AFRICA RESEARCH & IMPACT NETWORK

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ASSESSING THE EFFECTIVENESS OF CLIMATE ADAPTATION INTERVENTIONS IN EAST AFRICA

Scoping Report

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About ARIN

The Africa Research and Impact Network (ARIN) is a leading research and policy network committed to advancing sustainable development in Africa. With a focus on evidence-based solutions, ARIN brings together a diverse community of experts to address critical challenges facing the continent. This report, assessing the effectiveness of climate adaptation interventions in East Africa, is a testament to ARIN's dedication to generating actionable knowledge to inform policy and practice. By synthesizing existing research and data, this study contributes to ARIN's broader mission of fostering a research-informed policy environment in Africa. ARIN's role in this report extends beyond the production of the document itself. The network's deep understanding of the region's climate challenges and its relationships with key stakeholders were instrumental in shaping the research questions and methodology. Moreover, ARIN's commitment to knowledge dissemination ensures that the findings of this report will be widely shared and utilized to inform decision-making processes at various levels.

Acknowledgement

The Africa Research and Impact Network (ARIN) would like to express its sincere gratitude to the Foreign, Commonwealth & Development Office (FCDO) for their generous funding and support for this research. Their commitment to addressing climate change challenges in East Africa is commendable.

We would also like to extend our appreciation to the East Africa Research and Innovation Hub (EARIH) for their guidance and facilitation throughout the project. Their expertise in the region has been instrumental in shaping the study's focus and methodology.

We are indebted to the numerous experts, researchers, and practitioners who shared their insights and knowledge through interviews, consultations, and the provision of data. Their contributions have significantly enriched this report.

Finally, we acknowledge the contributions of the wider research community whose work has informed our understanding of climate change adaptation in East Africa.

We believe that this report represents a valuable contribution to the growing body of knowledge on climate change adaptation in the region and hope that it will inform future policies and interventions.

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Abbreviations and Acronyms

AGN:	African Group of Negotiators
ARIN:	Africa Research Impact Network
FCDO:	Foreign Commonwealth and Development Office
FGDs:	Focused Group Discussions
GCF	Green Climate Fund
GEF	Global Environment Facility
GDP:	Gross Domestic Product
GIS:	Geographic Information System
IPCC:	Intergovernmental Panel on Climate Change
KIIs:	Key Informant Interviews
LAMA:	Locally Led Adaptation Metrics for Africa
LDCs:	Least Developed Countries
LEAD:	Locate Evidence, Evaluate Evidence, Assemble Evidence, Inform
LLA:	Locally Led Adaptation
NDCs:	Nationally Determined Contributions
OECD:	Organisation of Economic Co-operation and Development
PwC:	PricewaterhouseCoopers
SAPs:	Structural Adjustment Programmes
SCCF:	Special Climate Change Fund
SSF:	Small Scale Farmers
UNFCCC:	United Nations Framework Conventions of Climate Change
VFM:	Value for Money

EXECUTVE SUMMARY

Background

East Africa is severely impacted by climate change due to its reliance on climate-sensitive sectors and limited adaptation capacity. The region is likely to experience increased rainfall intensity, unpredictable weather patterns, and rising temperatures, exacerbating flood and drought risks. Investing in effective climate adaptation and resilience is crucial to minimise future losses and promote positive economic, social, and environmental outcomes.

Climate adaptation is a top priority for the UK Government, aligned with its Nationally Determined Contributions (NDCs) and FCDO climate, development, and nature strategies and policies. The urgent need to scale up adaptation in East African countries is emphasised by their updated NDCs and National Adaptation Plans (NAPs).

This report summarises the initial scoping analysis for a broader study on the ***Assessment of Effectiveness of Climate Adaptation Interventions in East Africa***. Funded by the UK's Foreign, Commonwealth & Development Office (FCDO) through the East Africa Research and Innovation Hub (EARIH), the study aims to inform FCDO's future adaptation programming by generating robust evidence on the effectiveness of adaptation interventions across nine East African countries: Kenya, Tanzania, Uganda, Rwanda, Burundi, Ethiopia, Eritrea, Somalia, and South Sudan.

