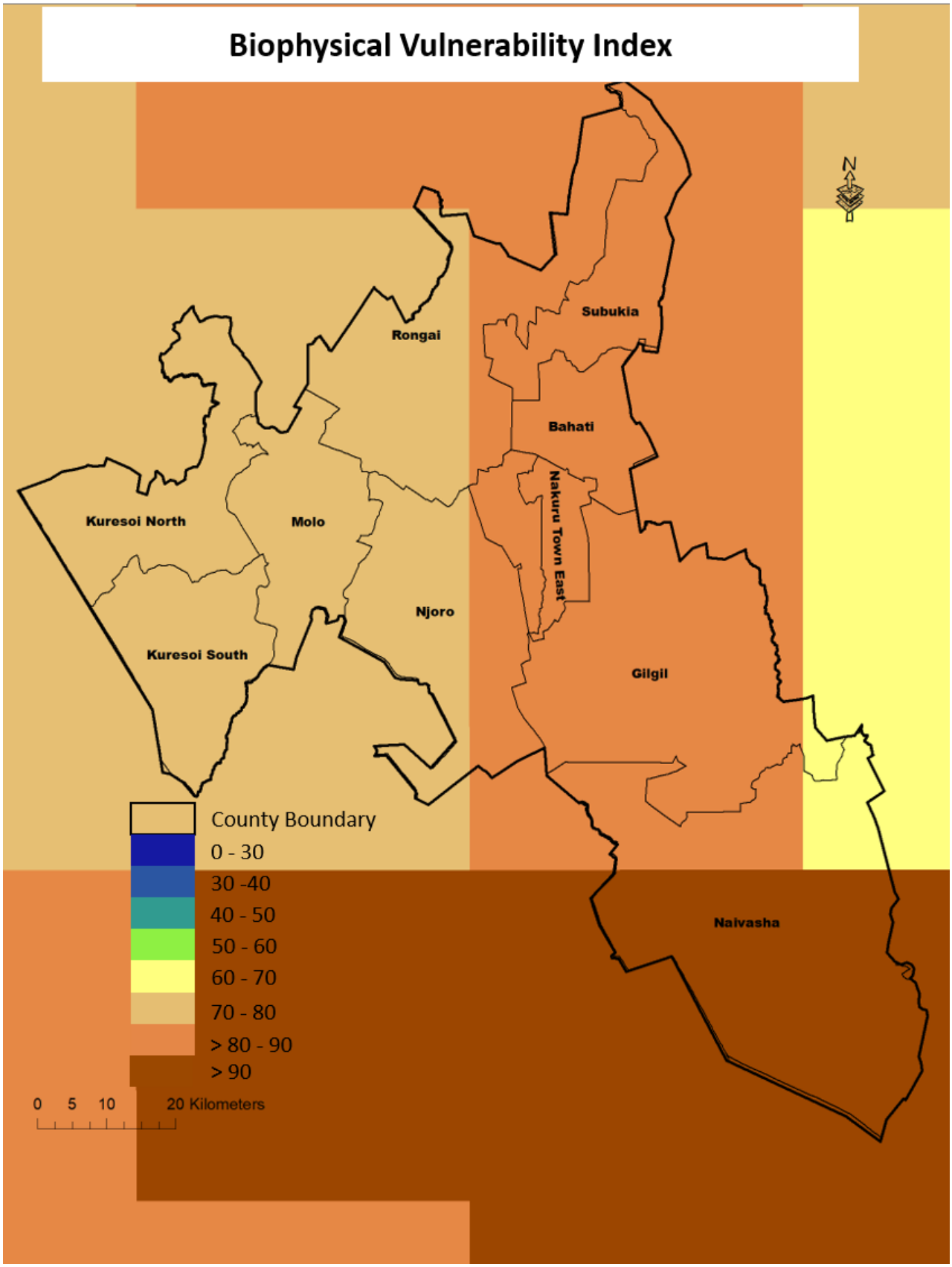

Coefficient of Variation Of Mean Annual Precipitation
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 – 0.05
0.05 – 0.1
0.1 – 0.15
0.15 – 0.2
0.2 – 0.25
0.25 – 0.3
0.3 – 0.4
0.4 – 0.5
> 0.5
0 5 10 20 Kilometers

