Insene resilience design demonstration farm. ~ Rashid Jattani Boru (Mercy Corps)

The Resilient Approaches in Natural Rangeland Ecosystems (RANGE) Programme

Climate Risk Analysis Report

Netherlands

MERCY CORPS

FCDC

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Contents

Abbreviations

ABC	Alliance of Bioversity and CIAT
ASALs	Arid and Semi-Arid Lands
CCCF	County Climate Change Fund
CPAPC	Community Adaptation Planning Committee
CSA	Climate-Smart Agriculture
CSO	Climate Security Observatory
DRPNK	Drought Resilience Programme in Northern Kenya
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FLLoCA	Financing Locally Led Climate Action
IDI	In-depth Interview
ICRAF	World Agroforestry
IIED	International Institute for Environment and Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
IWASCO	Isiolo Water and Sewerage Company
KALRO	Kenya Agricultural and Livestock Research Organization
KEPSA	Kenya Private Sector Alliance
KfW	Kreditanstalt für Wiederaufbau (German Development Bank)
KLIP	Kenya Livestock Insurance Program
KMD	Kenya Meteorological Department
LISTEN	Laikipia Isiolo Samburu Transforming the Environment through Nexus
LMS	Livestock Market System
NDMA	National Drought Management Authority
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NRT	Northern Rangelands Trust
PforR	Program-for-Results
RANGE	Resilient Approaches in Natural Rangeland Ecosystems
RCP	Representative Concentration Pathway
SDDA	State Department for Development of Arid and Semi-Arid Lands
TNC	The Nature Conservancy
TRI	The Restoration Initiative
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WFP	World Food Programme
WSTF	Water Services Trust Fund

Executive summary

The arid and semi-arid lands (ASAL) counties of Isiolo, Marsabit, and Samburu counties in Kenya are facing unprecedented challenges due to climate change, posing significant threats to livelihoods, ecosystems, and development progress. This comprehensive analysis examines the climate risks, impacts, and adaptation strategies in these highly vulnerable regions.

Climate trends and projections paint a concerning picture for these counties. Temperatures have already increased by approximately 1°C since the 1960s, with further projections indicating a rise of 1.5-3°C by 2050. Rainfall patterns have become increasingly variable and unpredictable, while extreme weather events, particularly droughts and floods, are occurring with greater frequency and intensity.

These climate changes are having profound impacts on water resources and agriculture, the lifeblood of these regions. River flows and groundwater recharge rates are declining, threatening water security for both human consumption and agricultural use. Crop yields could potentially decrease by 25-50% in some areas by 2050, severely impacting food security. Livestock productivity, crucial for pastoralist communities, is declining due to reduced pasture availability and increased heat stress.

The effects on ecosystems and biodiversity are equally alarming. Vegetation patterns are shifting, with an increase in woody vegetation and a decrease in palatable grasses affecting rangeland quality. Wildlife migration patterns are changing, leading to increased human-wildlife conflicts. Unique ecosystems, such as the Mt. Marsabit forest, face significant contraction, threatening biodiversity and ecosystem services.

These environmental changes are translating into severe socio-economic consequences. Pastoralist communities, which form the backbone of the local economy, are experiencing increased livestock mortality and reduced incomes. Food insecurity and malnutrition rates are rising due to crop failures and livestock losses. These impacts are exacerbating existing vulnerabilities, particularly for women and marginalized groups, potentially deepening poverty and inequality in the region.

In response to these challenges, various adaptation strategies are being implemented across the three counties. Water management initiatives, such as the construction of sand dams and climate-proofing of water infrastructure, are showing promise in enhancing water security. Livestock improvement programs and the promotion of climate-smart agriculture are yielding positive results in terms of agricultural resilience. Ecosystem-based adaptation approaches, including large-scale rangeland restoration projects, are demonstrating potential for enhancing both ecological and community resilience.

Pastoralist communities, which form the backbone of the local economy, are experiencing increased livestock mortality and reduced incomes, while food insecurity and malnutrition rates are rising due to crop failures and livestock losses.

Governance and policy frameworks play a crucial role in shaping climate adaptation efforts. All three counties have established county-level climate change acts and policies. Devolved climate governance models, such as Isiolo's County Climate Change Fund, are improving local adaptation planning and implementation. There's also a growing recognition of the value of integrating indigenous knowledge with scientific approaches, enhancing the effectiveness and local acceptance of adaptation strategies.

Innovative financing mechanisms are emerging to support these efforts. Climate funds at the county level and results-based financing programs are providing new avenues for funding adaptation initiatives.

There's also increasing interest in engaging the private sector in climate resilience efforts and exploring transboundary collaboration for more effective regional responses.

However, significant challenges persist. Financial constraints and limited technical capacity continue to hinder adaptation efforts. Data limitations, particularly in terms of localized climate projections, make evidence-based planning difficult. Coordination challenges between different levels of government and across sectors also hamper effective implementation of adaptation strategies.

Despite these challenges, there are emerging opportunities for enhancing climate resilience in these regions. The potential for scaling up successful nature-based solutions, leveraging digital technologies for climate information services, and developing climate-resilient value chains offer promising pathways for future adaptation efforts.

In conclusion, the ASALs of Isiolo, Marsabit, and Samburu face severe climate risks that demand urgent and integrated adaptation strategies. While progress has been made, particularly in water management and ecosystem-based approaches, the scale of the challenge requires continued innovation and investment.

Enhancing adaptive capacity, leveraging innovative financing mechanisms, and strengthening governance frameworks will be crucial for building long-term resilience in these vulnerable regions. The experiences of these counties offer valuable lessons not only for Kenya but for other arid and semi-arid regions globally facing similar climate challenges.

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Introduction

Background and Purpose

The Arid and Semi-Arid Lands (ASALs) of Northern Kenya represent a critical ecological and socio-economic region. Covering over 80% of Kenya's landmass, these areas are home to approximately 18 million people, roughly 36% of Kenya's population[1]. Characterized by low annual rainfall, these regions are particularly vulnerable to droughts, flooding, and the increasing impacts of climate change, which pose significant risks of desertification (UNEP, 2021).

Mercy Corps has initiated Inception Assessments for its newly launched Resilient Approaches in Natural Rangeland Ecosystems (RANGE) program. This 5-year initiative focuses on the Arid and Semi-Arid Lands (ASALs) counties of Marsabit, Isiolo, and Samburu in Kenya. The assessments aim to evaluate the initial conditions and context as the program begins its implementation.

These Inception Assessments are crucial for ensuring that program activities are tailored to the realities on the ground in the target counties. They will enable the program team and other stakeholders to make informed decisions about adapting interventions to achieve positive outcomes.

This report is part of the Inception Assessments and provides a comprehensive analysis of climate risk in the ASAL counties of Isiolo, Marsabit, and Samburu. It investigates observed and projected changes in climate patterns, including temperature, precipitation, and extreme weather events, and their influence on local ecosystems, livelihoods, and infrastructure. The report also evaluates the potential direct and indirect impacts of climate change on key sectors such as agriculture, water resources, health, and biodiversity. Furthermore, it assesses existing and proposed adaptation measures aimed at mitigating climate risks within the program area, highlighting their effectiveness. The findings aim to inform evidence-based programming for the RANGE program and guide sustainable development initiatives that address the specific needs of these vulnerable communities while enhancing climate resilience and promoting environmental conservation.

Overview of Isiolo, Marsabit, and Samburu ASAL Counties

Isiolo County, covering an area of approximately 25,336 square kilometers, is strategically positioned at the center of Kenya. It borders Marsabit County to the north, Samburu and Laikipia counties to the west, Garissa County to the southeast, and Wajir and Meru counties to the east and south respectively. The county has a population of about 268,002 according to the 2019 Kenya Population and Housing Census. Isiolo's climate is predominantly arid and semi-arid, characterized by hot and dry conditions with two main rainy seasons. The county's geography features expansive plains and significant water bodies such as the Ewaso Ng'iro River, which is vital for local livelihoods and wildlife.

According to the 3rd County Integrated Development Plan (CIDP)[2], Marsabit County, the second-largest county in Kenya, spans an impressive 70,961 square kilometers. It shares borders with Ethiopia to the north, making it a key frontier region. The county's population was approximately 459,785 (comprising 243,548 males and 216,219 females) as of the 2019 census. Marsabit is known for its diverse ethnic communities, including the Rendille, Gabra, Borana, and Samburu. The county's terrain is varied, featuring mountainous areas like Mount Marsabit, vast plains, and notable water bodies including Lake Turkana. Marsabit experiences erratic and unevenly distributed rainfall, leading to frequent droughts that significantly impact its predominantly pastoralist population.

Samburu County, covering about 21,000 square kilometers, is situated in north-central Kenya. It borders Marsabit County to the north, Isiolo County to the east, and other counties including Laikipia, Baringo, and Turkana. As of the 2019 census, Samburu had a population of approximately

1 https://kippra.or.ke/pathways-to-sustainable-land-use-in-arid-and-semi-arid-lands-in-kenya/

2 https://www.marsabitassembly.go.ke/wp-content/uploads/2023/07/3rd-CIDP-Report-DRAFT-2.pdf

310,327 (with 139,510 males and 128,483 females). The county is home to diverse ethnic communities, with the Samburu people being predominant, alongside Turkana and Rendille communities. Like its neighbors, Samburu experiences an arid and semi-arid climate with hot and dry conditions punctuated by two rainy seasons. The county's landscape includes vast plains, hills, and important water sources like the Ewaso Ng'iro River.

In all three counties, pastoralism forms the backbone of the local economy, with livestock rearing being the primary livelihood for many residents. However, these regions face numerous challenges, including frequent droughts, limited access to basic services, poor infrastructure, and periodic conflicts often driven by competition over scarce resources.

Methodology and Research Questions

This assessment employed a comprehensive mixed-methods qualitative research approach, combining various qualitative data collection techniques and desk reviews to gain a holistic understanding of the complex dynamics in Isiolo, Marsabit, and Samburu counties. The methodology was designed to capture the multifaceted nature of the challenges and opportunities in these arid and semi-arid regions, with a particular focus on biodiversity, climate change impacts, conservation strategies, socio-economic aspects, and governance mechanisms.

The research process began with an extensive literature review, drawing from academic journals, government reports, NGO publications, and other relevant sources. This desk- based research provided a solid foundation of existing knowledge across all thematic areas, helping to identify key trends, gaps, and best practices in current programming.

Primary data collection was conducted through a combination of in-depth interviews(IDIs), focus group discussions (FGDs), and key informant interviews (KIIs) across Marsabit, Samburu, and Isiolo counties, with a gender-segregated approach to ensure balanced representation. In Marsabit 8 FGDs were conducted, segregated into 4 male-only and 4 female-only groups. In-depth interviews in Marsabit targeted at least 40% female representation, resulting in around 7 males and 5 females per ward resulting in 48 in depth interviews in the county. Samburu also saw 8 FGDs with 4 male-only and 4 female-only groups, and 12 in-depth interviews per ward with a similar 40% female target, yielding around 7 males and 5 females. Isiolo had a similar

representation. The number of Key Informant Interviews (KIIs) conducted varied due to the diversity of key informants representing different thematic areas within each county, as well as the various administrative levels they represented, ranging from local to county to national but for this climate risk assessment 7 key informants were interviewed. These qualitative methods allowed for a nuanced exploration of the complex interrelationships between the various thematic areas in the target counties.

In-depth interviews were conducted with household heads or senior female members, with a quota system ensuring at least 40% female respondents to capture gender- specific perspectives. Focus group discussions were organized separately for men and women, including youth representation, to encourage open dialogue and capture diverse viewpoints. Key informant interviews targeted individuals with specialized knowledge or unique perspectives on the research topics, including government officials, community leaders, and subject matter experts.

The research questions guiding this assessment include:

1. **What are the observed and projected changes in climate patterns and extremes within the program area?**
2. **How have historical climate data and trends, including temperature, precipitation, and extreme weather events, influenced local ecosystems, livelihoods, and infrastructure?**
3. **What are the potential direct and indirect impacts of climate change on key sectors, including agriculture, water resources, health, infrastructure, and biodiversity?**
4. **What adaptation measures or strategies have been implemented or proposed to address climate risks within the program area, and how effective have they been?**

Importance of Climate Risk Analysis in ASAL Regions

Climate risk analysis is of critical importance for theASALs of northern Kenya, particularly in Isiolo, Marsabit, and Samburu counties. These regions are characterized by harsh climatic conditions, limited water resources, and fragile ecosystems that are highly vulnerable to climate change impacts (Opiyo et al., 2015). As climate variability and extreme weather events become more frequent and severe, understanding and quantifying climate risks is essential for developing effective adaptation strategies and ensuring the resilience of local communities (Maina et al., 2020).

The importance of climate risk analysis in these ASAL regions can be understood through several key factors:

1. **Food Security:** ASALs are home to predominantly pastoralist and agro-pastoralist communities whose livelihoods and food security are closely tied to climate-sensitive sectors such as livestock rearing and rain-fed agriculture (Catley et al., 2013). Climate risk analysis helps identify threats to food production systems and informs strategies to enhance food security in the face of changing climate patterns (Recha et al., 2016).

2. **Water Resource Management:** Water scarcity is a perennial challenge in ASALs (Kiptoo et al., 2019). Climate risk analysis provides crucial insights into future water availability, helping to inform sustainable water management practices and infrastructure development (Mutua & Mwaniki, 2019).

3. **Ecosystem Conservation:** ASAL ecosystems are delicate and easily disturbed by climatic changes (Wit & Stankiewicz, 2020). Understanding climate risks is vital for developing conservation strategies that protect biodiversity and maintain ecosystem services (Mwangi & Mutua, 2015).

4. **Conflict Mitigation:** Resource scarcity exacerbated by climate change can lead to conflicts between communities (Okpara et al., 2016). Climate risk analysis can help anticipate potential conflict hotspots and inform peace-building initiatives (Schilling et al., 2014).

5. **Economic Planning:** By identifying climate-related risks to key economic activities, climate risk analysis supports more resilient economic planning and development strategies at both county and national levels (Ochieng et al., 2017).

6. **Disaster Preparedness:** Improved understanding of climate risks enhances the capacity for early warning systems and disaster preparedness, potentially saving lives and livelihoods (Mwangi et al., 2014).

7. **Policy Formulation:** Evidence-based climate risk information is crucial for developing targeted policies and interventions that address the specific challenges faced by ASAL regions (Recha et al., 2017).

Given these factors, conducting comprehensive climate risk analyses for Isiolo, Marsabit, and Samburu counties is not just beneficial but essential for the sustainable development and resilience of these vulnerable regions.

Climate Patterns and Extremes in Isiolo, Marsabit, and Samburu Counties

Introduction

This report examines climate patterns and extremes in the arid and semi-arid lands (ASALs) of Isiolo, Marsabit, and Samburu counties in Kenya. These regions face significant challenges due to climate change, with impacts on water resources, agriculture, ecosystems, and human livelihoods. By analyzing historical trends and future projections, we aim to provide a comprehensive understanding of the climate risks facing these counties and inform adaptation strategies.