Methodology

A two-phase approach was adopted for the study, commencing with an initial scoping exercise to understand East Africa's adaptation action and knowledge landscape. Adaptation interventions were mapped across the region, focusing on key sectors such as agriculture and food security, water security and management, nature-based solutions, resilient land management, and disaster risk reduction. Intervention details were sourced from major multilateral databases (Global Environment Fund, Green Climate Fund, Adaptation Fund, World Bank, African Development Bank Fund (AfDB), Bill and Melinda Gates Foundation), bilateral arrangements (FCDO, JICA, BMZ, IFADGIZ, USAID, IKI), and other private sector and NGO-led platforms. Project documents were reviewed, and websites were scanned to characterise interventions based on activities, technologies/innovations, community engagement, and reported impacts. A systematic literature review of published and relevant policy documents complemented this process, identifying evidence on the effectiveness of different practices and research gaps. These scoping activities informed the empirical study conducted in phase two.

Results

The scoping exercise identified 242 projects and interventions across East Africa. The majority of these interventions were in Kenya, primarily focused on agriculture and food security (35.9%) and water security and management (21.1%). The mapping exercise revealed an uneven distribution of interventions across countries. This imbalance may be influenced by donor interests, political stability, and governance issues, affecting how effectively projects are mobilised, designed, and implemented. Notably, these disparities could trigger climate-induced migration as people move from underserved countries to those with more interventions and better resilience, potentially jeopardising the overall effectiveness of adaptation efforts.

In agriculture and food security, practices such as Climate-Smart Agriculture hold promise as they address multiple challenges faced by communities, including food security, climate resilience, and low-carbon development. Micro-irrigation and enhanced water harvesting technologies are also contextually suitable for diverse communities.

The analysis reveals that interventions with a "nexus" approach, connecting different sectors such as Water, Energy, Food, and Ecosystem (WEFE), Nature-based Solutions, Climate-Smart Agricultural Practices, and Integrated Water Management, offer potential impact and investment opportunities. However, more evidence is needed to identify effective strategies in these areas. For example, integrated approaches combining multiple Climate-Smart Agriculture (CSA) practices can provide better value for money and should be encouraged. Yet, there is limited evidence on successful models for integrated CSA practices. Key areas lacking evidence include cost-benefit analysis, socio-technical feasibility, and the integration of new and modern technologies with CSA practices. Adequate evidence on the nexus approach would provide key actors with crucial insights into linkages, design considerations, and investment opportunities to optimise outcomes.

At the institutional level, aligning interventions with national policy priorities outlined in NDCs and adaptation plans can secure political support. The nexus approach requires integrated institutional arrangements and governance that engage different sectors, stakeholders, and communities in decision-making. Local leadership is crucial for aligning interventions with local needs and incorporating indigenous knowledge. While technological innovation can drive immediate impact, building long-term adaptive capacity requires a broader focus. Evidence suggests that effectiveness extends beyond technological solutions, influenced by political systems, local financing, indigenous knowledge, benefit-sharing, cultural factors (including gender), and other contextual elements.

Funding conditions (source, instrument, and expectations) significantly influence intervention effectiveness, particularly design and implementation. Most projects rely on grants from non-profit organisations, incentivising benefit transfers and non-market transactions. This can discourage the development of innovative business models attracting private financing for promising technologies. Transitioning from

project-based initiatives to sustainable business models remains a challenge, hindering long-term effectiveness. Short project implementation periods (typically five years) exacerbate this issue, as benefits often end after the funding period.

Nonetheless, efforts are underway to mobilise private sector financing and investments for adaptation through multilateral development banks and flagship programmes such as the African Development Bank's Adaptation Accelerator Programme. While this holds promise for enhanced effectiveness, investing in institutional preparedness and capacity building is essential to facilitate the adoption of private financing for promising practices.

This scoping report has identified promising opportunities for understanding the effectiveness of climate adaptation interventions across East Africa. The findings highlight key areas for further investigation through in-depth empirical studies in Phase 2 of the project.

1. INTRODUCTION

1.0 INTRODUCTION

East African communities, particularly vulnerable populations, are on the frontline of climate change, experiencing devastating impacts on livelihoods, food security, and well-being. Despite contributing minimally to global greenhouse gas emissions (4%) (IEA, 2022; UN, 2006), Africa, including East Africa, faces severe current and future climate risks due to its reliance on climate-sensitive sectors and limited adaptive capacity. The region's diverse climate, ranging from hot, arid regions to cooler, wetter highlands, exacerbates the impact of frequent and intense extreme weather events, hindering recovery efforts.

East Africa's climate is diverse, ranging from hot, arid deserts to cooler, wetter highlands, with significant seasonal rainfall variability (Richardson et al., 2022). The region's vulnerability to extreme weather events is exacerbated by this climatic diversity, impacting sectors such as water security, education, health, agriculture, biodiversity, livelihoods, and the overall economy (Klein et al., 2014; Nyasimi et al., 2014; Jayne et al., 2018; Richardson et al., 2022).