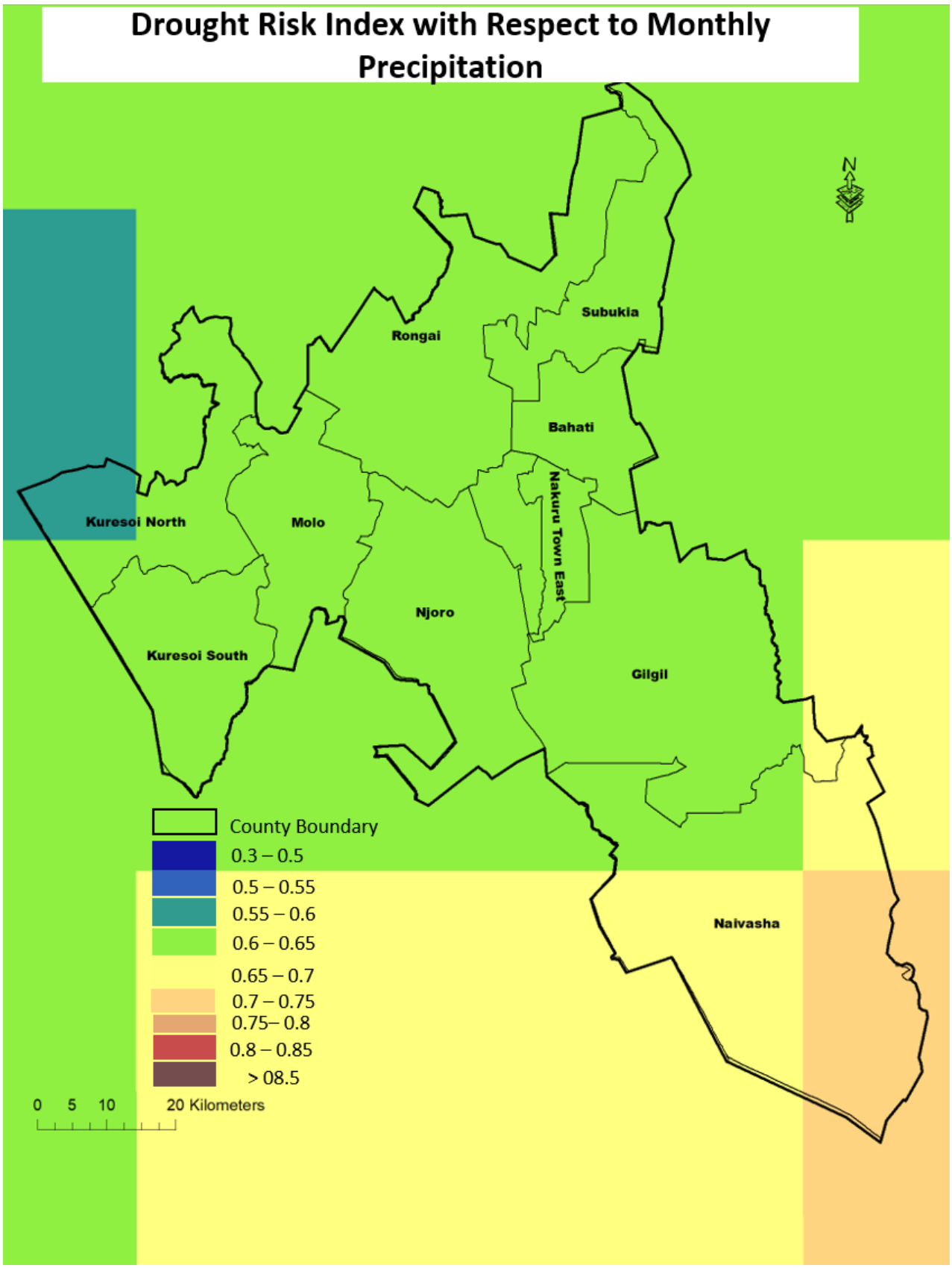

Probability_ of Annual Precipitation in any Year being less than 75% of the long term mean (%)
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 -
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
> 35
0 5 10 20 Kilometers