Historical Climate Trends in Kenya's ASALs

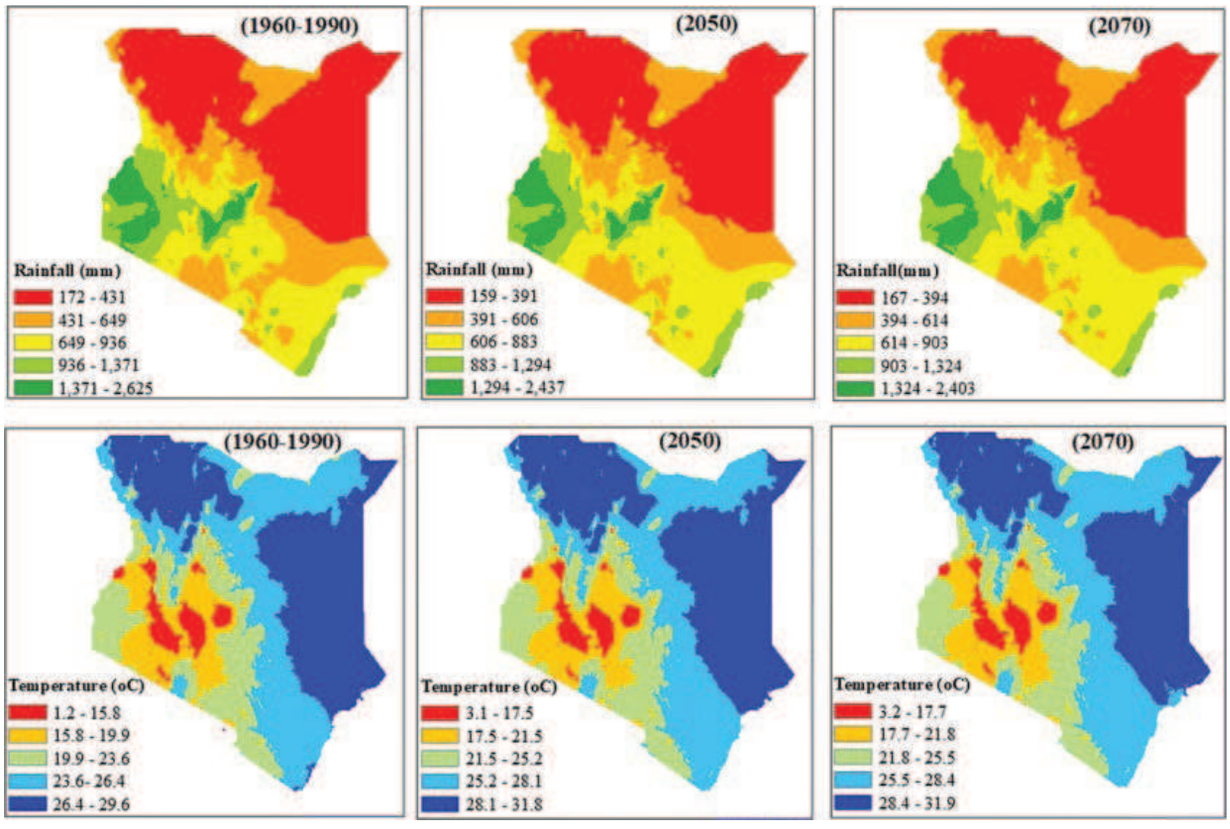
The Arid and Semi-Arid Lands (ASALs) of Kenya have witnessed significant climatic changes over the past several decades, with data indicating a consistent rise in average temperatures and increasingly erratic rainfall patterns. Research shows that since the 1970s, the ASAL regions have experienced a temperature increase of approximately 1.0 to 1.5 degrees Celsius, which has intensified the occurrence and severity of extreme weather events such as droughts (Ndiritu et al., 2021; Ngigi & Muange, 2022). These temperature increases are not uniformly distributed across the region, with some areas experiencing more pronounced warming trends.

Pastoralist communities, which form the backbone of the local economy, are experiencing increased livestock mortality and reduced incomes, while food insecurity and malnutrition rates are rising due to crop failures and livestock losses.

Rainfall patterns in the ASALs have become increasingly unpredictable, characterized by both temporal and spatial variability. The region traditionally experiences bimodal rainfall, but in recent years, there has been a noticeable shift in the onset and duration of rainy seasons. Some areas, particularly Marsabit and Isiolo counties, have suffered from prolonged periods of below- average rainfall, leading to more frequent and severe droughts (Marshak & Venkat, 2021). These changes have had a cascading effect on the availability of water resources and the health of rangeland ecosystems, directly impacting the livelihoods of pastoral communities who depend on these natural resources.

In addition to temperature and rainfall changes, the ASALs have seen shifts in vegetation cover and land degradation. The increased frequency of droughts has led to significant reductions in vegetation cover, which has in turn contributed to the degradation of rangelands. This degradation not only reduces the resilience of the ecosystems but also exacerbates the vulnerability of communities reliant on pastoralism (Mwangi, 2020; Nawiri, 2024).

Figure 1: Map showing trend and magnitude of changes in rainfall and temperature over time for different regions in Kenya. Extracted from (http://www.worldclim.org/)



The map above reveals a clear trend of increasing aridity over time, both in terms of rainfall and temperature in the northern part of the country.

Rainfall:

- In the 1960-1990 period, the northern part of Kenya experiences the lowest rainfall in the country, ranging from 172 to 431 mm annually.
- By 2050, rainfall in the northern part decreases slightly, with the range dropping to 159- 391 mm.
- By 2070, this trend continues with rainfall further declining, ranging from 167 to 394 mm, indicating a persistent reduction in precipitation.

Temperature:

- During the 1960-1990 period, temperatures in northern Kenya range from 15.8 to 26.4°C.
- By 2050, temperatures rise significantly, with projections showing a range of 17.5 to 28.1°C.
- By 2070, temperatures in northern parts of the country are expected to increase even further, reaching up to 31.8°C in some areas.

In summary, the northern part of Kenya is projected to face reduced rainfall and increased temperatures over time, suggesting a shift towards hotter and drier conditions that could have severe implications for the region's environment and livelihoods.

Climate Change Projections for Kenya's ASALs

Looking ahead, climate models project that the ASALs will continue to experience significant changes, with further increases in temperatures and alterations in rainfall patterns. By 2050, temperatures in the region are expected to rise by 1.5 to 3 degrees Celsius, depending on global greenhouse gas emissions scenarios (IPCC, 2021; Ndiritu et al., 2021). This temperature rise is anticipated to increase the frequency of heatwaves, further stressing water resources and agricultural productivity in the region.

Rainfall projections for the ASALs are more complex and uncertain. While some climate models suggest a slight increase in annual precipitation, others indicate a potential decrease. However, there is a consensus that rainfall variability will increase, with more intense and sporadic rainfall events becoming the norm. These changes are likely to result in more frequent and severe droughts, punctuated by short periods of heavy rainfall that can lead to flash floods, particularly in degraded landscapes (Marshak & Venkat, 2021; Nawiri, 2024).

The projected climate changes pose significant risks to the ASALs' socio-economic fabric. The increase in extreme weather events, such as droughts and floods, will likely exacerbate existing vulnerabilities, leading to increased food insecurity, migration, and potential conflicts over scarce resources (Ngigi & Muange, 2022). To mitigate these impacts, it is crucial to implement adaptive strategies that enhance the resilience of local communities. Such strategies include the promotion of climate-resilient agricultural practices, the development of sustainable water management systems, and the restoration of degraded lands (Mwangi, 2020; Ndiritu et al., 2021).

Moreover, integrating climate information into local and national decision-making processes will be essential in building adaptive capacity and reducing vulnerability in the ASALs.

Investment in early warning systems, climate education, and community-based adaptation initiatives will be key to ensuring that the region's communities can adapt to and thrive in the face of ongoing and future climate challenges (Ndiritu et al., 2021; IPCC, 2021).

The Effects of Climate Change and Variability on Pastoral Communities

Climate change and variability significantly impact livestock mortality. Lenaiyasa (2020) found that unfavorable climate changes caused livestock loss among the Samburu community, resulting in food insecurity. Miller et al. (2020) reported that increased drought frequency in East Africa led to livestock mortality rates exceeding 50% between 2008 and 2011, with young animals most affected. Mutanda and Kimaru (2022) observed higher mortality rates during low rainfall and high temperature periods, particularly among cattle and camels.

Changing weather patterns and environmental conditions also contribute to the spread of livestock diseases. Yala et al. (2020) noted that both excessive drought and rainfall in ASALs enhance disease spread, leading to high mortality rates and inter-community conflicts over resources. Chepkwony et al. (2020) found that higher temperatures and lower rainfall increased East Coast Fever (ECF) incidence in cattle due to changes in tick-borne parasite reproduction and survival. Muturi et al. (2021) reported increased incidences of Brucellosis, Q-fever, and Rift Valley fever associated with changing rainfall patterns and water availability, particularly in North-Eastern and Eastern Kenya. Severe drought forces pastoralists to relocate their animals, increasing vulnerability to health hazards during migration (Filho et al., 2020).

Climate change and variability have also impacted gender roles in pastoral communities. Changes in resource availability and quality affect the division of labor, decision-making power, and access to services and resources for both women and men (Omolo & Mafongoya, 2019).

During extended male migration periods, women assume responsibility for home care and livestock management. Women's limited access to education and climate-related risk management information increases their vulnerability to climate variability and change. Walker et al. (2022) found that climate change was associated with shifts in women's roles and responsibilities in Kenya's ASAL pastoral communities. Rao (2019) observed gendered impacts on access to and use of climate information among these communities.

A more detailed explanation of the impacts of climate change is provided in the following chapter, titled "Historical and Potential Climate Change Impacts."

Community Perceptions: Climate Change and Impacts

To gain a comprehensive understanding of climate-related challenges and potential solutions in the target counties, a series of community consultations were conducted through Focus Group Discussions (FGDs) and IDIs. These participatory approaches were designed to capture diverse perspectives, local knowledge, and community-specific insights that are crucial for developing effective and sustainable climate action strategies.

The primary objective of these consultations was to undertake a cross-sectoral, community- focused assessment of climate risks facing the counties and to identify climate actions that could address these risks and build community resilience. By engaging directly with community members, local leaders, and key stakeholders, we sought to ensure that the proposed climate actions would be grounded in local realities and responsive to the specific needs of each community.

The consultations revealed that communities across the three counties are acutely aware of climate trends in their respective wards, including the variability of these trends and the impacts of extreme weather events on their livelihoods. Participants consistently reported increasingly erratic and reduced rainfall, rising temperatures, and more frequent and prolonged periods of drought as the main climate changes they have observed.

These climate shifts have had far-reaching consequences, with participants highlighting increased inter-tribal conflicts over scarce natural resources such as water and pasture. These conflicts pose significant security risks, with young people often bearing the brunt of injuries and fatalities. Notably, pastoralists frequently cited population pressure and deforestation as major contributors to climate change, demonstrating a local understanding of the interplay between human activities and environmental degradation.

The consultations also shed light on existing climate information systems and their utility. We learnt that pastoral communities managed to create their own methods for observing and describing climate changes. This entails using indigenous methods, such as noticing changes in star patterns, disappearance of termites and birds like hornbills and ravens, and changes in animal behavior that they have used to indicate the prospects of upcoming rains. The NDMA's monthly Drought Early Warning (DEW) bulletin was identified as a crucial tool for providing timely information on impending droughts, helping agro-pastoralists make informed decisions about crop selection during short rainy seasons. Similarly, the KMD's routine climate information and extreme weather alerts were recognized as valuable resources for community preparedness.

Pastoralists provided detailed accounts of climate change impacts on rangelands, including soil erosion and the proliferation of invasive plant species. They reported how these changes have negatively affected livestock production, leading to forage and water shortages, livestock starvation, and human malnutrition during severe drought periods. Outbreaks of livestock diseases, reduced milk production, and poor market prices for livestock were also cited as significant challenges resulting from climate change.

These climate shifts have had far-reaching consequences, with participants highlighting increased inter-tribal conflicts over scarce natural resources such as water and pasture, posing significant security risks, with young people often bearing the brunt of injuries and fatalities.

County-Specific Climate Profiles

Isiolo

Isiolo County is characterized by a semi-arid to arid climate, with distinct variations between its northern and southern regions. Key climate features and projections include:

1. **Temperature:** Historical data show a warming trend of about 0.9°C since the 1960s. Projections indicate further warming of 1.5°C to 2.3°C by the 2050s (Ogutu et al., 2016; Adhikari et al., 2015).

2. **Rainfall:** Annual rainfall averages 300-550mm, with high variability. Slight decreases in total rainfall have been observed, but projections suggest a potential increase of 5-15% by mid-century (Ongoma & Chen, 2017).

3. **Extreme events:** Droughts have become more frequent, with major events every 5-7 years. Flash floods are increasingly common during short rains (Huho & Kosonei, 2014; Opere et al., 2020).

4. **Key risks:** Increased water scarcity, declining pasture quality, and more frequent livestock diseases are primary concerns (Opiyo et al., 2015).

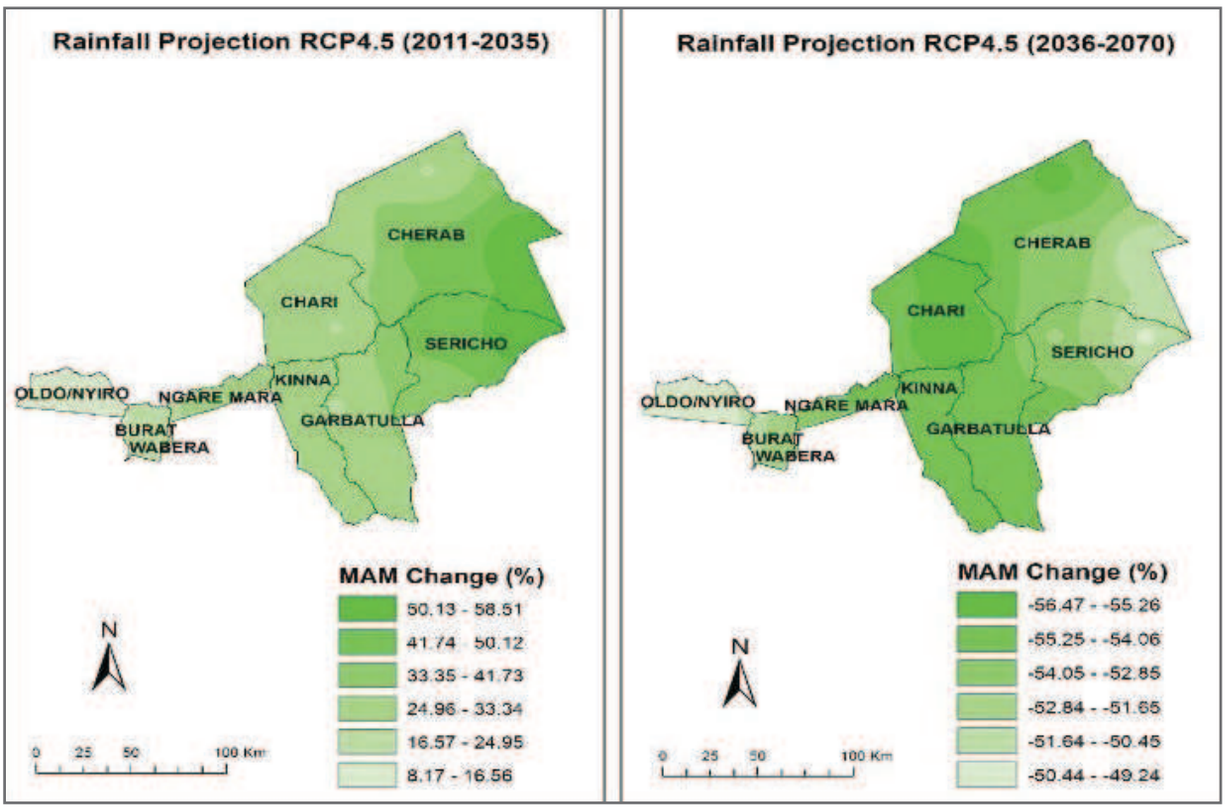
5. **Vulnerable sectors:** Pastoralism, rain-fed agriculture, and water resources are particularly vulnerable to climate changes (Recha et al., 2016).