The consequences of East Africa's cyclical droughts have intensified in recent decades (Haile et al., 2019). The 2015-2016 drought resulted in poor harvests, a surge in food insecurity, and exacerbated poverty, hunger, and inequality in Kenya, Ethiopia, and Somalia, leaving over 12 million people reliant on humanitarian aid (Funk, 2020). Climate extremes have also had significant economic impacts. In 2020, unprecedented weather events compounded by the COVID-19 pandemic contributed to a 3.3% decline in average GDP (World Bank, 2020). The same year witnessed the displacement of 1.4 million East Africans due to floods, with 309 fatalities or missing persons (International Organization for Migration, 2023; Agulonye et al., 202

Despite these striking climate impacts, the East Africa's adaptative capacity index remains relatively low compared to other African regions. The East Africa Economic Outlook (AfDB, 2022) indicates a low the Climate Resilience Index (**CRI)**[1] of 25.0 for the region, significantly lower than Southern Africa (43.6) and North Africa (63.5) (**Figure 1**). The CRI varies among East African countries, ranging from 18.3 to 28.9, with Djibouti, Kenya, Tanzania, and Uganda leading and South Sudan lagging[2].

[1] The Climate Resilience Index is calculated as **RI=(ACI*TCI)/(EI*SI)**; where RI: climate resilience index, ACI: adaptive capacity index, TCI: transformative capacity index, EI: exposure index, and SI: sensitivity index. The index is derived by considering GDP as well as readiness and vulnerability to climate change.

[2] Climate Resilient Index

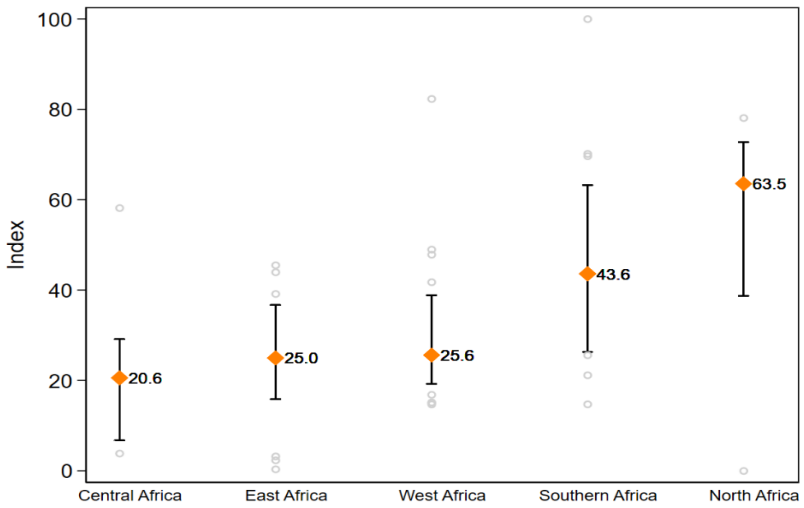


Figure 1: Climate Resilience Index Scores Across Regions in Africa (2010-2019). Source: AfDB, 2022.

Global and national policies increasingly prioritise locally led and inclusive adaptation (LLA) to address community vulnerabilities (GEF, 2011). LLA promotes community-driven climate action, including decision-making, technology adoption, financing, and tailored responses to specific vulnerabilities (Soanes et al., 2017). Recognising the diverse impacts of climate change within communities, LLA empowers communities by devolving decision-making, finances, and resources (Soanes et al., 2017). The COP26 agreement emphasised scaling up adaptation for vulnerable communities, including women and marginalised groups, by increasing adaptation funding to $50 billion annually.

In East Africa, these efforts are hindered by a lack of robust evidence on the effectiveness of interventions in addressing vulnerabilities and scaling up investments in promising options. Key questions remain: are these initiatives benefiting vulnerable communities? Are they achieving desired impacts, such as promoting equity and providing value for money? Without clear answers, valuable resources may be wasted, hindering progress towards a more resilient future. This project aims to bridge this gap by generating evidence on the effectiveness of adaptation interventions across East Africa.