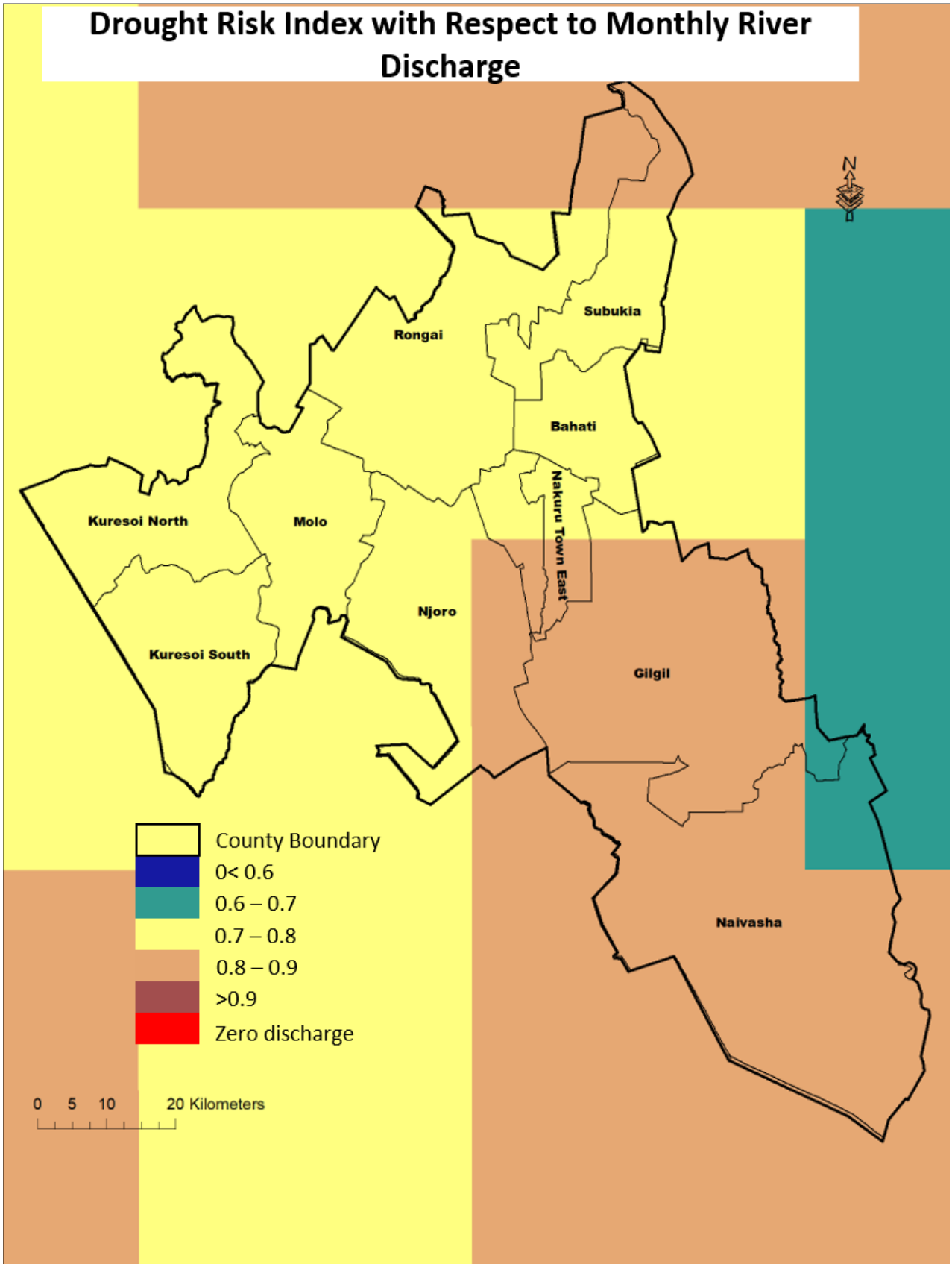

Per Capita Mean Annual River Discharge ((000) m3 per person)
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 - 001
0.001 -10
10 - 100
100 – 1,000
1,000 – 10,000
10,000 – 100,000
> 100,000
0 5 10 20 Kilometers

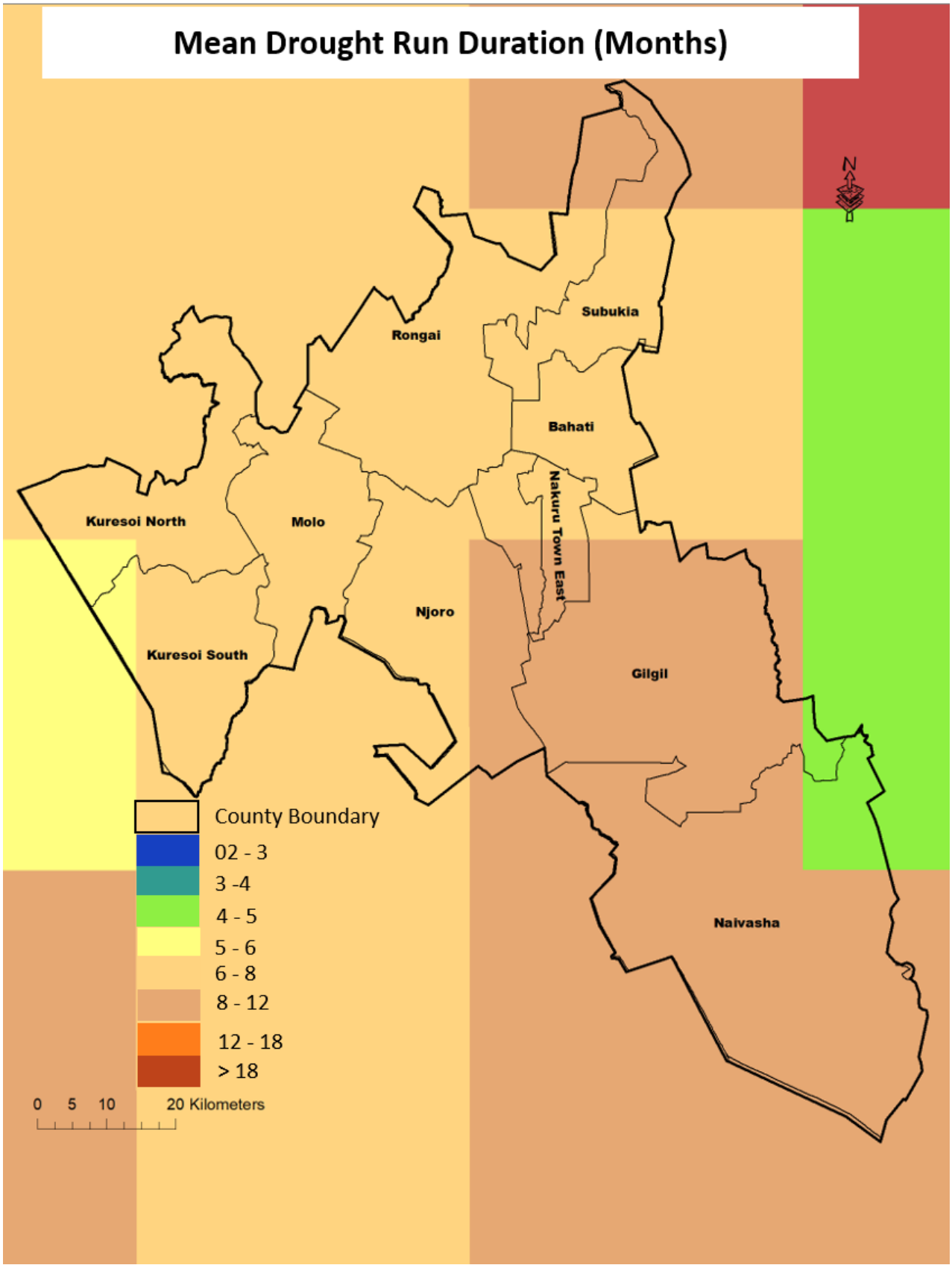

Agricultural Water Crowding with Respect to Average Annual Rainfall (Population (000) m³)
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 - 50
50 -100
100 - 300
300 - 600
600 - 1000
1000 - 2000
> 2000
0 5 10 20 Kilometers


Agricultural Water Crowding with respect to mean annual river discharge
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 - 50
50 -100
100 - 300
300 - 600
600 - 1000
1000 - 2000
> 2000
0 5 10 20 Kilometers


Biophysical Vulnerability Index
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0 - 30
30 -40
40 - 50
50 - 60
60 - 70
70 - 80
> 80 - 90
> 90
0 5 10 20 Kilometers