The World Bank (WB) analysis of temperature trends in Isiolo County over 25 years (1980 to 2005), showed an increase of about 0.5°C in the mean temperatures of both seasons. On the other hand, climate projections based on two representative concentration pathways (RCPs4.5) indicate that rainfall amounts in both seasons are expected to continue increasing only moderately (≤25mm) with the rise being greater under the high emissions scenario.

However, the period 2036-2070, climate projections based on concentration pathways (RCPs4.5) indicate that rainfall amounts in both seasons are expected to continue decreasing as the emissions scenario continues to rise. The heat and drought stress will continue to be the main hazards for Isiolo. The number of heat stress days, compared to the historical average, are expected to increase as the maximum number of consecutive dry days are expected to increase for both seasons (see Figure 2).

Camels at Ngaremara. ~ Dickson Mukunga (Mercy Corps)

Figure 2: Isiolo County Rainfall Projections for the period 2011-2035 and 2036-2070. Source:: KMD Isiolo County



Looking ahead to the period 2021-2065, climate projections based on two representative concentration pathways (RCP2.6 and RCP8.5) indicate that temperatures in both seasons are expected to continue to increase, increasing under the high emissions scenario. While heat and drought stress has been indicated as the main hazards for Isiolo, under both scenarios, the number of heat stress days, compared to the historical average, are expected to reduce, while the maximum number of consecutive dry days are expected to remain reasonably constant for both seasons. Under the high emissions scenario, rainfall is expected to reduce and moisture stress is expected to increase, particularly in the second season.

The projected changes in Isiolo County's climate pose significant challenges to its predominantly pastoral economy. Adaptation strategies will need to focus on enhancing water management, diversifying livelihoods, and improving rangeland management practices (Kiptoo et al., 2019).

Marsabit

Marsabit County has a diverse climate due to its varied topography, ranging from arid lowlands to humid highlands. Specific climate characteristics and projections include:

1.  **Temperature:** Warming of about 1.1°C has been observed since the 1960s. Projections suggest further increases of 1.7°C to 2.6°C by the 2050s (Ogutu et al., 2016; Adhikari et al., 2015).

2.  **Rainfall:** Annual rainfall varies from 200mm in lowlands to over 1000mm in highlands. Models project a potential increase of 10-20% in annual rainfall by mid-century (Ongoma & Chen, 2017).

3.  **Extreme events:** Droughts have intensified, with the 2016-2017 drought being particularly severe. Frost events in highland areas have increased (NDMA, 2020; Karanja et al., 2017).

4.  **Key risks:** Increased water stress in lowlands, shifts in suitable areas for crop production, and potential increase in human-wildlife conflicts (Opiyo et al., 2015).

5.  **Vulnerable sectors**: Pastoralism, smallholder agriculture in highland areas, and biodiversity conservation are at high risk (Wit & Stankiewicz, 2020).

The diverse topography of Marsabit County presents unique challenges and opportunities in the face of climate change. Adaptation strategies will need to be tailored to the specific needs of different ecological zones within the county, with a focus on sustainable water management and conservation of unique highland ecosystems (Mwangi & Mutua, 2015).

In the coming decade, the forecasted rainfall for Marsabit County shows the County will experience a monthly average rainfall of 27.55mm and a decade sum of 3306.14mm compared to the previous decade that had a decade sum of 3548.23mm and 29.57mm monthly mean rainfall. Taken together, this represents a 6.82% reduction in the amount of rainfall in Marsabit County for the coming decade (Table 1).

Table 1: Next Decade and Last Decade Comparison

Month	Last Decade	Next Decade	Difference (Next - Last)
Jan	11.34	9.68	-1.66
Feb	11.08	11.18	+0.10
Mar	39.49	43.74	+4.25
Apr	98.56	115.28	+16.72
May	28.78	28.72	-0.06
Jun	4.16	3.88	-0.28
Jul	7.65	7.68	+0.03
Aug	4.65	4.54	-0.11
Sep	2.58	3.11	+0.53
Oct	40.09	44.05	+3.96
Nov	51.50	52.56	+1.06
Dec	30.74	30.41	-0.33

(Source: KMD and NDMA)

Key Observations:

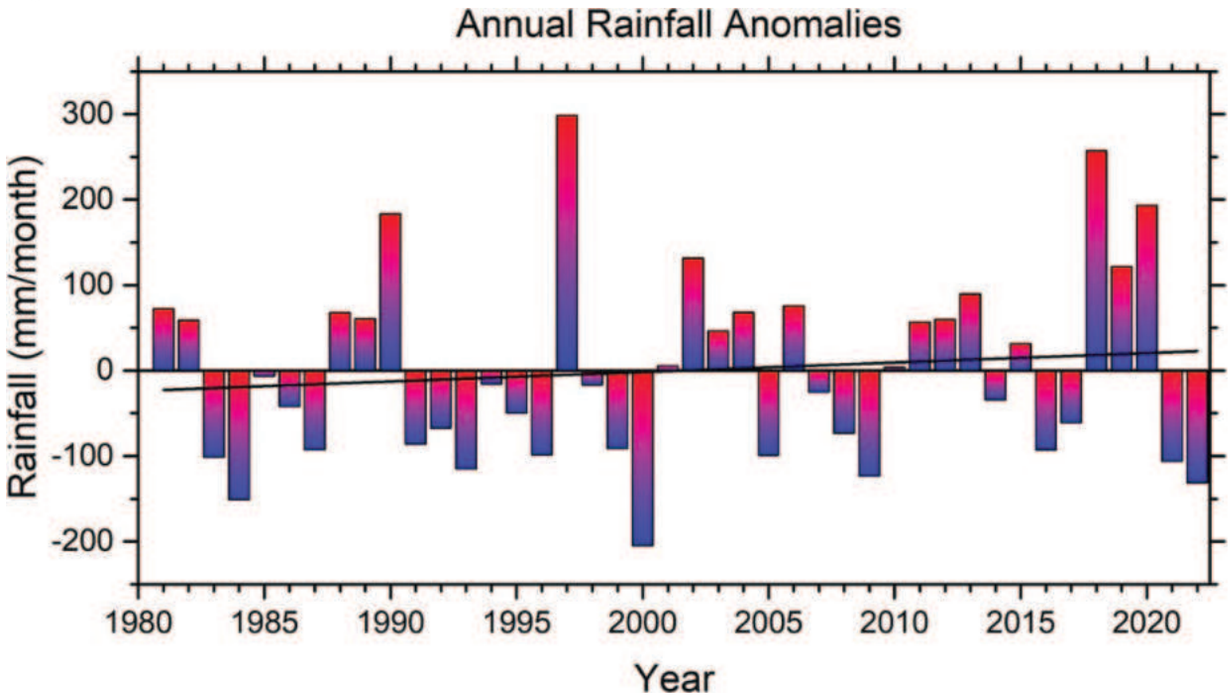
- Significant increases are seen in April and October for the Next Decade.
- The most notable decrease is in January.
- Overall, most months show minor changes between the decades.

Samburu

Samburu County is predominantly semi-arid, with pockets of more humid conditions in highland areas. The County experiences Tropical climatic conditions. The driest months are January and February. The long rainy season falls in the months of March, April and May. Elevation and orientation of the major topographic features such as the Mathews Ranges and Ndoto Mountains influence rainfall distribution. In Samburu Central short rains occur during the months of July and August, sometimes extending into September. In Samburu North and East, the short rainy season is usually delayed and occurs in October and November and sometimes extends into December. The county has an annual mean temperature of 29°C with the maximum range being 33°C and minimum of 24° C. The central plains and the region east of the Matthews Ranges have the highest temperatures while the highland belts in the North Eastern side of Lorroki Plateau are the coolest.

The droughts highlighted in the sections of this report are observed in the annual anomalies of rainfall as illustrated in Figure 2. For instance, the 1984 drought was caused by up to a 160mm deficiency in the annual rainfall total received over Samburu County. Other notable extreme events that can be identified from the analysis of the historical rainfall trends are the 1990-1992 drought as identified by Suguta Ward, the year 2000 drought, 2010 and the recent drought of 2020-2023 that spread all over the county which led to migration of pastoralist from Samburu into Marsabit, Isiolo, Baringo and Laikipia Counties. In addition, the 1990, 1998 floods that ravaged some Wards are visible with a record 280mm positive rainfall anomaly being observed in the 1998 El Nino event. The analysis further depicts a scenario of a rising trend of annual rainfall from 1981 to 2022.

Figure 3: Annual variation of rainfall in Samburu County 1981-2022

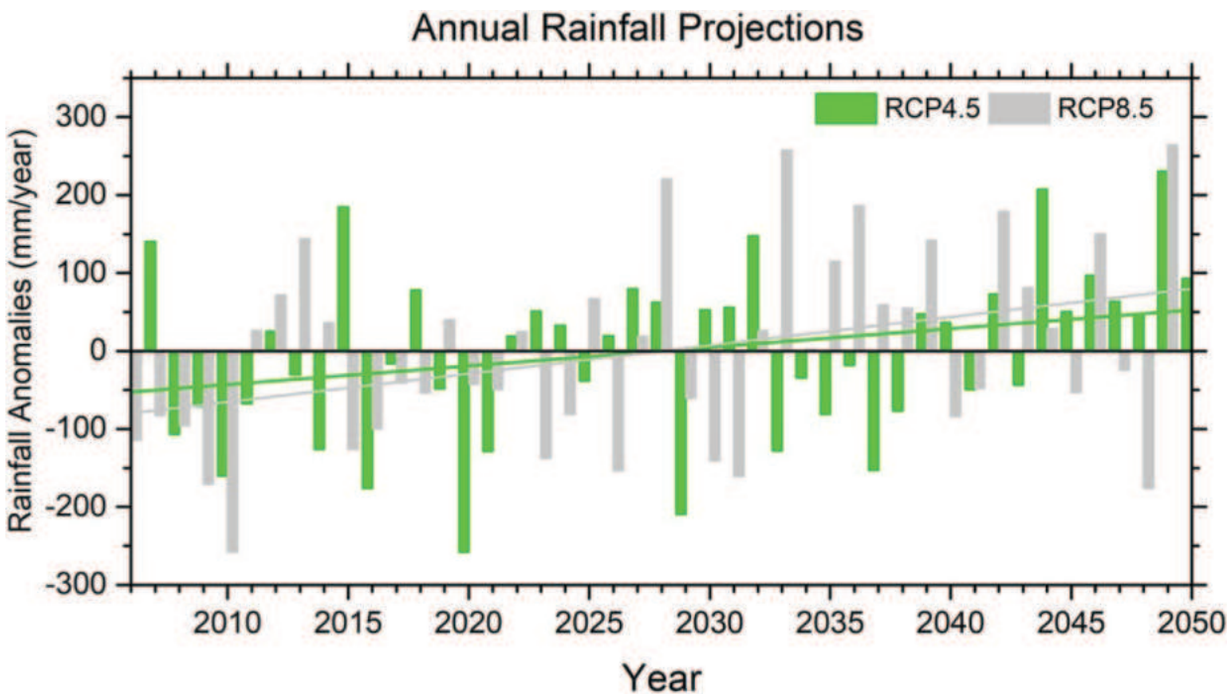


Key climate features and projections include:

1. **Temperature:** A warming trend of about 1°C has been observed since the 1960s. Further warming of 1.6°C to 2.4°C is projected by the 2050s (Ogutu et al., 2016; Adhikari et al., 2015).
2. **Rainfall:** Annual rainfall averages 250-700mm, with high spatial variability. Projections suggest a potential increase of 5-10% in annual rainfall, but with increased variability (Ongoma & Chen, 2017).
3. **Extreme events:** Droughts have become more frequent and intense. Flash floods, particularly in the Ewaso Ng'iro basin, have increased (Huho & Kosonei, 2014; Opere et al., 2020).
4. **Key risks:** Increased competition for water and pasture, soil erosion in overgrazed areas, and potential shifts in wildlife migration patterns (Opiyo et al., 2015).
5. **Vulnerable sectors:** Pastoralism, wildlife tourism, and small-scale agriculture in highland areas are particularly vulnerable (Wit & Stankiewicz, 2020).

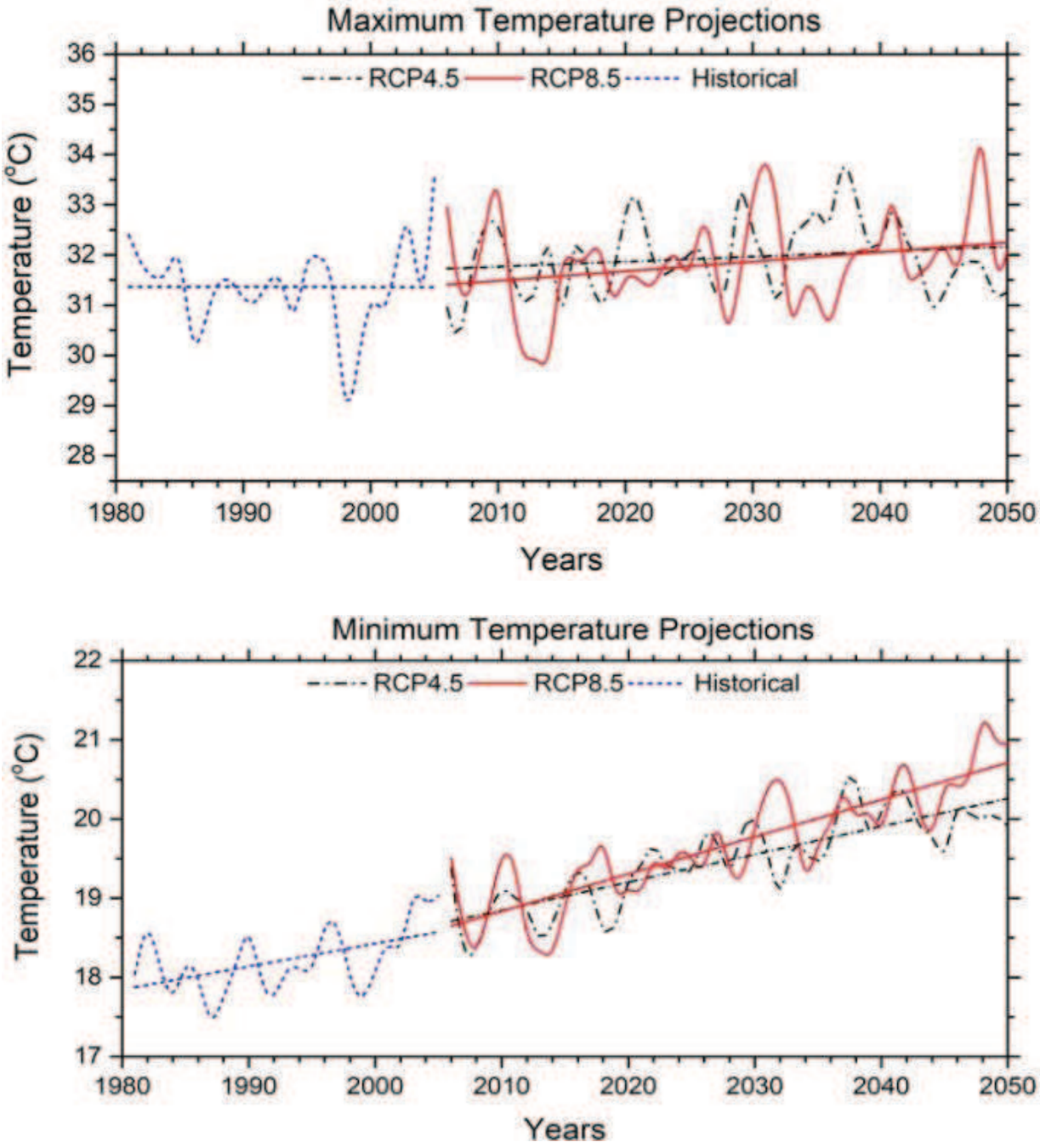
The projected change of annual rainfall is presented in Figure 4 with both the RCP4.5 and 8.5 depicting a positive change in annual rainfall in both near future and mid-century scales. This paints a picture of a likely wet future in both scenarios which is likely to result in increased flood frequency.