Drought Risk Index with Respect to Monthly Precipitation
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0.3 – 0.5
0.5 – 0.55
0.55 – 0.6
0.6 – 0.65
0.65 – 0.7
0.7 – 0.75
0.75– 0.8
0.8 – 0.85
> 08.5
0 5 10 20 Kilometers


Drought Risk Index with Respect to Monthly River Discharge
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
0< 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
>0.9
Zero discharge
0 5 10 20 Kilometers


Mean Drought Run Duration (Months)
N
Subukia
Rongai
Bahati
Nakuru Town East
Kuresoi North
Molo
Njoro
Kuresoi South
Gilgil
Naivasha
County Boundary
02 - 3
3 -4
4 - 5
5 - 6
6 - 8
8 - 12
12 - 18
> 18
0 5 10 20 Kilometers

6.3 Appendix III: Climate and Landscape Smart Practices for Agricultural Production System (Tick Based on adaptation pathway)

Menu Item	Description
Farm-level solutions	
Course 1: Undertake water management practices to reduce erosion optimize the water for future use in case of inadequacies	
Rainwater harvesting	Reduce water wastage by adopting roof harvesting and other practices to capture water for household and farm use.
Recycle wastewater	Recycle wastewater for irrigation, especially in backyard farming.
Irrigation	If possible, carry out irrigation, especially for critical periods.
Water capture	Redirect road runoff/establish Zai pits that capture more water and use especially for agroforestry systems.
Precision water use	Reduction of water use while maintaining/increasing yields through improved practices.
Course 2: Reduce soil erosion and surface runoff by adopting soil and water management practices for improved soil health and soil carbon sequestration	
Conservation tillage	Adopt minimum till and zero tillage practices, e.g., ripping, basin, green mulching, etc.
Mulching	Use available plant materials for mulching.
Establish soil erosion farm-level structures	Using farm-level trenches and contours on the farm.
Establish landscape-based soil erosion control infrastructure	Work with County authorities and communities to establish terraces and gabions for heavily impacted areas and those prone to landslides.
Crop integration	Use cover crops like legumes that have additional benefits on fertility.
Adopt practices that optimize soil moisture use	Practice dry planting and timely planting to take advantage of seasonal moisture.
Course 3: Adopt practices that enhance soil fertility and soil amendment, reduce inorganic fertilizer use and nutrient leakage	
Soil testing	Need to test the soils and make necessary corrections, farmers need to adopt liming and other fertilization practices with reduced acidity.
Precision fertilization	Apply fertilizers based on soil test recommendations; still, needs to reduce NPK use by mixing with organic fertilizers.
Organic fertilization	Integrate crop-livestock systems and, benefit from organic manure, embrace legume intercrops for nitrogen fixation.

Green manure	Need to train farmers on green manure making, especially from plants like tithonia and legumes with high phosphorus and nitrogen levels.
Biochar	The residue from the agricultural system (e.g., maize stalks and cobs) could be used to make Biochar mixed with mineral fertilizers. Train farmers on biochar while developing youths' business cases in the biochar trade.
On-farm nutrient recycling	Substituting synthetic fertilizers through alternate amendments. Examples include compost, Manure, and cow dung.
Course 4: Select varieties/plant management practices that require reduced use of external inputs and guarantee resilience to climate change and ecosystem threats	
Local germplasm	Integrate local traditional varieties and varieties already adapted to the conditions.
Participation in adaptive research	Work with input suppliers to test tolerant varieties.
Varietal selection	Target tolerant short-season early maturing crops to avoid impacts of extreme climate variability.
Course 5: Practice integrated pest and disease management practices that are friendly to the ecological system	
Adopt IPM	Adopt IPM to reduce pesticide use for enhanced food safety.
Biological control	Maintain a crop agroecosystem that enhances or conserves pest enemies/antagonists (including predators, parasitoids, pathogens, and competitors).
Appropriate Technologies	Non-chemical pest management practices that treat pest problems, e.g., technologies such as push and pull at the farm level, are to be promoted across all farmers.
Cultural methods	Adopt practices that reduce pest build-up, like scouting pests, farm hygiene, timely/early planting, cover crops, and crop rotation.
Course 6: Undertake Natural resources management actions to create a favorable ecosystem for agricultural production	
Agroforestry	Adopt polyculture systems with multipurpose trees for areas around forests; plant indigenous trees that are compatible with the forest system (all areas).
Forest restoration	Convening communities to undertake afforestation activities would entail areas around schools or forests in collaboration with county authorities.
Water management	Water management and water governance to avoid overdrawing and chemical loading in rivers, lakes, and riparian zones.
Post-Harvest Solutions	

Course 1: Undertake timely harvesting and safe storage for good quality produce	
Appropriate variety selection	Select appropriate varieties of agriculture for different locations.
Drying	Apply appropriate harvest and dry practices of selected commodities, e.g., drying on clean surfaces on raised beds.
Timely harvesting	Conduct timely harvesting to avoid rotting or losses of agricultural commodities.
Course 2: Implement storage practices that guarantee secure and safe produce	
Storage areas	Ensure well-aerated and raised storage areas devoid of water.
Appropriate technology	Information is easily available across stakeholders using hematic storage bag technologies and household metallic silos.
Course 3: Undertake Adaptive Marketing to take advantage of market dynamics as dictated by climate change and changing consumer preferences	
Market information	Ensure access to information on market trends.
Value addition	Undertake value addition and safe storage to take advantage of market opportunities.
Producer consumer connection	Business support for re-establishing the connection between producers and consumers, production systems based on consumer needs.
Innovative marketing	Engage communities to explore local markets, and encourage and sensitize for seasonal and regional demand.
Course 4: Undertake circularity innovations to recycle waste into energy or feed	
Waste to Energy	Reducing fuel consumption in farming through renewable, low-carbon energy sources can be used on farms (biofuels are rated separately).
Waste to feed	Agricultural waste is to be utilized for livestock and poultry feeding.
Waste to fertilizer	Convert agricultural waste to mulch or biochar for use on farms.
Water recycling	Recycling of wastewater for agricultural use, agricultural water reuse.
Course 6: Undertake Natural resources management actions to create a favourable ecosystem for agricultural production	
Agroforestry	Adopt polyculture systems with multipurpose trees for areas around forests; plant indigenous trees that are compatible with the forest system.
Forest restoration	Convening communities to undertake afforestation activities would entail areas around schools or conserving forest fragments around agricultural lands in collaboration with county authorities.

Water management	Water management and water governance to avoid overdrawing and chemical loading in rivers, lakes, and riparian zones.
Risk Management Solutions	
Course 1: Diversification to take advantage of temporal and spatial landscape opportunities.	
Local seed/breed diversity	Supporting the development and promotion of local seeds and encouraging communities to be part of classical breeding activities.
Crop rotation	Integrate simple crop rotation with two or more crops.
Spatial diversification	Encourage farmers to diversify over space.
Income diversification	Beyond the farm, farmers need to diversify into other forms of work or access to markets for their products.
Course 2: Develop Seasonal forecasting and climate information systems	
Seasonal planning	Work with the County and Meteorology to do seasonal forecasting to facilitate season management to avoid /manage risks.
Develop Nakuru County Climate Atlas	There is a need to develop Nakuru County Climate Atlas, which should be managed by a local 'owner' for sustainability. The Nakuru County Climate Atlas can then be made available for County planning for resilient agriculture.
Enabling Environment Solutions	
Course 1: Support Policy and governance systems for enhanced uptake of practices, increased environmental protection, and improved trade	
Resilience frameworks	Work with County to frequently assess the resilience of agricultural sector systems and develop response measures to facilitate the development of County Integrated Adaptation Plans based on empirical evidence (farmer realities).
Producer consumer linkages	Stakeholder activities on market regulations and policies that strengthen local marketing systems like County procurement and school feeding programs.
Good governance	Strengthen traditional and customary governance models and policies that ensure and protect equitable land tenure systems and secure access to natural resources.
Policy development/integration	Develop or facilitate the integration of agroecology, Ecological based adaptation (EBA), and smart landscape management SLM as critical processes in tackling global changes, such as climate change.
Course 2: Facilitate access to early warning information for improved response.	
Weather alerts	Work with weather information digital information providers and connect farmers to access detailed site-specific weather alerts and ensure relevant climate and weather data/information tailored towards relevant agro-climatic indicators in agriculture.

Soil nutrient alerts	Adopt digital satellite-based soil scanners and provide early warning information on soil nutrient management.
Web GIS-Based Real-time Monitoring	Develop a Web GIS-Based Real-time Monitoring System to monitor value chain performance from the farm to the market.
Course 2: Knowledge sharing and extension systems that facilitate the transfer of both traditional and scientific knowledge	
Co-creation and Sharing of Knowledge	Engage farmers in co-creation and sharing knowledge, integrate producer's knowledge and management experience into research.
Farmer-researcher networks	Facilitate sessions where farmer's groups share experiences and bottom-up technology transfer models.
Participatory and multi-stakeholder approaches	Establish County/landscape level multi-stakeholder platforms to facilitate the integration of farmers and other actors' views in all decision-making stages.
Course 3: Support the creation of financial models that guarantee increased access to finance during climate extremes.	
Table banking and SACCOs	Encourage table banking and Saccos to develop a savings pool to support farmers during climate extremes.
Linkages to financial solutions	Hold dialogue with local financiers to build smallholder-based financial products to support farmers during climate extremes like crop failure during drought or excess rainfall.
Course 4: Develop interventions that focus on Gender and social inclusion	
Gender and vulnerable group approach	Developing and informing policies and approaches that empower women or other vulnerable groups (including youth).
Self-organization	Increasing the organizational capacities of farmers by encouraging them to be part of groups and associations.

6.4 Appendix IV: Description of FAO Agroecology Principles and Dimensions

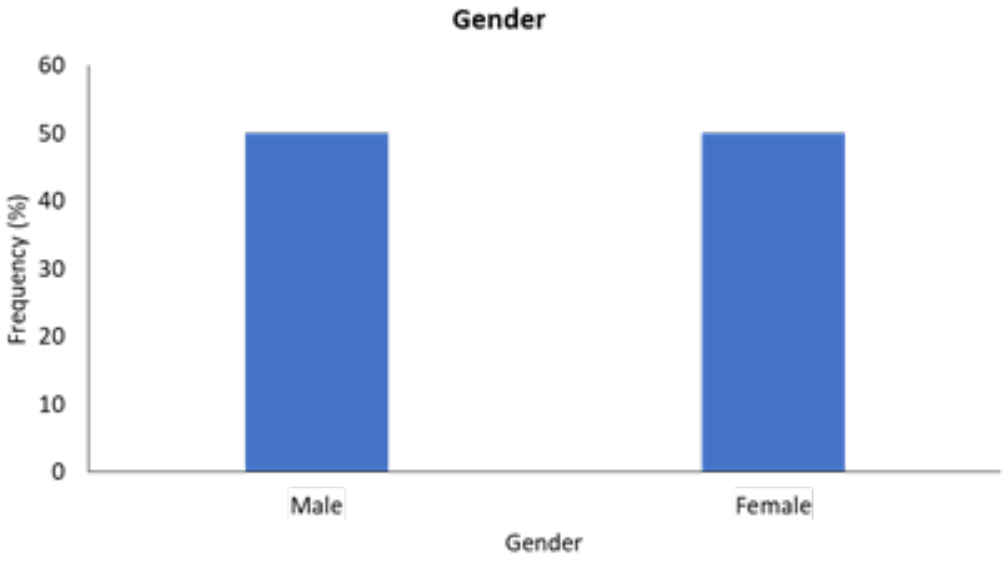
https://biovision-act.herokuapp.com/#/act