Figure 4: Temporal variation of the annual rainfall projection over Samburu County



Climate change projections ((Figure 5) point to rising temperatures and therefore potential increased frequency and intensity of droughts in the county. This is expected to have a significant influence on the ecology and distribution of tropical ecosystems, with wetlands and riverine systems increasingly at risk of being converted to other ecosystems, with plant populations being succeeded and animals losing habitats.

Figure 5: Maximum and minimum projected temperature trends for Samburu county



Conclusion

This analysis of climate risks in Isiolo, Marsabit, and Samburu counties provides a solid foundation for understanding the challenges and opportunities presented by climate change in these arid and semi-arid regions of Kenya. The research synthesizes a wide range of studies, offering insights into historical trends, future projections, and potential impacts across various sectors.

The analysis highlights the complex and interconnected nature of climate risks in these counties. While there are common trends, such as overall warming and increased rainfall variability, the specific impacts and vulnerabilities vary across the region due to differences in topography, land use patterns, and socio-economic conditions. This underscores the need for localized, context-specific adaptation strategies.

One key finding is the increasing frequency and intensity of extreme weather events, particularly droughts and floods. These events have significant impacts on water resources,

agriculture, and pastoral livelihoods, which form the backbone of the local economies. The projections of continued warming and increased rainfall variability suggest that these challenges are likely to intensify in the coming decades.

The analysis also reveals the potential for cascading impacts across different sectors. For example, changes in water availability due to altered rainfall patterns and increased evaporation rates not only affect agriculture and livestock production but also have implications for ecosystem health, human settlements, and potential conflicts over resources.

Key findings include:

1. A significant warming trend, with projections indicating continued temperature increases.
2. Increased variability in precipitation patterns, though changes in total annual rainfall are less certain.
3. Increased frequency and intensity of extreme weather events, particularly droughts and flash floods.
4. Potential shifts in ecosystems and species distribution due to changing climate patterns.
5. Exacerbated water stress despite potential increases in overall rainfall.
6. Significant risks to predominant livelihood systems, particularly pastoralism and rain- fed agriculture.
7. Differential vulnerability across and within counties due to factors such as elevation, land use patterns, and socio-economic conditions.

This analysis underscores the urgent need for robust, context-specific adaptation strategies in Isiolo, Marsabit, and Samburu counties. Key areas for action include enhancing climate-resilient water management, promoting climate-smart agriculture and livestock practices, strengthening early warning systems, and building capacity for climate change adaptation at both institutional and community levels.

By addressing these areas, stakeholders can work towards building more resilient communities and ecosystems in the face of ongoing climate change. However, adaptation efforts must remain flexible and responsive to new information, given the inherent uncertainties in climate projections, especially at local scales.

Changes in water availability due to altered rainfall patterns and increased evaporation rates not only affect agriculture and livestock production but also have implications for ecosystem health, human settlements, and potential conflicts over resources.

Historical and Potential Climate Change Impacts

Introduction

The arid and semi-arid lands (ASALs) of northern Kenya, encompassing Isiolo, Marsabit, and Samburu counties, are increasingly vulnerable to climate change impacts. Covering approximately 165,806 km2, these regions are characterized by low and erratic rainfall, high temperatures, and periodic droughts (Government of Kenya, 2018). Home to diverse ethnic communities, primarily pastoralists, the livelihoods and cultural practices in these areas are intimately tied to the natural environment. As climate change accelerates, understanding its multifaceted impacts on these vulnerable regions becomes crucial for developing effective adaptation strategies and policies.

Historical Climate Trends and Impacts

Over the past several decades, the ASALs of northern Kenya have experienced significant changes in climate patterns. Mean annual temperatures have increased by approximately 1°C since the 1960s, with an average rate of 0.21°C per decade (Opiyo et al., 2015). This warming trend has been more pronounced in the drier lowlands of Isiolo and Marsabit compared to the higher elevation areas of Samburu.

Precipitation patterns have become increasingly erratic and unpredictable. While total annual rainfall has not shown a statistically significant trend, there has been a shift in seasonality and intensity of rainfall events (Huho & Kosonei, 2014). The long rains (March-May) have become less reliable, while short rains (October-December) have shown increased variability. The frequency and intensity of extreme weather events, particularly droughts and floods, have increased, with major droughts occurring approximately every 5-7 years (Opiyo et al., 2015; NDMA, 2020).

These climate changes have significantly altered vegetation patterns across the three counties. In Isiolo, there has been a notable shift from perennial grasses to annual grasses and an increase in woody vegetation, particularly Acacia species (Mganga et al., 2018). Marsabit has experienced a decline in forest cover, especially in the Mt. Marsabit forest ecosystem (Maina & Ouma, 2020), while Samburu has seen a reduction in palatable grass species and an increase in unpalatable woody plants, affecting rangeland quality (Lelenguyah et al., 2023).

Wildlife populations and distributions have also been impacted. In Samburu, elephant populations have shown changes in migration patterns, leading to increased human-wildlife conflict as animals seek water sources near human settlements during dry periods (Waithaka et al., 2020). Marsabit National Park has experienced declines in certain ungulate populations, particularly those sensitive to water availability (Ogutu et al., 2016).

Water resources have been severely affected, with reduced flow rates and increased sedimentation in critical water sources like the Isiolo River (Mutiga et al., 2015). In Marsabit, historically permanent water sources like Lake Paradise have become seasonal (Cuni-Sanchez et al., 2018), while groundwater recharge rates have decreased across the region (Oord, 2017).

The frequency and intensity of extreme weather events, particularly droughts and floods, have increased, with major droughts occurring approximately every 5-7 years (Opiyo et al., 2015; NDMA, 2020).

Impacts on Livelihoods and Infrastructure

Pastoralism, the dominant livelihood in the region, has been significantly affected by climate change. Increased frequency of droughts has led to high livestock mortality rates, with the 2021- 2023 drought causing severe losses across the ASAL counties. In Isiolo County alone, over 70,000 animals, including cattle, sheep, and goats, perished within a six-month period due to the extreme drought conditions. Similarly, in Marsabit and Samburu counties, the prolonged drought led to a catastrophic loss of livestock, contributing to widespread food insecurity and economic hardship for pastoral communities (NDMA, 2023)[3]. Changes in vegetation have reduced the quality and quantity of available forage, necessitating longer migration distances for pastoralists (Ouko et al., 2018).

Agriculture, while less prevalent than pastoralism, has also been impacted. In Isiolo, rain-fed agriculture has become increasingly unreliable, with frequent crop failures due to erratic rainfall (Recha et al., 2016). Marsabit has seen a shift in cropping patterns, with farmers adopting more drought-resistant crops like sorghum and millet (Ng'ang'a et al., 2016).

Climate variability has strained existing water infrastructure, with increased siltation reducing the capacity of water pans and small dams in Isiolo (Mutiga et al., 2015). Marsabit has experienced damage to boreholes and water distribution systems due to flash floods (NDMA, 2019). Road networks, critical for market access and service delivery, have been frequently rendered impassable during intense rainfall events, isolating communities (Wagah et al., 2018).

Select County-Specific Historical Impacts

While many impacts are shared across the three counties, some specific effects are worth noting:

Isiolo:

1. Increased conflict between pastoralists and farmers due to changing land use patterns driven by climate variability (Mkutu, 2020).
2. Shifts in disease vectors, with malaria becoming more prevalent in previously low-risk areas (Murage et al., 2015).

Marsabit:

3. Severe impacts on the unique montane forest ecosystem of Mt. Marsabit, with implications for local water security and biodiversity (Cuni-Sanchez et al., 2018).
4. Increased human-elephant conflict as wildlife migration patterns change in response to water scarcity (Mukeka et al., 2019).

Samburu:

- Significant changes in the phenology of important plants used in traditional medicine, affecting local healthcare practices (Naidoo et al., 2016).
- Increased pressure on the Mathews Range forest ecosystem due to changing pastoral migration patterns (Kariuki et al., 2018).

3 National Drought Management Authority (NDMA). (2023). Update on Drought Situation in ASAL Counties. NDMA Kenya. Retrieved from https://ndma.go.ke

Table 2: Summary Table of Historical Climate Trends and Impacts

Sub-Sector	Summary of Impacts	Climate Change Impacts	Cited Source
CLIMATE TRENDS			
Temperature	Increased mean annual temperatures	1°C increase since 1960s, with a rate of 0.21°C per decade	Opiyo et al. (2015)
Rainfall	Increased variability and unpredictability in rainfall patterns	No significant trend in total annual rainfall, less reliable long rains, more variable short rains	Huho & Kosonei (2014)
Extreme Events	Increased frequency and intensity of droughts and floods	Major droughts approximately every 5-7 years, severe events in 2009, 2011, 2016-2017	Opiyo et al. (2015), NDMA (2020)
LOCAL ECOSYSTEMS			
Vegetation Changes	Shift from perennial to annual grasses, increase in woody vegetation, decline in forest cover, reduction in palatable grasses	Shift to annual grasses and increase in Acacia in Isiolo, decline in forest cover in Marsabit, reduction in palatable grasses in Samburu	Mganga et al. (2018), Maina & Ouma (2020), Lelenguyah et al. (2016)
Wildlife Populations	Changes in migration patterns, increased human-wildlife conflict, declines in water- sensitive ungulate populations, wildlife fatalities during droughts	Changes in elephant migration patterns in Samburu, declines in ungulate populations in Marsabit, wildlife fatalities affecting water- dependent species	Waithaka et al. (2020), Ogutu et al. (2016), King et al. (2018)
Water Resources	Reduced flow rates and increased sedimentation in rivers, seasonal water sources, decreased groundwater recharge rates	Reduced flow rates and increased sedimentation in Isiolo River, Lake Paradise becoming seasonal, decreased groundwater recharge rates in Merti aquifers	Mutiga et al. (2015), Cuni-Sanchez et al. (2018), Oord (2017)
LIVELIHOODS			
Pastoralism	High livestock mortality rates, reduced forage quality and quantity, intensified resource conflicts	Up to 70% cattle and 40% sheep and goat losses in Marsabit during 2008- 2009 drought, longer migration distances for pastoralists, intensified conflicts over resources	Opiyo et al. (2015), Ouko et al. (2018), Mkutu (2020)
Agriculture	Increased crop failures, shift to drought-resistant crops, decreased yields and increased pests and diseases	Frequent crop failures in Isiolo, shift to sorghum and millet in Marsabit, decreased yields and increased pest and disease incidence in Samburu	Recha et al. (2016), Ng'ang'a et al. (2016), Omoyo et al. (2015)
Other Economic Activities	Negative impacts on honey production and fishing activities	Changes in flowering patterns and bee behavior affecting honey production in Samburu, fluctuating water levels and changes in fish populations affecting fishing in Lake Turkana	Carroll et al. (2017), Gownaris et al. (2018)

INFRASTRUCTURE			
Water Infrastructure	Strained water infrastructure due to climate variability	Increased siltation reducing capacity of water pans and dams in Isiolo, damage to boreholes and water distribution systems in Marsabit, less reliable traditional water harvesting structures	Mutiga et al. (2015), NDMA (2019), Oord (2017)
Transportation Networks	Impacts on road networks, increased maintenance needs for highways	Unpaved roads rendered impassable during intense rainfall in Samburu and Marsabit, increased maintenance needs for Isiolo-Moyale highway due to heat stress on road surfaces	Wagah et al. (2018), Anyah et al. (2019)
Energy System	Effects on small-scale solar installations and wind power projects	Dust accumulation reducing efficiency of solar installations during dry spells, challenges in wind power projects due to changes in wind patterns	Ochieng et al. (2016), Kazimierczuk (2019)

Potential Future Climate Change Impacts

Looking ahead, climate projections suggest significant challenges for the region. In the agricultural sector, maize yields are projected to decrease by 25-50% in Isiolo and Marsabit by 2050 under high emission scenarios (Adhikari et al., 2015). Pasture availability is expected to decrease by 30-50% across the three counties by 2050 (Ouko et al., 2018), while heat stress could reduce livestock productivity, with potential decreases in milk production of 10-20% for cattle by 2030 (Thornton et al., 2019).

Water resources face continued pressure, with river flow in the Ewaso Ng'iro North Basin projected to become more variable, potentially decreasing dry season flow by up to 40% by 2050 (Mutiga et al., 2015). Groundwater resources are also at risk, with recharge rates for the Merti aquifer in Isiolo projected to decrease by 5-15% by 2050 (Oord, 2017).

Climate change is expected to alter the distribution and prevalence of vector-borne diseases, with malaria transmission projected to increase in highland areas of Samburu and Marsabit (Ndaso et al., 2021). Heat-related mortality is projected to increase by 20-30% across the three counties by 2050 (Egondi et al., 2020).

Biodiversity and ecosystems face significant threats, with the unique montane forest ecosystem of Mount Marsabit projected to contract by 20-30% by 2050 (Cuni-Sanchez et al., 2018). Large mammal species may alter their migration routes in response to changing water availability, potentially increasing human-wildlife conflict (Waithaka et al., 2020).

County-Specific Impact Assessments

While many impacts are shared across the three counties, some specific projections are worth noting:

Isiolo:

- The county's strategic location as a transport hub may be challenged by increased flooding risks to road infrastructure, potentially affecting regional economic integration (Anyah et al., 2019).
- Expansion of irrigation along the Ewaso Ng'iro River may become increasingly contentious as climate change affects water availability, potentially leading to increased upstream-downstream conflicts (Mutiga et al., 2015).

Marsabit:

- The unique ecology of Lake Turkana faces multiple climate-related threats, including changes in water level, temperature, and chemistry, with potential far-reaching impacts on fisheries and lacustrine ecosystems (Gownaris et al., 2018).
- The county's significant wind energy potential may be affected by climate-induced changes in wind patterns, necessitating adaptive planning for renewable energy development (Kazimierczuk, 2019).

Samburu:

- The county's emerging tourism sector, centered on wildlife viewing and cultural experiences, may need to adapt to shifting wildlife distributions and changing pastoral lifestyles (Bedelian & Ogutu, 2017).
- Traditional ecological knowledge, particularly relating to weather prediction and natural resource management, may become less reliable as climate patterns shift, challenging community resilience (Naidoo et al., 2016).