FAO Principle	Agroecology Dimension
Efficiency	Reduced water consumption
	Reduced application of pesticides and veterinary drugs
	Reduced synthetic fertilizer application and use of animal feed
	Reduced energy use
	Reduced seed use
	Reduced waste
	Improved plant variety and animal breed
Recycling	Alternative soil inputs
	Green manure
	Recycling of wastewater
	Use of biomass residues for energy generation
	Climate mitigation through alternative practices
	Other practices that enhance the recycling of biomass and organic matter
Regulation and balance	Improved animal welfare and health
	Biological pest management
	Cover crops for pest management
	Other pest management
	Cover crops for improved soil conditions
	Perennial crops
	Reduced tillage
	Adoption of organic and low-input farming
	Domesticated pollinators
	Other Gliessman Level 2 systems
Synergies	Non-crop plants
	Agroforestry
	Rotational/regenerative grazing
	Integrated crop-livestock systems
	Other selective combinations/integrations at the farm level to optimize (ecological) synergies
	Integrated pest management by habitat manipulation
	Other landscape planning and synchronized landscape activity leading to improved agricultural ecosystem services
	Climate mitigation through redesigned system (increasing carbon stocks, reducing GHG emissions)

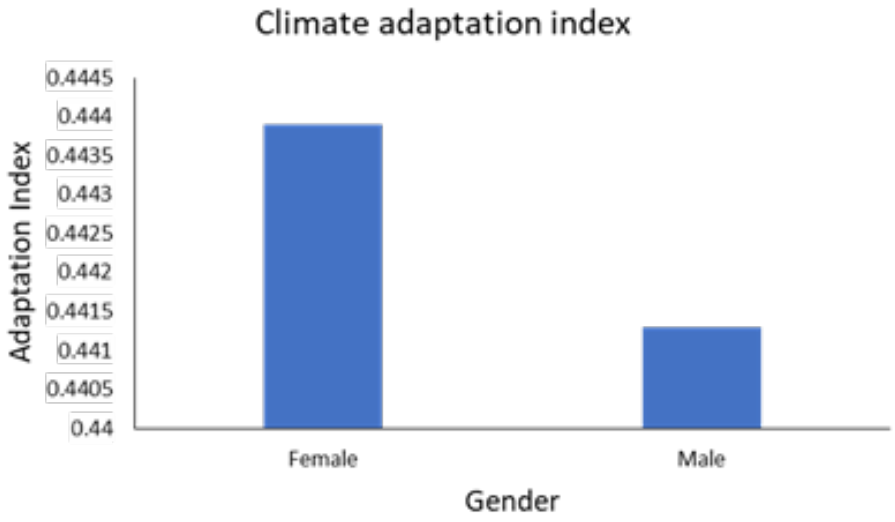
Diversity	Improving local seed/breed diversity
	Integrating locally adapted crops/races
	Two-crop rotation
	Three+ crop rotation
	Spatially diversified farms
	Biodiversity
	Natural pollinators
	Multi-habitat approach
	Diversification of diets and consumption
Resilience	Systemic resilience of agroecosystems to extreme weather events and other disturbances
	Systemic resilience and adaptive capacity to changing environmental conditions due to climate change
	Livelihood resilience
Circular and solidarity economy	Business support for re-establishing the connection between producers and consumers
	Supporting regional value generation
	Encourage and sensitize for seasonal and regional demand
Culture and food traditions	Support healthy, diversified, and culturally appropriate food traditions and diets
	Support the right to adequate and culturally appropriate food
Co-creation and sharing of knowledge	Connecting farmers to share knowledge
	Promote participatory and multi-stakeholder approaches in knowledge generation
	Promote formal and non-formal "production and food" education
Human and social value	Gender and vulnerable group approach
	Strengthen organizational capacities
	Equity, dignity, inclusion
	Support right to food (sufficient, access, adequate)
	Promote food sovereignty
	Creating decent jobs for rural youth
Responsible governance	Policy development on producer-consumer links
	Inclusive policy making
	Establishment of equitable governance and rights over natural resources
	Policy development on the links between agroecology and global changes
	Policy development that rewards agricultural management that enhances biodiversity and the provision of ecosystem services