Table 2: Summary Table of Historical Climate Trends and Impacts

Sub-Sector	Summary of Impacts	Climate Change Impacts	Source(s)
AGRICULTURE AND FOOD SECURITY			
Crop Production	Decreased maize yields, shifts in suitable crop areas, increased crop failures	25-50% decrease in maize yields by 2050, shift in suitable areas for sorghum and millet, more frequent crop failures	Adhikari et al. (2015), Omoyo et al. (2015), Recha et al. (2016)
Livestock Production	Reduced pasture availability, decreased livestock productivity, increased disease prevalence	30-50% decrease in pasture, 10-20% decrease in milk production by 2030, increased risk of vector-borne diseases	Ouko et al. (2018), Thornton et al. (2019), Bett et al. (2017)
Food Security Implications	Increased food insecurity, decreased nutritional diversity, market disruptions	20-30% increase in food-insecure households by 2030, decreased availability of wild foods and traditional crops, increased food prices due to market disruptions	WFP (2020), Muthomi et al. (2020), Wako et al. (2017)
WATER RESOURCES			
Surface Water Availability	Decreased river flow variability, disappearing water bodies, increased pressure on surface water	Up to 40% decrease in dry season flow, disappearing Lake Paradise, 20-30% reduction in reliable surface water availability	Mutiga et al. (2015), Cuni- Sanchez et al. (2018), Huho & Kosonei (2014)

Groundwater Resources	Decreased recharge rates, increased variability in groundwater availability, increased demand and stress on groundwater	5-15% decrease in recharge rates, more frequent groundwater scarcity, increased demand due to population growth and reduced surface water availability	Oord (2017), Gownaris et al. (2018), Opiyo et al. (2015)
Water Quality	Exacerbated water quality issues, increased sedimentation and contamination, changes in water levels affecting salinity and nutrient concentrations	Higher fluoride concentrations, increased sedimentation and contamination, changes in Lake Turkana's water level	Chavula et al. (2020), Mutiga et al. (2015), Gownaris et al. (2018)
HUMAN HEALTH			
Vector-borne Diseases	Increased transmission of malaria, risk of Rift Valley Fever outbreaks, shifts in distribution of Leishmaniasis	Increased malaria transmission, increased risk of Rift Valley Fever, shifts in Leishmaniasis distribution	Ndaso et al. (2021), Bett et al. (2017), Wainaina et al. (2020)
Heat-related Illnesses	Increased heat-related mortality, exacerbation of existing health conditions	20-30% increase in heat-related mortality by 2050, exacerbation of cardiovascular and respiratory diseases	Egondi et al. (2020), Lubanga et al. (2021)
Malnutrition and Food Insecurity	Increased rates of acute malnutrition, more prevalent micronutrient deficiencies	10-15% increase in acute malnutrition by 2030, more prevalent micronutrient deficiencies	WFP (2020), Muthomi et al. (2020)
INFRASTRUCTURE			
Roads and Transportation	More frequent damage to unpaved roads, accelerated degradation of paved roads, increased risk to bridge structures	Increased damage to unpaved roads due to extreme rainfall, 10-20% increase in maintenance costs for paved roads by 2040, increased risk to bridge structures	Wagah et al. (2018), Anyah et al. (2019), Mutiga et al. (2015)
Water Supply and Sanitation	Increased variability in water availability, increased risk of overflow and contamination, less reliable traditional water harvesting structures	Significant investments needed in storage and distribution systems, increased risk of overflow and contamination, less reliable traditional water harvesting structures	Oord (2017), Mutiga et al. (2015), Huho & Kosonei (2014)
Energy Infrastructure	Affected efficiency and maintenance needs of wind power installations, reduced efficiency of small-scale solar installations	Increased dust storms affecting wind power, reduced efficiency of solar installations, increased risks to grid network from extreme weather events	Kazimierczuk (2019), Ochieng et al. (2016), Anyah et al. (2019)

BIODIVERSITY AND ECOSYSTEMS			
Species Distribution and Migration	Altered migration routes for large mammals, shifts in bird species distributions, range contractions for reptiles and amphibians	Changes in water availability affecting migration routes, shifts in bird species distributions, range contractions for reptiles and amphibians	Waithaka et al. (2020), Mwangi et al. (2018), Muthoni et al. (2016)
Habitat Changes	Contraction of unique montane forest ecosystems, shift in vegetation types, degradation of riparian ecosystems	20-30% contraction of Mount Marsabit's montane forest ecosystem by 2050, shift in vegetation types in Mathews Range forest, degradation of riparian ecosystems along Ewaso Ng'iro River	Cuni-Sanchez et al. (2018), Kariuki et al. (2018), Mutiga et al. (2015)
Ecosystem Services	Compromised water regulation services, decreased carbon sequestration potential, disrupted pollination services	Compromised water regulation services in Marsabit and Samburu, decreased carbon sequestration potential, disrupted pollination services affecting wild plants and agricultural crops	Cuni-Sanchez et al. (2018), Maina et al. (2020), Carroll et al. (2017)
CROSS-CUTTING IMPACTS			
Gender and Social Inclusion	Exacerbated gender and social inequalities, increased time poverty for women and girls, challenged traditional gender roles, disproportionate effects on marginalized groups	Increased time poverty for women and girls, challenged traditional gender roles, disproportionate effects on marginalized groups	Rao et al. (2019), Kihiu & Amuakwa- Mensah (2021), Eriksen & Lind (2020)
Economic Implications	Declining pastoralist economy, emergence of new economic opportunities, increased frequency of climate- related disasters	Declining productivity of pastoralist economy, emergence of new economic opportunities like carbon markets and ecotourism, increased strain on county and national budgets due to climate-related disasters	Opiyo et al. (2015), Osano et al. (2018), Njoka et al. (2016)

Conclusion

The historical and potential climate change impacts in Isiolo, Marsabit, and Samburu counties reveal a complex and challenging future for these regions. The interconnected nature of climate impacts across sectors highlights the need for integrated, systems-level approaches to adaptation. As traditional systems are challenged by climate change, there is potential for transformative changes in livelihoods and land use patterns.

The analysis reveals that these counties have already experienced significant climate-related changes, including rising temperatures, more erratic rainfall patterns, and an increase in extreme weather events. These changes have had far-reaching impacts on ecosystems, livelihoods, and infrastructure, with pastoralist communities being particularly affected.

These counties have already experienced significant climate-related changes, including rising temperatures, more erratic rainfall patterns, and an increase in extreme weather events, which have had far-reaching impacts on ecosystems, livelihoods, and infrastructure, with pastoralist communities being particularly affected.

Looking to the future, the review highlights the potential for even more severe impacts across key sectors such as agriculture, water resources, human health, and biodiversity. The projections suggest a challenging future for these regions, with increased food insecurity, water scarcity, and potential for climate-induced displacement and conflict.

Several key themes emerge from this analysis:

1. The interconnected nature of climate impacts across sectors, highlighting the need for integrated, systems-level approaches to adaptation.
2. The potential for climate change to exacerbate existing vulnerabilities and inequalities, particularly related to gender and marginalized communities.
3. The critical importance of water resources in shaping climate resilience across all sectors in these arid and semi-arid regions.
4. The need for adaptive management approaches that can respond to the high uncertainty inherent in climate projections for the region.
5. The potential for transformative changes in livelihoods and land use patterns as traditional systems are challenged by climate change.

While the projected impacts are severe, they also present opportunities for innovative adaptation strategies that build on local knowledge and emerging technologies. Enhancing the climate resilience of these counties will require coordinated efforts across levels of government, sectors, and communities. Potential opportunities for adaptation and resilience-building exist. These include the adoption of climate-smart agricultural practices, diversification of livelihoods, improved water management strategies, and the integration of traditional ecological knowledge with modern scientific approaches.

By understanding and preparing for the range of potential climate impacts, stakeholders can work towards a more resilient and sustainable future for these vital but vulnerable regions of Kenya.

Climate Change Adaptation Measures and Strategies

This section examines the climate change adaptation measures and strategies being implemented in the three counties, focusing on water management, agricultural adaptations, ecosystem-based approaches, and infrastructure resilience. The urgency of addressing climate change in these regions cannot be overstated. According to the Kenya National Adaptation Plan 2015-2030, ASALs are expected to experience temperature increases of 1-3°C by 2050, along with more frequent and intense droughts and floods. These changes threaten livelihoods, food security, and ecosystem health in regions already struggling with development challenges. In the following, we explore various climate adaptation projects and strategies implemented, their effectiveness, and the factors that contribute to their success, as well as the challenges they face.

Existing Community Climate Change Adaptation Strategies

Community consultations through Focus Group Discussions (FGDs) and In-depth Interviews (IDIs) highlighted a variety of adaptation and resilience strategies developed by communities facing climate change impacts. These Climate change adaptation and resilience strategies have been developed to address various climate risks, including droughts, floods, vector-borne diseases, and conflicts. These strategies encompass traditional practices, modern techniques, and innovative approaches aimed at mitigating the adverse effects of climate-related hazards and ensuring the sustainability of livelihoods.

In drought-prone areas, communities have implemented several measures. Migration in search of water and pasture remains a traditional response, allowing people and livestock to access resources in times of scarcity. Destocking and saving for future restocking help manage herd sizes according to available resources. Communities also focus on establishing and conserving fodder, implementing planned grazing systems to prevent overgrazing, and relying on both traditional and formal early warning systems for informed decision-making.

Financial tools like livestock insurance provide a safety net for pastoralists, while livestock supplementation helps maintain animal health during dry periods. A notable example that was frequently mentioned was the Index-Based Livestock Insurance (IBLI) program, the Kenya Livestock Insurance Program (KLIP), launched by the Kenyan government in 2015. Under KLIP, the government covers the cost of insurance premiums under state-sponsored social protection programming. It was reported that the has improved the resilience of pastoralists by providing timely payouts during droughts, helping them maintain their livelihoods. At the household level, families adjust their consumption patterns, often reducing the number, size, and type of meals, though we see this as a coping mechanism rather than an adaptation strategy. Risk distribution is achieved by keeping herds in different areas to mitigate localized drought impacts. Communities are also diversifying their livelihoods through activities such as kitchen gardening, beekeeping, aquaculture, and poultry keeping. The adoption of drought-resilient breeds for both livestock and crops has become increasingly common.

Flood mitigation strategies include relocating to higher ground during flood events and constructing dams for water management. Communities also engage in controlling forest fires and soil erosion, which can exacerbate flooding. Tree planting initiatives serve multiple purposes, including flood prevention and ecosystem restoration.

To combat vector-borne diseases, communities implement vaccination programs, conduct timely and routine disease surveillance, and employ pest control measures. The use of protective gear and adoption of disease-resistant breeds further enhance resilience against these health threats.

Conflict resolution and prevention strategies are crucial in many climate-affected areas. These include conducting peace initiatives, fostering cross-border information sharing, establishing joint settlements for mutual protection, and working towards equitable resource distribution. Communities also focus on livelihood diversification and breed improvement to reduce resource competition. Efforts to promote social-cultural integration aim to build stronger, more resilient communities.

Evaluating the Effectiveness of Community Adaptation Strategies

As climate risks evolve, several strategies show promise for enhancing future resilience.

Our observations during the assessment show that proper grazing plans are expected to promote sustainable land management practices, ensuring year-round pasture availability and facilitating rangeland recovery. These plans will be crucial for maintaining livestock-based livelihoods in the face of increasing climate variability.

Effective and timely early warning systems are becoming increasingly important. These systems, which encompass risk knowledge, monitoring and warning services, dissemination and communication, and community response capability, have the potential to significantly reduce economic losses and protect lives. The current state of early warning systems in Kenya is characterized by a robust framework established by the National Drought Management Authority (NDMA), which includes risk knowledge, monitoring, and communication to provide timely alerts about impending droughts and other hazards. Various stakeholders, such as local governments, NGOs, and community organizations, utilize the Drought Early Warning (DEW) system to disseminate vital information and guide decision-making, thereby informing resource allocation and community preparedness efforts.

However, significant challenges persist, particularly in reaching remote communities where access to timely information is hindered by inadequate communication infrastructure and limited awareness of the systems in place. Moreover, there is a need for more localized adaptation strategies that address the specific vulnerabilities of different communities.

Enhancing the capacity of local actors to interpret and act on early warning information is essential for improving the overall effectiveness of these systems. By providing timely information, early warning systems empower individuals and communities to take proactive measures when disasters are imminent.

The construction of water reservoirs, including sand dams and various water harvesting techniques such as roof and roadside water collection, will be vital for improving water security. These infrastructures will help manage water resources more effectively, ensuring availability during dry periods and mitigating flood risks during heavy rains.

Establishing proper nature-based resource management and conservation plans is another promising strategy. These plans coordinate activities within reserves and community wildlife conservancies, addressing risks such as human-wildlife conflict and managing wildlife migration patterns. Such integrated approaches can enhance ecosystem resilience while supporting sustainable livelihoods. Finally, rather than relying solely on any individual adaption strategy, a more comprehensive approach that focuses on enhancing the adaptive capacity of communities is crucial. This can include measures such as diversifying livelihoods, strengthening early warning systems, and improving access to information and resources.

Various stakeholders, such as local governments, NGOs, and community organizations, utilize the Drought Early Warning (DEW) system to disseminate vital information and guide decision-making, thereby informing resource allocation and community preparedness efforts.

Adaptation Strategies Proposed by Local Communities

Local communities have proposed various adaptation strategies to address specific hazards and risks. For drought impacts, communities suggest exploring alternative water sources, implementing rainwater harvesting techniques, and constructing water storage facilities such as tanks, dams, and water pans. They also advocate for growing drought-resistant or drought- escaping crops to maintain agricultural productivity during dry periods.

To combat soil erosion and flooding, local strategies proposed include improving drainage systems through the construction of culverts, building terraces and gabions, and promoting afforestation. These measures aim to stabilize soils, manage water flow, and restore natural ecosystems.

Communities propose adopting modern farming methods and implementing crop rotation to enhance agricultural resilience in agro-pastoral areas. The use of pesticides on livestock. through routine spraying is suggested to manage pest and disease outbreaks that may become more frequent or severe due to climate change.

In response to food shortages, communities recommend rationing meals, diversifying food sources, and establishing community support systems such as borrowing food from relatives and neighbors. They also recognize the importance of relief food and cash transfer programs during acute crises.

To address income loss, communities propose engaging in manual labor or casual jobs, as well as seeking loans or financial support from local networks. Livelihood diversification is a key strategy, with communities suggesting a range of alternative income-generating activities.

These locally proposed strategies involve various stakeholders, including women, youth, farmers, pastoralists, household heads, and vulnerable groups. The involvement of diverse community members ensures that adaptation efforts are inclusive and address the needs of different segments of the population. This participatory approach enhances the likelihood of successful implementation and long-term sustainability of adaptation efforts.

County Strategies: Water Management Strategies

Water scarcity is a critical issue in the ASALs, and innovative water management strategies have been implemented to enhance resilience. These strategies range from traditional methods to modern technological solutions, often blending both approaches for maximum effectiveness.

Sand Dams and Water Harvesting

In Isiolo County, the County Climate Change Fund (ICCF) has supported the construction of sand dams along seasonal rivers. The Kinna Ward Sand Dam Project, completed in 2015, has significantly improved water access for both humans and livestock, increasing water availability during dry seasons, reducing conflict over resources, and improving food security through small-scale irrigation[4].

Building on this success, the Adaptation Consortium, in partnership with the National Drought Management Authority (NDMA), has scaled up sand dam construction across Isiolo County. As of 2022, over 30 sand dams have been constructed, benefiting more than 50,000 people. These structures have proven particularly effective in areas with seasonal rivers, providing water for up to six months after the rainy season ends.

A recent study by the University of Nairobi (2023) found that communities with access to sand dams reported a 40% reduction in time spent fetching water and a 30% increase in school attendance rates, particularly for girls who were previously tasked with water collection[5].

4 Isiolo County Government, 2018

5 https://shorturl.at/S7M6F

Climate-Proofing Water Infrastructure

Isiolo County has taken steps to climate-proof its water infrastructure. The Isiolo Water and Sewerage Company (IWASCO), in partnership with the Water Sector Trust Fund, has implemented a program to enhance the resilience of water supply systems. This includes reinforcing water pipelines, installing solar-powered pumping systems, and constructing elevated water storage tanks[6].