6.5 Appendix V: Additional Household, Climate adaptation index analysis data

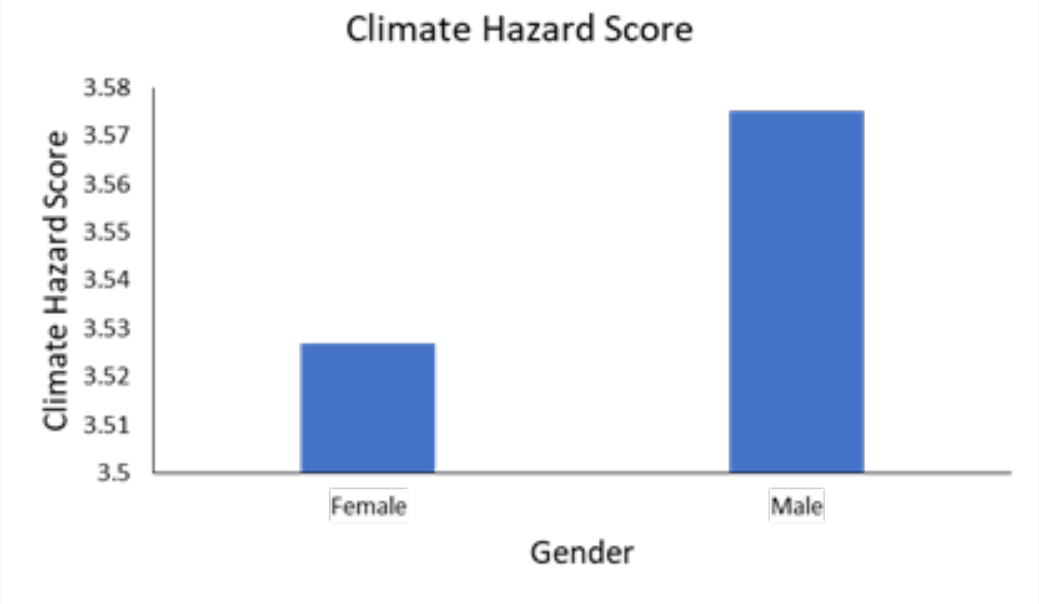
Gender



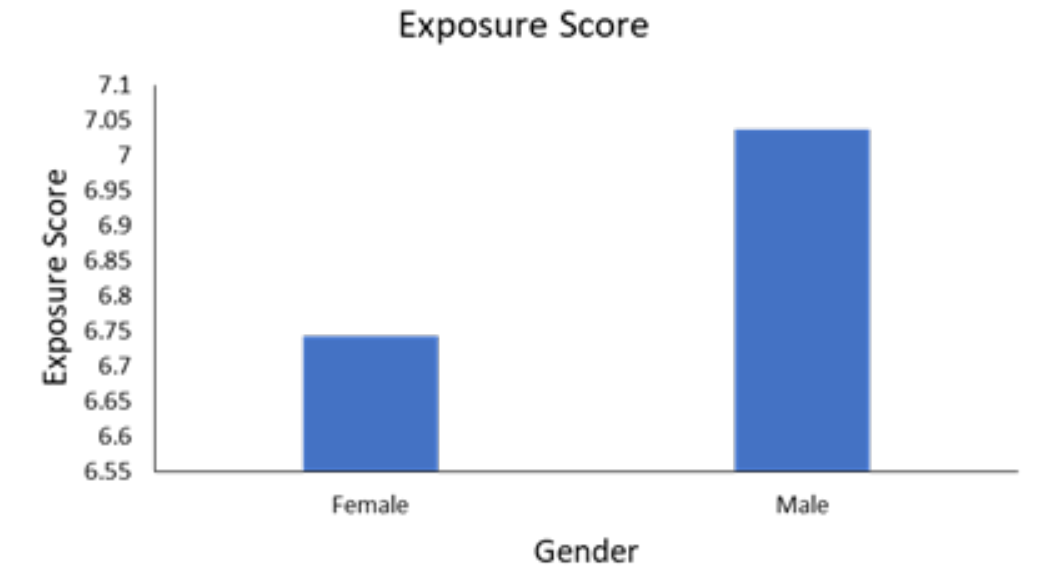
Gender vs Climate Adaptation index



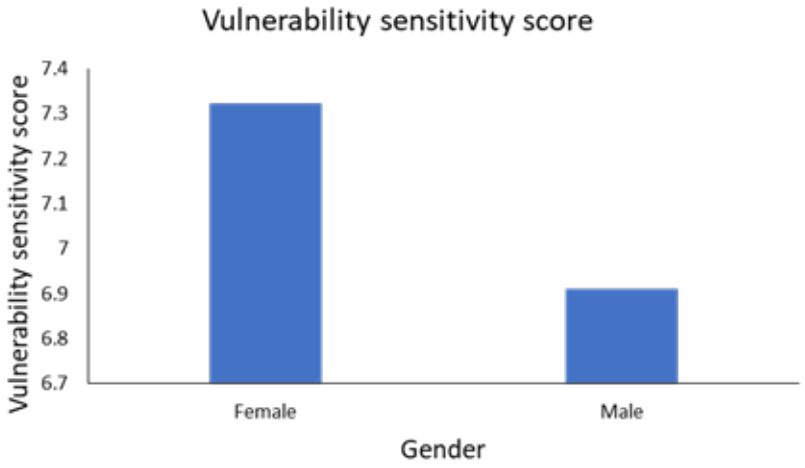
Gender Vs Climate Hazard Scores



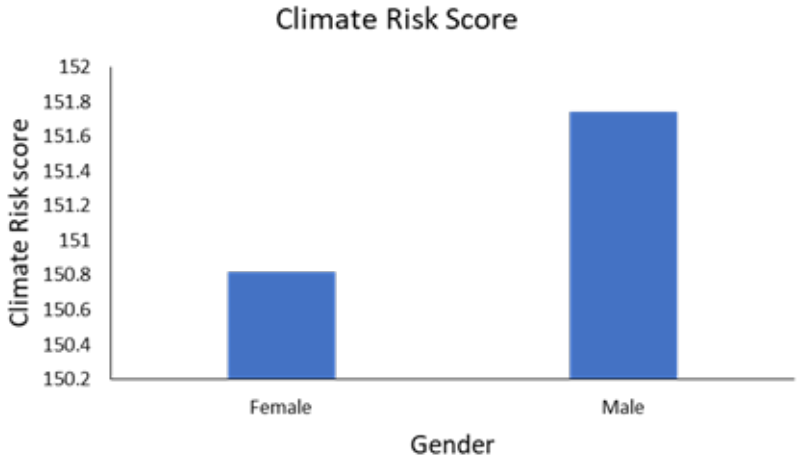
Gender Vs Exposure Score



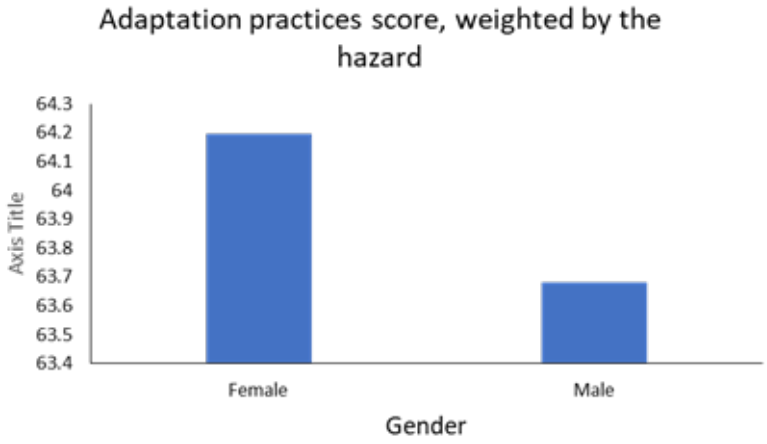
Gender Vs Vulnerability sensitivity score



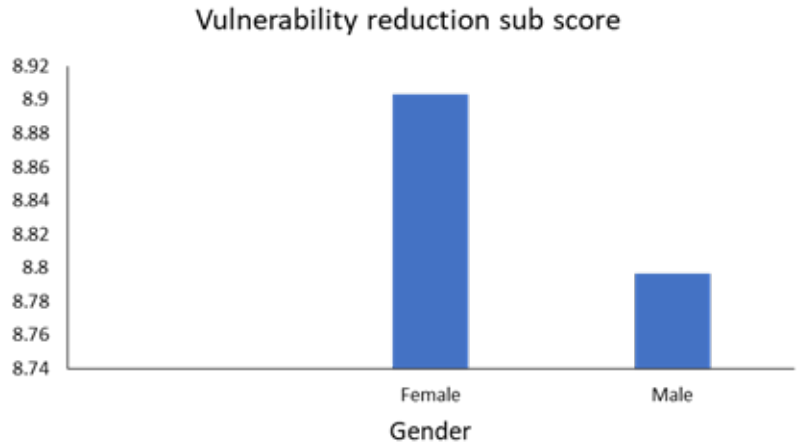
Gender Vs Climate Risk Score



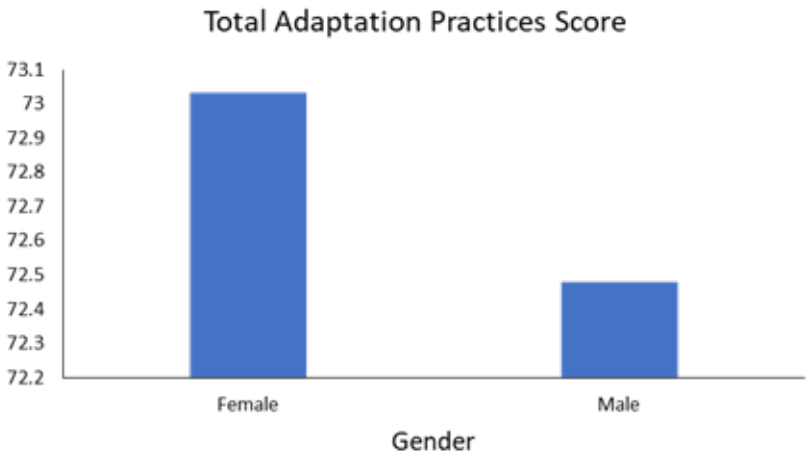
Gender Vs Adaptation practices score, weighted by the hazard



Gender Vs Vulnerability Reduction Score



Gender Vs Total Adaptation Score



Endnotes

1 National Climate Change Response Strategy 2010. | UNEP Law and Environment Assistance Platform

2 National Climate Change Action Plan (NCCAP) 2018 - 2022. | UNEP Law and Environment Assistance Platform

3 Climate Change Act, 2016 - Kenya - Climate Change Laws of the World (climate-laws.org)

4 National Environment Management Authority | National Environment Management Authority (nema.go.ug)

5 National Environment Management Authority (NEMA) - Environmental Act (EMCA)

6 Forest Conservation and Management Act, 2016 (No. 34 of 2016). | InforMEA