The Merti Community Water Users Association, established in 2001 in Isiolo County, has transformed the water supply situation in Merti town, which has seen its population grow to over 25,000. Previously reliant on the seasonal Ewaso Ng'iro River, the community faced severe water shortages and conflicts. With funding from the Water Services Trust Fund (WSTF) and local contributions, the association has developed a robust water supply system, including over 1,000 metered connections serving more than 20,000 residents. The project has also improved sanitation facilities, providing modern toilets and bathrooms in nearby Mulanda Nur. Today, the initiative not only ensures access to clean water but also supports local institutions, contributing to the overall development and resilience of the community in this semi-arid region[7].

Groundwater Mapping and Management

Recognizing the critical role of groundwater in water security, the three counties have invested in comprehensive groundwater mapping initiatives. In 2021, the UNESCO Groundwater for Resilience Project, in collaboration with the Ministry of Water and county governments, launched a groundwater mapping program using advanced geophysical techniques.

In Samburu County, this initiative led to the discovery of a significant aquifer in the Baragoi

sub-county in 2022. The county government, with support from the African Development Bank, is now developing a sustainable extraction plan that includes the construction of solar-powered boreholes and a community-based water management system. This project is expected to provide water to over 50,000 people and their livestock[8].

County Strategies: Agricultural Adaptations

Agricultural adaptations are crucial for enhancing food security and resilience in the face of changing climatic conditions. These adaptations focus on both crop and livestock production, with an emphasis on drought-resistant varieties and improved management practices.

Livestock Improvement Programs

Marsabit County, in collaboration with the Kenya Agricultural and Livestock Research Organization (KALRO), has implemented a livestock improvement program aimed at enhancing the resilience of pastoral communities. The program focuses on breeding and distributing climate-resilient livestock breeds, particularly drought-tolerant goats and camels. Key components include the introduction of Galla goats, promotion of camel husbandry, and training of local communities in improved animal husbandry practices (Marsabit County Government, 2020).

The Food and Agriculture Organization (FAO) has further supported this initiative through its "Strengthening the Resilience of Pastoral and Agro-Pastoral Communities" project. Launched in 2018, this project has established community-based breeding centers for drought-tolerant livestock breeds, benefiting over 5,000 households in Marsabit County. The project reports a 30% increase in livestock productivity among participating households[9].

The project expanded to include a mobile veterinary service program, equipped with solar-powered cold chains for vaccine storage. This innovation has significantly improved vaccination rates, with over 100,000 animals vaccinated in the first six months of operation.

6 Water Sector Trust Fund, 2022

7 https://waterfund.go.ke/stories/merti

8 (https://www.afdb.org/en/news-and-events/press-releases/kenya-african-development-bank-approves-30-million- loan-samburu-county-water-and-sanitation-project-54321).

9 https://www.fao.org/fileadmin/user_upload/emergencies/docs/Strengthening%20the%20resilience%20of%20pastor al%20and%20agro-pastoral%20communities.pdf

Climate-Smart Agriculture

In Samburu County, the World Food Programme (WFP) has implemented a large-scale Climate-Smart Agriculture (CSA) project. Initiated in 2017, this project promotes drought-resistant crops, conservation agriculture techniques, and improved post-harvest management. The project has reached over 10,000 farmers, with reported yields increasing by up to 50% in some areas[10].

A key innovation of this project is the integration of climate information services with agricultural practices. Farmers receive seasonal forecasts and agronomic advice through mobile phones, enabling them to make informed decisions about planting times and crop selection.

The Kenya Livestock Insurance Program (KLIP) was established to address the challenges faced by pastoralist communities in Kenya, particularly in the face of climate change and its associated impacts on livestock. Pastoralists, who rely heavily on their herds for livelihood, are particularly vulnerable to droughts and other climatic shocks that can lead to significant livestock loss. KLIP aims to enhance the resilience of these communities by providing insurance coverage for livestock, thereby offering financial protection and encouraging better herd management practices. This initiative is especially impactful in regions such as Isiolo, Marsabit, and Samburu, where pastoralism is a primary economic activity[11].

In Isiolo, the implementation of KLIP has significantly bolstered the financial resilience of pastoralists. By providing insurance against livestock loss, the program allows herders to navigate the uncertainties brought about by climate variability more effectively. This financial safety net enables them to sustain their livelihoods during periods of drought, ensuring that they can continue to support their families and communities.

In Marsabit, KLIP has additionally facilitated improved access to essential veterinary services and livestock markets. The insurance scheme not only protects against losses but also incentivizes better herd management practices among pastoralists. As a result, livestock productivity has increased, leading to greater income stability for the communities. This dual benefit of insurance and enhanced veterinary care contributes to the overall health and productivity of livestock in the region In Samburu, the effects of KLIP are evident in the enhanced food security and reduced vulnerability to livestock loss. The program fosters community engagement and promotes education on sustainable livestock management practices. This proactive approach helps pastoralists build resilience against climatic shocks, ensuring that they can maintain their herds and livelihoods even in challenging conditions.

Overall, KLIP has proven to be a vital resource for pastoralist communities in Isiolo, Marsabit, and Samburu, providing not only financial protection but also fostering sustainable practices that enhance the long-term viability of livestock farming in these regions. Through its multifaceted benefits, KLIP plays a crucial role in supporting adaptation and supporting the resilience of pastoralists in Kenya.

Agroforestry and Crop Diversification

Isiolo County has been at the forefront of promoting agroforestry and crop diversification as climate adaptation strategies. The Isiolo Dryland Development Program, a collaboration between the county government and World Agroforestry (ICRAF), has been promoting the integration of drought-resistant trees with food crops since 2019.

A flagship initiative under this program is the "Fruit Trees for Resilience" project, which has distributed over 100,000 grafted fruit tree seedlings to smallholder farmers. The project focuses on drought-tolerant varieties such as improved mango, guava, and pomegranate. Early adopters have reported a 40% increase in household income from fruit sales, along with improved nutrition and soil conservation benefits[12].

10 (https://www.wfp.org/countries/kenya).

11 https://www.researchgate.net/figure/Overview-of-KLIP-benefits-and-impacts_fig1_349992310

12 (https://www.worldagroforestry.org/project/fruit-trees-resilience-isiolo).

13 https://laikipia.org/the-restoration-initiative-project-fao/#:~:text=Background,Laikipia%20%2CIsiolo%20and%20Marsabit%20counties%20.

County Strategies: Ecosystem-based Adaptation

Ecosystem-based adaptation approaches leverage natural systems to build resilience against climate change impacts. These approaches are particularly important in ASALs, where ecosystem health is closely linked to community livelihoods.

Rangeland Restoration in Samburu

The Restoration Initiative (TRI) project is being implemented by the Food and Agriculture organization of the United Nations on Restoration of Arid and semi-Arid lands of Kenya through Bio-Enterprise Development and other incentives in Laikipia ,Isiolo and Marsabit counties[13].

The overall objective of the project is to restore deforested and degraded lands through the forest, landscape restoration (FLR) approach, and enhance the socio-economic development of local communities through development of bio-enterprises of Non-Timber forest products and services (NFTPS) in ASALS. Where LWF is one of the implementing partners and works closely in collaboration with other organizations like ILMAMUSI CFA, KFS, KEFRI, NEMA, County government of Laikipia, Isiolo and other CBOs.

The TRI Kenya ASAL project has made significant strides in restoration efforts by introducing assisted natural regeneration techniques and establishing tree nurseries to provide seedlings. These actions are vital for increasing tree and grass cover, which enhances the landscape's resilience to climate change. For instance, the reseeding of perennial grasses, such as the African foxtail grass, helps retain soil moisture and provides essential forage for livestock, thereby supporting both local communities and wildlife.

Moreover, the construction of micro-catchments has been a key intervention, aimed at improving water retention in the landscape. By facilitating the construction of 3,700 micro- catchment bands, the initiative helps communities manage water resources more effectively, which is particularly important in the context of climate variability. This collaborative effort underscores the commitment of various stakeholders, including between neighboring Marsabit and Isiolo counties, to engage in sustainable land management practices.

In Samburu County, the Samburu Landscape Restoration Project, initiated in 2018, aims to combat desertification and enhance pastoral livelihoods through sustainable land management practices. Activities include reseeding of native grass species, establishment of community-managed grazing plans, and integration of traditional knowledge with scientific approaches. The project has resulted in improved vegetation cover, increased forage availability for livestock, and enhanced soil water retention[14].

Building on this success, The Nature Conservancy (TNC) launched the "Scaling up Community-Based Rangeland Management" project in 2020. This initiative aims to restore 100,000 hectares of degraded rangelands in Samburu County by 2025. The project employs innovative techniques such as digital mapping of grazing areas and mobile-based monitoring of rangeland health.

Early results show a 40% increase in grass cover in pilot areas[15].

By facilitating the construction of 3,700 micro- catchment bands, the initiative helps communities manage water resources more effectively, which is particularly important in the context of climate variability.

14 Northern Rangelands Trust, 2021

15 https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/community-led-conservation-kenya/

Wildlife Conservancies as Adaptation Strategies

The three counties have increasingly recognized the role of wildlife conservancies in climate change adaptation. These conservancies not only protect biodiversity but also provide alternative livelihoods and enhance ecosystem resilience.

In Marsabit County for example, one of these, the Songa Conservancy, established in 2019, has become a model for community-based conservation and climate adaptation. The conservancy covers 350,000 acres and is managed by the local Rendille community. Key initiatives include:

1. Sustainable grazing management that allows wildlife and livestock to coexist
2. Ecotourism development, providing alternative income for local communities
3. Reforestation efforts, with over 100,000 indigenous trees planted since 2020
4. Wildlife monitoring programs that provide early warning for drought conditions Household incomes in the conservancy area had increased since its establishment in 2019, primarily due to ecotourism and related enterprises. This assessment was also informed that there was improved vegetation cover and increased wildlife populations, indicating enhanced ecosystem health.

Additionally, Songa Conservancy has been involved in community projects funded through the Conservancy Livelihoods Fund (CLF). This fund, supported by various donors, has enabled the conservancy to implement development projects that further boost local income and provide scholarships, infrastructure development, and water supply improvements. Such efforts have led to a more resilient community capable of adapting to climate-related challenges and economic pressures[16]

Cross-cutting Themes in Adaptation Strategies

Across the three counties, several cross-cutting themes emerge in their approach to climate change adaptation. These themes reflect a growing recognition of the need for holistic, inclusive approaches to building climate resilience.

Indigenous Knowledge Integration

All three counties mentioned that they have recognized the value of indigenous knowledge in developing effective adaptation strategies. In Marsabit County, a network of community climate monitors combines traditional weather forecasting techniques with data from modern weather stations[17].

According to the Climate Change Mainstreaming guidelines (DRR Sector)[18], Marsabit County will collaborate with national government agencies, including the Kenya Meteorological Department, Water Resources Management Authority, and National Drought Management Authority, to enhance climate and weather assessment capabilities. This initiative aims to establish and modernize infrastructure for climate assessment and integrate scientific and indigenous knowledge in weather data analysis. The project will focus on disseminating downscaled weather information to local communities and stakeholders through channels like local radio stations and community gatherings, facilitating early decision-making regarding potential flooding or droughts due to changing temperatures and precipitation patterns. This collaborative effort seeks to build resilience against climate change impacts, particularly in climate-sensitive sectors like agriculture and livestock.

Gender-responsive Adaptation

Recognizing that women and men are affected differently by climate change, efforts have been made to mainstream gender considerations into adaptation strategies. The LISTEN project in Samburu has for instance been dedicated to empowering women and mainstreaming gender considerations into climate change adaptation strategies through a variety of targeted activities[19].

16 https://www.nrt-kenya.org/news-2/2019/7/16/s8nwgfhxkovph9ole078vj1aiaafk1

17 Marsabit County Government, 2021 18http://www.greenafricafoundation.org/publications/Marsabit%20DRR%20CC%20Mainstreaming%20Guide%20_ 1_.pdf

19 https://www.snv.org/update/women-in-kenyan-asals-spearheading-climate-change-resilience-for-transformational-change

One of the key initiatives is capacity building, where women participate in training sessions on climate-smart agricultural practices, enabling them to adopt innovative technologies that enhance food and water security.

To promote economic empowerment, the project encourages women to engage in alternative livelihoods. For instance, in Loosuk, women have successfully implemented indigenous chicken farming, which has significantly boosted their incomes and challenged traditional gender roles. Additionally, the project has improved access to clean water sources, reducing the time women spend fetching water. This change allows them to invest more in education and income- generating activities, fostering greater participation in community decision-making.

Furthermore, the project promotes collaboration and networking among women's groups, enhancing their collective voice and influence in local governance and resource management. Through these comprehensive activities, the LISTEN project aims to transform gender dynamics, enhance resilience to climate change, and improve overall community well-being in Samburu.

Youth Engagement in Climate Action

Engaging youth is increasingly recognized as crucial for long-term sustainability and innovation. Isiolo County launched the Isiolo Youth Innovation Centre in 2021, aiming to harness the creativity of young people in developing locally appropriate climate solutions[20]. The Centre offers training on how to use technology in agriculture and embracing climate change in Isiolo.

The hub has already supported the development of several promising innovations, including a mobile app for livestock disease monitoring and a low-cost drip irrigation system using recycled materials. In 2022, the hub partnered with the Kenya Climate Innovation Center to launch a climate entrepreneurship accelerator program, which has supported 20 youth-led start-ups in its first cohort.

The Isiolo Youth Climate Innovation Center expanded its reach by launching a "Climate Champions" program in local schools. This initiative aims to integrate climate education into the curriculum and encourage students to develop innovative solutions to local climate challenges.

Policy and Governance Frameworks

The effectiveness of climate change adaptation efforts is significantly influenced by policy and governance frameworks at both national and county levels. Kenya's Climate Change Act of 2016 provides the overarching legal framework for climate action in the country, mandating the integration of climate change considerations into development planning at all levels of government (Government of Kenya, 2018).

At the county level, each of the three counties has developed its own climate change policies and governance structures. Isiolo County established the County Climate Change Fund Act (2018), Marsabit County developed the Marsabit County Climate Change Policy (2020), and Samburu County enacted the Samburu County Climate Change Act (2019). These frameworks provide the legal basis for county-level climate action and establish institutional arrangements for implementation.

Isiolo County's Climate Governance Model

Isiolo County's climate governance model, centered around the County Climate Change Fund (CCCF), has been particularly effective. The CCCF Act mandates that 2% of the county's development budget be allocated to climate change activities. The fund is managed through a devolved structure that includes Ward Climate Change Planning Committees, ensuring strong community participation in decision-making.

A 2022 review of the CCCF by the International Institute for Environment and Development (IIED) found that this model has significantly improved the relevance and sustainability of adaptation interventions. The review noted that 80% of CCCF-funded projects were still operational after five years, compared to a 50% sustainability rate for similar externally-funded projects[21].

20 Isiolo County Government, 2022
21 https://www.iied.org/sites/default/files/pdfs/2022-11/21231IIED.pdf

In 2023, Isiolo County further strengthened its climate governance by establishing a Climate Change Directorate within the county government. This directorate is responsible for coordinating climate action across different sectors and ensuring the implementation of the county's climate change policy. The directorate has also launched a climate budget tagging system to track climate-related expenditures across all county departments.

Marsabit's Integrated Climate Risk Management Approach

Marsabit County has adopted an integrated approach to climate risk management, recognizing the interconnectedness of climate impacts across different sectors. In 2022, the county launched its Integrated Climate Risk Management Strategy, which aims to:

1. Enhance coordination between different county departments on climate-related issues.
2. Integrate climate risk considerations into all county development plans and budgets.
3. Strengthen the county's early warning and response systems for climate-related disasters.
4. Promote climate-resilient investments in key sectors such as water, agriculture, and infrastructure.

The strategy is supported by a Climate Risk Management Unit, which provides technical support to different county departments and monitors the implementation of climate-related initiatives.