7 https://www.health.go.ke/wp-content/uploads/2015/09/County Government Act.pdf

8 https://www.wri.org/initiatives/global-commission-adaptation

9 Commodities and Development Report 2019 | UNCTAD

10 *Such as the Agricultural Sector Transformation Strategy (2019-2029), Vision 2030, Kenya Climate Smart Agriculture Strategy (2017-2026), National Food and Nutrition Security Policy (2011) and Implementation Framework (2017 – 2022)*

11 *The KS 1758-2:2016 Code of Practice/ Standard aims at providing rules for safe and sustainable production and supply of fruits and vegetables in Kenya for both export and domestic markets*

12 *https://www.irena.org/newsroom/pressreleases/2021/mar/fast-track-energy-transitions--to-win-the-race-to-zero*

13 *https://www.who.int/publications/i/item/cop24-special-report-health-climate-change*

14 *https://www.un.org/sg/en/content/sg/speeches/2021-09-24/opening-remarks-high-level-dialogue-energy*

15 *https://www.who.int/publications/i/item/cop24-special-report-health-climate-change*

16 Nakuru County Population - Gichinga (gicinga.com)

NAKURU COUNTY
COUNTY OF UNLIMITED OPPORTUNITIES

ALIN | Arid Lands Information Network

WWF KENYA
TOGETHER FOR NATURE

VCA
VOICES FOR JUST CLIMATE ACTION