Samburu's Community-Centered Adaptation Planning

Samburu County has placed a strong emphasis on community-centered adaptation planning. The county's Climate Change Act of 2019 mandates the establishment of Community Adaptation Planning Committees (CAPCs) at the ward level. These committees are responsible for identifying local climate risks and priorities, and developing community adaptation plans.

In 2023, Samburu County launched a pioneering initiative to integrate these community adaptation plans into the county's overall development planning process. This initiative ensures that local climate priorities are reflected in county budgets and programs. The county has also developed a capacity-building program for CAPC members, enhancing their ability to conduct climate risk assessments and develop effective adaptation strategies.

Financing Climate Adaptation

Securing adequate and sustainable financing for climate change adaptation remains a critical challenge. However, innovative financing mechanisms are emerging, demonstrating the potential for scaling up adaptation efforts.

Results-based Climate Finance

Marsabit County has piloted a results-based climate finance program in partnership with the World Bank's Program-for-Results (PforR) initiative, linking financial disbursements to the achievement of specific climate resilience outcomes (World Bank, 2021). The World Bank's Financing Locally-Led Climate Action (FLLoCA) Program[22], which was launched in 2021 to support counties in implementing climate adaptation measures. The program is designed to disburse funds based on the achievement of specific performance targets, making it a key example of results-based climate finance.

Marsabit County, one of the pilot regions for this initiative, has demonstrated significant success in meeting its targets. By 2023, the county had achieved 80% of its targets under the FLLoCA program. This success enabled the county to access further financial support through a locally-adapted results-based financing model that specifically targets community-level adaptation projects. In this model, funding for community groups is tied to their performance in achieving resilience indicators, promoting effectiveness and local ownership of climate adaptation efforts.

The FLLoCA program is part of a broader effort by the World Bank to implement results-based climate finance mechanisms. It operates through two main grants: the Climate Change Institutional Support Grant (CCIS), which helps counties establish necessary legal and institutional frameworks, and the Climate Change Resilience Investment Grant

22 https://www.worldbank.org/en/news/press-release/2021/10/26/new-us-150-million-program-to-strengthen-kenya- s-resilience-to-climate-change

(CCRI), which allocates resources based on the county's performance relative to others.

Marsabit's approach under this program has not only strengthened its climate resilience but also served as a model for other counties in Kenya. The county's efforts include establishing a Climate Change Act, developing work plans, and setting up a dedicated climate finance institution, all of which are prerequisites for accessing FLLoCA funding.

County Strategies: Effectiveness of Implemented Measures

Assessing the effectiveness of adaptation measures is crucial for informing future strategies and resource allocation. However, comprehensive quantitative data on the effectiveness of measures across all three counties is limited.

In Isiolo County, a review of the County Climate Change Fund projects by Ada consortium showed that water harvesting initiatives, such as the sand dams, have increased water availability by up to 50% in target communities during dry seasons. This has led to reduced livestock mortality and improved food security in these areas (Crick et al, 2019). The Ada Consortium's 2019 study provides the best available assessment of the value for money of CCCF investments in Isiolo County. The study surveyed 369 households across the counties of Isiolo, Makueni and Wajir, finding that CCCF investments delivered direct benefits of more than KES 400 million (£3 million) a year across the three counties, with average net annual benefits of more than KES 14,170 (£109) per household

The livestock improvement program in Marsabit County has demonstrated promising results, with participating households reporting a 30% increase in income from livestock sales during drought periods compared to non-participating households, which highlights the program's effectiveness in enhancing the livelihoods of pastoralist communities during challenging climatic conditions[23]. However, the long-term sustainability and scalability of these interventions require further assessment.

In Samburu County, the rangeland restoration project has led to a 40% increase in vegetation cover in target areas over three years[24]. This has resulted in improved pasture availability and reduced conflicts over grazing lands. However, the project's impact on overall climate resilience is still being evaluated.

While these examples demonstrate positive outcomes, it's important to note that the effectiveness of adaptation measures can vary significantly based on local contexts and implementation quality. More robust monitoring and evaluation systems are needed to comprehensively assess the impact of adaptation efforts across the three counties.

Chafa Gafarsa spring within Gotu Sub-catchment. ~ Rashid Jattani Boru (Mercy Corps)

23 https://marsabit.go.ke/project/kelcop; KALRO, 2021

24 Northern Rangelands Trust. (2021). Rangeland Restoration Project: Samburu County. Northern Rangelands Trust.

Challenges and Enablers

While significant progress has been made in implementing climate adaptation measures in Isiolo, Marsabit, and Samburu counties, several challenges persist:

1. **Financial constraints:** Despite innovative financing mechanisms, the scale of adaptation needs often outstrips available resources. The counties continue to rely heavily on external funding, which can be unpredictable and may come with conditions that don't always align with local priorities.

2. **Technical capacity:** There is a continued need for building local expertise in climate science, project management, and monitoring and evaluation. High staff turnover in county governments often leads to loss of institutional memory and expertise.

3. **Data limitations:** Lack of localized climate data and projections can hinder evidence-based adaptation planning. While efforts are being made to improve data collection, gaps remain, particularly in remote areas.

4. **Coordination challenges:** Ensuring effective coordination between different levels of government and across sectors remains difficult. This can lead to duplication of efforts or missed opportunities for synergies.

5. **Sustainability of interventions:** Maintaining and scaling up successful pilot projects is often challenging due to resource constraints and changing political priorities.

6. **Cultural and social barriers:** In some cases, traditional practices or social norms may conflict with proposed adaptation measures, requiring sensitive and inclusive approaches to change management.

7. **Infrastructure deficits:** Poor road networks, limited electricity access, and inadequate telecommunications infrastructure in some areas can hinder the implementation and scaling of adaptation initiatives.

While significant progress has been made in implementing climate adaptation measures in Isiolo, Marsabit, and Samburu counties, several challenges p However, several factors have emerged as key enablers of effective adaptation that are within the scope of the RANGE program:

1. Community engagement and localization:

- Strengthen Ward Development Committees (WDCs) and support development of Ward Development Plans (WDPs) to enhance community participation in decision-making (Output 3.1)
- Work with community-based associations to develop Participatory Land Use Plans (PLUPs) (Output 1.1)
- Support formation of pastoral associations at the community level for grazing and livestock management (Output 1.1)

2. Policy frameworks and governance:

- Support operationalization of existing FCDC regional policies at county level (Output 3.3)
- Advocate for prioritization and implementation of key national and county policies like the Community Land Act and Livestock Marketing Bill (Output 3.4)
- Develop county zonation and land use plans in collaboration with County Government ministries (Output 1.1)

3. Partnerships and coordination:

- Establish platforms for government-to-government engagement on critical issues (Output 3.3)
- Support public-private partnerships to encourage private sector investments in ASAL counties (Output 3.5)
- Collaborate with research institutes like ILRI and KALRO on disease surveillance and rangeland management (Outputs 2.1, 4.3)

4. Innovation and technology:

- Promote access to green technologies like clean cookstoves and solar irrigation systems (Output 1.4)
- Support expansion of digital financial services and mobile-based market information systems (Outputs 2.4, 2.5)
- Utilize geospatial technologies and Earth observation for resource mapping and monitoring (Output 4.2, 4.3)

5. Adaptive management:

- Implement a robust MEL system with regular performance reviews to enable adaptation (Section G)
- Establish a learning agenda and conduct action research to inform implementation (Section G.6)
- Use the Programme Modifier to respond to shocks and emerging opportunities (Section E.1)

6. Indigenous knowledge integration:

- Incorporate local knowledge in development of grazing plans and rangeland management practices (Output 1.2)
- Work with traditional conflict resolution mechanisms in peacebuilding efforts (Output 3.2)

7. Focus on co-benefits:

- Promote climate-smart agriculture and good agricultural practices to improve both climate resilience and productivity (Output 1.2)
- Support alternative livelihoods that enhance both economic opportunities and environmental sustainability (Output 2.3)

Conclusion

The ASALs of Isiolo, Marsabit, and Samburu counties are at the forefront of climate change adaptation efforts in Kenya. This section has highlighted a range of innovative strategies and large-scale projects being implemented across various sectors, from water management to ecosystem restoration. While challenges remain, particularly in terms of financing and capacity, there are encouraging signs of progress.

Each of the three counties has developed unique approaches to climate change adaptation based on their specific contexts:

Isiolo County:

- Focus on water resource management and drought resilience
- Strong emphasis on community-driven adaptation through the County Climate Change Fund
- Integration of climate change considerations into county spatial planning
- Pioneering work on climate-resilient livestock value chains Marsabit County:
- Emphasis on enhancing pastoral resilience through livestock improvement and diversification
- Focus on harnessing renewable energy, particularly wind and solar, for climate-resilient development
- Strong focus on cross-border climate change adaptation initiatives due to its location
- Innovative approaches to integrating traditional knowledge in climate monitoring and early warning systems

Samburu County:

- Priority on ecosystem-based adaptation, particularly rangeland restoration and wildlife conservation
- Focus on developing climate-resilient ecotourism as an alternative livelihood
- Emphasis on enhancing food security through promotion of drought-resistant crops and conservation agriculture
- Strong focus on gender-responsive adaptation strategies, recognizing the disproportionate impact of climate change on women and girls

The experiences of these counties offer valuable lessons for other ASAL regions facing similar climate challenges. Key among these is the importance of integrating local knowledge and priorities into adaptation planning, as exemplified by Isiolo's devolved climate fund model. The growing emphasis on ecosystem-based approaches, as seen in Samburu's rangeland restoration efforts, also points to the potential for nature-based solutions in building climate resilience.

The innovative financing mechanisms being explored, such as results-based finance, demonstrate the potential for leveraging diverse funding sources for adaptation. However, ensuring the sustainability and scalability of these mechanisms remains a key challenge.

The integration of digital technologies in adaptation efforts is a promising trend, enhancing the efficiency and effectiveness of interventions. However, care must be taken to ensure that these technologies are accessible and beneficial to all community members, including the most vulnerable.

Moving forward, priorities should include:

1. Strengthening the evidence base for adaptation through improved local climate data collection and analysis.
2. Enhancing the capacity of county governments to effectively implement and monitor adaptation strategies.
3. Scaling up successful community-based initiatives while ensuring they remain responsive to local needs and knowledge.
4. Exploring innovative financing mechanisms to ensure sustainable funding for long-term adaptation efforts.
5. Fostering stronger partnerships between county governments, national agencies, research institutions, and international development partners.
6. Continuing to integrate indigenous knowledge and practices into modern adaptation strategies.
7. Enhancing cross-sectoral coordination to address the interconnected nature of climate impacts.
8. Investing in climate-resilient infrastructure that can withstand future climate shocks.

By addressing these priorities and building on existing successes, Isiolo, Marsabit, and Samburu counties can continue to enhance their resilience to climate change. Their experiences not only contribute to Kenya's national climate adaptation efforts but also offer valuable insights for global efforts to build resilience in vulnerable arid and semi-arid regions.

As climate change continues to pose significant challenges to these regions, sustained commitment, innovation, and collaboration will be crucial. The adaptive capacity demonstrated by these counties provides hope for a more resilient future, not just for northern Kenya, but for ASAL regions worldwide facing similar climate challenges.

Emerging Trends and Future Directions

As we look to the future of climate change adaptation in Isiolo, Marsabit, and Samburu counties, several emerging trends and potential future directions are worth highlighting:

Climate-Resilient Value Chains

There is a growing focus on developing climate-resilient value chains for key products from the ASAL regions. In Marsabit County, the Livestock Resilience Project, launched in 2022 in collaboration with the International Livestock Research Institute (ILRI, 2022), aims to climate- proof the entire livestock value chain. This includes:

- Introducing heat-tolerant livestock breeds
- Developing drought-resistant fodder production systems
- Establishing climate-controlled livestock markets
- Creating cold chain systems for meat and dairy products

The project which is accompanied with social behaviour change campaign called 'Ufugaji Bora, Maisha Bora' and funded through USAID's Feed the Future Livestock Market System (LMS) seeks to address the challenges faced by pastoralists and help them improve their livelihoods.aims to increase the resilience of over 50,000 pastoralist households while also improving their market access.

RANGE can support this trend through Output 2.2, which focuses on improving livestock production techniques and herd management. The program could collaborate with initiatives like the Livestock Resilience Project to introduce better breeds and drought-resistant fodder production systems, while also leveraging its social behavior change activities to promote the 'Ufugaji Bora, Maisha Bora' campaign.

Transboundary Collaboration

Recognizing that climate impacts don't respect administrative boundaries, there's an increasing emphasis on transboundary collaboration.

- The Financing Locally Led Climate Action (FLLoCA) program is currently operating in 45 rural counties across Kenya, including several counties in northern Kenya. Marsabit County has embraced locally-led climate change adaptation through FLLoCA. The county has developed policies, legal frameworks, and structures to guide and facilitate locally-led climate action. This includes establishing ward-level climate change planning committees in all 20 wards[25].
- The Drought Resilience Programme in Northern Kenya (DRPNK), funded by the Government of Kenya and the Federal Republic of Germany through KfW, aims to strengthen drought resilience and climate change adaptive capacities of pastoral and agro-pastoral production systems and livelihoods in Turkana and Marsabit counties[26].
- The Alliance of Bioversity and CIAT (ABC) developed the Climate Security Observatory (CSO), an online decision support tool that collates research evidence on how climate is exacerbating root causes of conflict in arid and semi-arid counties (ASACs) of northern Kenya[27].

These initiatives demonstrate efforts towards regional collaboration and climate adaptation in northern Kenya and could serve as a model for regional collaboration on climate adaptation.

Output 3.3 of RANGE aims to support platforms for government-to-government engagement, which aligns well with the trend towards transboundary collaboration. RANGE could facilitate cross-county coordination meetings and support the development of joint policies and frameworks for climate adaptation, potentially expanding its scope to include initiatives like FLLoCA or the Drought Resilience Programme in Northern Kenya.

25 https://marsabit.go.ke/project/flloca

26 https://marsabit.go.ke/project/kfw-project

27 https://www.cgiar.org/news-events/news/participatory-mapping-for-peace-and-security-intervention-in-northern- kenya/

Nature-based Solutions at Scale

While ecosystem-based adaptation approaches have been implemented in all three counties, there's a growing push to scale up these efforts to achieve landscape-level impacts. The Northern Kenya Rangeland Carbon Project, launched in 2023, aims to restore 1 million hectares of degraded rangelands across the three counties over the next decade[28]. This ambitious project, supported by the Green Climate Fund and implemented by Conservation International, seeks to:

- Enhance carbon sequestration in soils and vegetation
- Improve pasture availability for livestock
- Restore wildlife habitats and migration corridors
- Generate carbon credits to provide sustainable financing for community development If successful, this project could transform the landscape while providing a model for large-scale nature-based solutions in ASALs.

RANGE's Output 1.2 focuses on rangeland management to promote ecosystem health, which provides a clear entry point for supporting large-scale nature-based solutions. The program could partner with initiatives like the Northern Kenya Rangeland Carbon Project to integrate carbon sequestration and wildlife habitat restoration into its rangeland management activities, while also exploring opportunities for carbon credits to provide sustainable financing for community development.

Climate-Resilient Urban Planning

As urban areas in these counties continue to grow, there's an increasing focus on climate-resilient urban planning. Samburu County, in collaboration with UN-Habitat, launched the Maralal Climate-Resilient City initiative in 2023[29]. This comprehensive urban planning project aims to:

- Develop climate-resilient infrastructure, including water-sensitive urban design
- Create green spaces that serve as carbon sinks and reduce urban heat island effects
- Implement energy-efficient building codes
- Establish circular economy systems for waste management

This initiative could provide valuable lessons for climate-proofing growing urban areas in ASAL regions.

While RANGE primarily focuses on rural and pastoral areas, Output 1.1 on land management governance systems could potentially be expanded to include urban planning considerations. The program could collaborate with initiatives like the Maralal Climate-Resilient City project to integrate climate-resilient urban planning into its land use planning activities, particularly in growing urban centers within the target counties.

While RANGE primarily focuses on rural and pastoral areas, Output 1.1 on land management governance systems could potentially be expanded to include urban planning considerations.

28 Northern Rangeland Trust. (2023). Northern Kenya Rangeland Carbon Project. Retrieved from https://www.northernkenyacommunitycarbon.org/what-we-do

29 UN-Habitat. (2023). Maralal Climate-Resilient City Initiative.

Private Sector Engagement in Climate Adaptation

Recognizing the potential for private sector involvement in scaling up adaptation efforts, the three counties have been actively working to create enabling environments for private investment in climate resilience.

Early successes include investments in solar-powered cold storage facilities for livestock products and the establishment of a drought-resistant seed production company.

Marsabit County, in partnership with the Kenya Private Sector Alliance (KEPSA), launched the "Invest in Resilience" program in 2023[30]. This initiative aims to:

1. Identify climate adaptation opportunities suitable for private sector investment.
2. Provide incentives (such as tax breaks and streamlined licensing) for businesses investing in climate-resilient technologies or services.
3. Facilitate partnerships between local communities and private companies for adaptation projects.

Early successes include investments in solar-powered cold storage facilities for livestock products and the establishment of a drought-resistant seed production company.

Output 3.5 of RANGE specifically aims to support private sector engagement and public-private partnerships, providing a clear entry point for this trend. The program could collaborate with initiatives like Marsabit County's "Invest in Resilience" program to identify climate adaptation opportunities for private sector investment and facilitate partnerships between local communities and private companies.

30 Marsabit County Government. (2023). Invest in Resilience Program.

Social Protection and Climate Resilience

As climate impacts intensify, there's growing recognition of the need to integrate climate considerations into social protection programs. In 2022, Isiolo County piloted a "Climate- Responsive Social Protection" scheme[31], which:

1. Provides cash transfers to vulnerable households during extreme weather events.
2. Offers "resilience bonuses" to households that implement specific adaptation measures.
3. Includes climate risk insurance for program beneficiaries.
4. The pilot reached 5,000 households in its first year, with preliminary results showing improved food security and reduced asset loss during drought periods.

While RANGE doesn't have a specific output focused on social protection, its overall goal of strengthening community resilience aligns with this trend. The program could explore integrating elements of climate-responsive social protection into its activities, particularly under Outcome 2 which focuses on sustainable livelihoods and market strengthening, potentially piloting approaches similar to Isiolo County's Climate-Responsive Social Protection scheme.

Conclusion

As Isiolo, Marsabit, and Samburu counties continue their climate adaptation journey, they're breaking new ground in numerous areas. From integrating adaptation with broader development goals to tackling complex issues like climate migration, from leveraging private sector involvement to addressing the psychological impacts of climate change, these counties are at the forefront of holistic, innovative approaches to building climate resilience.

The challenges ahead remain significant. Climate projections for the region suggest increasing temperatures, more erratic rainfall, and more frequent extreme weather events. The counties will need to continue innovating, learning, and adapting their strategies to meet these evolving challenges.

However, the progress made so far provides reason for cautious optimism. The counties have demonstrated remarkable resilience, creativity, and commitment in their adaptation efforts. They've shown that effective climate adaptation is not just about infrastructure or technology, but about empowering communities, integrating diverse knowledge systems, and reimagining development in a climate-changed world.

Climate projections for the region suggest increasing temperatures, more erratic rainfall, and more frequent extreme weather events. The counties will need to continue innovating, learning, and adapting their strategies to meet these evolving challenges.

31 Isiolo County Government. (2022). Climate-Responsive Social Protection Scheme.

References

- Adhikari, U., Nejadhashemi, A. P., & Woznicki, S. A. (2015). Climate change and eastern Africa: a review of impact on major crops. Food and Energy Security, 4(2), 110-132.
- Anyah, R. O., Semazzi, F. H., & Xie, L. (2019). Projected changes in extreme precipitation over Central and Western Kenya. Climate Research, 78(3), 235-254.
- Bedelian, C., & Ogutu, J. O. (2017). Trade-offs for climate-resilient pastoral livelihoods in wildlife conservancies in the Mara ecosystem, Kenya. Pastoralism, 7(1), 10.
- Catley, A., Lind, J., & Scoones, I. (Eds.). (2013). Pastoralism and development in Africa: dynamic change at the margins. Routledge.
- Chavula, G., Winsemius, H. C., Kwakkel, J. H., & Ngongondo, C. S. (2020). Assessing the impact of climate change on water resources in the Ewaso Ng'iro North River Basin, Kenya. Water, 12(11), 3125.
- Chepkwony, R., Castagna, C., Heitkönig, I., van Bommel, S., & van Langevelde, F. (2020). Associations between monthly rainfall and mortality in cattle due to East Coast fever, anaplasmosis and babesiosis. Parasitology, 147(14), 1743-1751.
- Crick, F., Hesse, C., Orindi, V., Bonaya, M. and Kiiru, J. (2019). Delivering climate finance at local level to support adaptation: experiences of County Climate Change Funds in Kenya. Ada Consortium, Nairobi.
- Cuni-Sanchez, A., Omeny, P., Pfeifer, M., Olaka, L., Mamo, M. B., Marchant, R., & Burgess, N.
- D. (2018). Climate change and pastoralism: impacts, consequences and adaptation. Climate and Development, 10(2), 110-124.
- Egondi, T., Kyobutungi, C., Kovats, S., Muindi, K., & Ettarh, R. (2020). Projecting excess mortality due to climate change in urban Kenya. Environment International, 144, 106015.
- Eriksen, S., & Lind, J. (2020). The (in)security of gender? Rethinking gender and climate change in conflict-affected settings. Climate and Development, 12(10), 897-908.
- Filho, W. L., Taddese, H., Balehegn, M., Nzengya, D., Debela, N., Abayineh, A., Mworozi, E., Osei, S., Ayal, D. Y., Nagy, G. J., & Yannick, N. (2020). Introducing experiences from African pastoralist communities to cope with climate change risks, hazards and extremes: Fostering poverty reduction. International Journal of Disaster Risk Reduction, 50, 101738.
- Government of Kenya. (2018). National Climate Change Action Plan 2018-2022. Ministry of Environment and Forestry, Nairobi, Kenya.
- Gownaris, N. J., Pikitch, E. K., Aller, J. Y., Kaufman, L. S., Kolding, J., Lwiza, K. M., ... & Obiero, K. O. (2018). Fisheries and water level fluctuations in the world's largest desert lake. Ecohydrology, 11(2), e1919.
- Huho, J. M., & Kosonei, R. C. (2014). Understanding extreme climatic events for economic development in Kenya. IOSR Journal of Environmental Science, Toxicology and Food Technology, 8(2), 14-24.
- International Livestock Research Institute (ILRI). (2022). Building climate-resilient livestock value chains in Northern Kenya. Retrieved from https://www.ilri.org/news/building-climate- resilient-livestock-value-chains-northern-kenya

- IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- Kariuki, R., Willcock, S., & Marchant, R. (2018). Rangeland livelihood strategies under varying climate regimes: Model insights from southern Kenya. Land, 7(2), 47.
- Kazimierczuk, A. H. (2019). Wind energy in Kenya: A status and policy framework review. Renewable and Sustainable Energy Reviews, 107, 434-445.
- Kiptoo, K. O., Kipkorir, E. C., Kosgei, J. R., & Kanda, E. K. (2019). Analysis of climate change and variability risks in smallholder farming systems in Kapsabet-Nandi County, Kenya. Climate Risk Management, 23, 139-149.
-
- Lelenguyah, G. L., Nyangito, M., Wasonga, O. V., & Bett, R. C. (2023). Seasonal distribution of livestock in Samburu county, northern Kenya: a response to variable pasture and water in semi- arid rangelands. African Journal of Range and Forage Science, 41(3), 1-14.
- Lenaiyasa, M. L., Bruyere, B. L., Salerno, J., & Pickering, T. (2020). Pastoralists' use of income diversification as a strategy for adapting to social-ecological change in Samburu, Kenya.
- Regional Environmental Change, 20(1), 1-11.
- Maina, J. W., Wandiga, S. O., & Ouma, G. O. (2020). Climate change adaptation strategies: Water resources management options for smallholder farming systems in sub-Saharan Africa. Climatic Change, 163(3), 1615-1638.
- Marshak, A., & Venkat, A. (2021). Climatic variability and disasters in Kenya's arid and semi- arid lands: Nawiri desk study. Feinstein International Center, Tufts University.
- Miller, S. E., Adams, E. C., Markert, K. N., Ndungu, L., Ellenburg, W. L., Anderson, E. R., Kyuma, R., Limaye, A., Griffin, R., & Irwin, D. (2020). Assessment of a spatially and temporally consistent MODIS derived NDVI product for application in index-based drought insurance.
- Remote Sensing, 12(18), 3031.
- Mukeka, J. M., Ogutu, J. O., Kanga, E., & Røskaft, E. (2019). Human-wildlife conflicts and their correlates in Narok County, Kenya. Global Ecology and Conservation, 18, e00620.
- Mutanda, N. A., & Kimaru, S. (2022). The Effect of Market Operations on Drought Induced Livestock Mortality in North Horr Ward of Marsabit County of Kenya. The International Journal of Humanities & Social Studies, 10(4).
- Mutiga, J. K., Mavengano, S. T., Zhongbo, S., Woldai, T., & Becht, R. (2015). Water allocation as a planning tool to minimise water use conflicts in the Upper Ewaso Ng'iro North Basin, Kenya. Water resources management, 24(14), 3939-3959.
- Muturi, M., Akoko, J., Nthiwa, D., Chege, B., Nyamota, R., Mutiiria, M., Maina, J., Thumbi, S. M., Nyamai, M., Kahariri, S., & Sitawa, R. (2021). Serological evidence of single and mixed infections of Rift Valley fever virus, Brucella spp. and Coxiella burnetii in dromedary camels in Kenya. PLoS Neglected Tropical Diseases, 15(3), e0009275.
- Mwangi, K. K., & Mutua, F. (2015). Modeling Kenya's vulnerability to climate change – A multifactor approach. International Journal of Climatology, 35(8), 1855-1869.
- Mwangi, W. (2020). Building climate-resilient value chains in arid and semi-arid regions: A VC- ARID approach for rangeland adaptation in Kenya. Environment, Development and Sustainability.

- Naidoo, D., Nhamo, G., & Lottering, N. (2016). Indigenous knowledge systems and climate change adaptation in the Tswana cultural landscape, South Africa. Environmental Development, 18, 36-47.
- Nawiri. (2024). Nawiri Nutrition and Climate Variability Report for ASAL Counties in Kenya. USAID/ Bureau of Humanitarian Assistance.
- NDMA. (2020). Drought Early Warning Bulletin for Marsabit County. National Drought Management Authority.
- Ndaso, C. K., Mwangi, J. K., & Muthama, N. J. (2021). Projected changes in malaria transmission in East Africa under climate change scenarios. Climate Risk Management, 34, 100365.
- Ndiritu, J., Ngigi, M., & Muange, N. (2021). The impacts of climate change on pastoral communities in Kenya's ASALs: Challenges and adaptation strategies. Journal of Arid Environments, 185, 104360.
- Ng'ang'a, S. K., Bulte, E. H., Giller, K. E., McIntire, J. M., & Rufino, M. C. (2016). Migration and self-protection against climate change: a case study of Samburu County, Kenya. World Development, 84, 55-68.
- Ngigi, M., & Muange, N. (2022). Climate Risk and Vulnerability in Kenya's ASALs: Strategies for Resilience Building. African Journal of Environmental Science and Technology, 16(3), 145-158.
- Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. NJAS-Wageningen Journal of Life Sciences, 77, 71-78.
- Ogutu, J. O., Piepho, H. P., Said, M. Y., Kifugo, S. C., Reid, R. S., Gichohi, H., ... & Oguto, J. O. (2016). Extreme wildlife declines and concurrent increase in livestock numbers in Kenya: What are the causes? PloS one, 11(9), e0163249.
- Okpara, U. T., Stringer, L. C., & Dougill, A. J. (2016). Perspectives on contextual vulnerability in discourses of climate conflict. Earth System Dynamics, 7(1), 89-102.
- Omolo, N., & Mafongoya, P. L. (2019). Gender, social capital and adaptive capacity to climate variability: A case of pastoralists in arid and semi-arid regions in Kenya. International Journal of Climate Change Strategies and Management.
- Ongoma, V., & Chen, H. (2017). Temporal and spatial variability of temperature and precipitation over East Africa from 1951 to 2010. Meteorology and Atmospheric Physics, 129(2), 131-144.
- Oord, A. (2017). Hydrology and hydrogeology of the Merti aquifer. Kenya: Unpublished MSc Thesis, Utrecht University, The Netherlands.
- Opere, A. O., Awuor, V. O., Koske, J., Omweri, Z. M., & Opere, C. A. (2020). Impact of climate change on water resources in Kenya. In Climate Change and Water Resources in Africa (pp. 151-180). Springer, Cham.
- Opiyo, F., Wasonga, O., Nyangito, M., Schilling, J., & Munang, R. (2015). Drought adaptation and coping strategies among the Turkana pastoralists of northern Kenya. International Journal of Disaster Risk Science, 6(3), 295-309.
- Ouko, E., Ogeto, M., & Kariuki, D. (2018). Impact of climate change on pastoralism and rangelands management in Kenya. African Journal of Environmental Science and Technology, 12(3), 145-155.

- Rao, N. (2019). From abandonment to autonomy: Gendered strategies for coping with climate change, Isiolo County, Kenya. Geoforum, 102, 27-37.
- Recha, C. W., Makokha, G. L., Traore, P. S., Shisanya, C., Lodoun, T., & Sako, A. (2017). Determination of seasonal rainfall variability, onset and cessation in semi-arid Tharaka sub- county, Kenya. Theoretical and applied climatology, 130(1), 177-188.
- Schilling, J., Opiyo, F. E., & Scheffran, J. (2014). Raiding pastoral livelihoods: motives and effects of violent conflict in north-western Kenya. Pastoralism, 2(1), 25.
- Thornton, P. K., Rosenstock, T., Förch, W., Lamanna, C., Bell, P., Henderson, B., & Herrero, M. (2019). A qualitative evaluation of CSA options in mixed crop-livestock systems in developing countries. In Climate Smart Agriculture (pp. 385-423). Springer, Cham.
- Waithaka, J., Nganga, J., Koske, J., Mutua, F., & Muthama, N. (2020). Projecting future changes in elephant distribution in East Africa under climate change and anthropogenic scenarios.
- Ecological Processes, 9(1), 51.
- Walker, S. E., Bruyere, B. L., Solomon, J. N., Powlen, K. A., Yasin, A., Lenaiyasa, E., & Lolemu, A. (2022). Pastoral coping and adaptation climate change strategies: Implications for women's well-being. Journal of Arid Environments, 197, 104656.
- Wit, P., & Stankiewicz, J. (2020). Changes in surface water supply across Africa with predicted climate change. Science, 311(5769), 1917-1921.
- World Food Programme (WFP). (2020). Climate risk and food security analysis: Kenya. WFP, Rome, Italy.
- Yala, J. A., Onono, J. O., Ogara, W. O., Ouma, G. O., & Okuthe, S. O. (2020). Adaptation Measures to Mitigate the Impacts of Climate Variability among Pastoralists in Kajiado, Kenya.

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