This study, funded by the UK's Foreign, Commonwealth and Development Office (FCDO) through their East Africa Research and Innovation Hub (EARIH), aims to enhance understanding of the effectiveness of adaptation interventions in East Africa to inform future investments. It seeks to 1) identify priority adaptation sectors and interventions, along with institutional frameworks for building adaptive capacity. 2) Understanding the factors influencing intervention adoption and the specific needs of marginalized groups is crucial. 3) Mapping the landscape of key adaptation actors will also be undertaken. By thoroughly investigating and analysing the focus and effectiveness of interventions, this project will inform future strategies for building resilient communities in East Africa, ensuring equitable and sustainable adaptation action for all East Africans facing climate challenges.

2. METHODOLOGY

2.0 METHODOLOGY

2.1. Geographical and Thematic Scope

The study focuses on nine countries in East Africa (**Figure 2**). To analyse interventions, the study focused on four key sectors or themes: nature-based solutions and regenerative land management; agriculture and food security; water security and management; and disaster risk reduction (DRR), encompassing drought and flood risk reduction in both rural and urban areas.

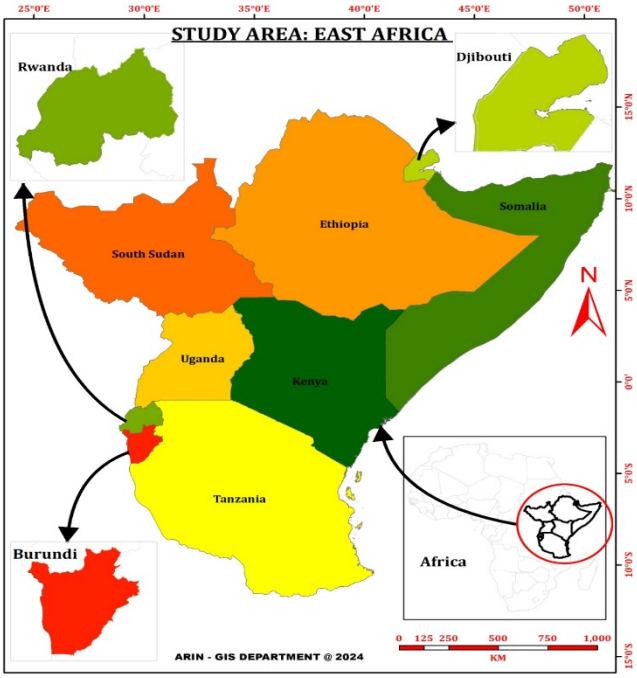


Figure 2: East African Countries Targeted by the Study

2.2. Analytical Framework

Effective adaptation manifests in various outcomes for different stakeholder groups. This study defines effective adaptation interventions as those likely to achieve their intended goals. The study considers diverse adaptation goals, including 1) maximising economic benefits, 2) improving well-being, 3) reducing vulnerability and enhancing adaptive capacity, 4) enhancing resilience, 5) promoting sustainable adaptation, 6) avoiding maladaptation, 7) promoting ecosystem-based adaptation, 8) facilitating community-based adaptation, 9) achieving adaptive governance, 10) ensuring equity and justice, and 11) promoting transformation. These indicators, adapted from Singh et al. (2022), acknowledge the spectrum of effective adaptation, covering both process-based and outcome-based approaches. Effective adaptation entails minimising costs, maximising economic benefits, supporting well-being, and reducing vulnerability, particularly for the most vulnerable populations.

Evidence appraisal was conducted to understand how effectiveness has been assessed and identify gaps in accuracy, relevance, methodological robustness, and other aspects. The Locate, Evaluate, Assemble, and Decide (LEAD) framework was applied to assess how evidence answers practical questions, enabling evaluation of the relevance of existing evidence for informed decision-making.

2.3 Data collection

Figure 3 presents the three phases of data collection for this study. The report covers phases 0 and 1. The data-gathering process began with an inception phase in January 2024. This phase involved a collaborative meeting among the project consultant (Africa Research and Impact Network, ARIN), the project commissioners (Foreign, Commonwealth and Development Office, FCDO), and the fund managers of the East Africa Research and Innovation Hub (EARIH), PricewaterhouseCoopers (PwC). The meeting aimed to review and confirm the project's objectives, scope, timelines, and methodology.

Phase 1 involved an initial scoping exercise to understand East Africa's adaptation landscape. This included mapping adaptation interventions across the region in the four key sectors outlined in 2.1. Information on the interventions of multilateral agencies was reviewed via their databases, including the Global Environment Fund, Green Climate Fund, Adaptation Fund, World Bank, and African Development Bank Fund (AfDB). Additionally, interventions funded by bilateral agencies such as FCDO, JICA, BMZ, IFAD, GIZ, USAID, IKI, Bill & Melinda Gates Foundation, and other private sector and NGO-led platforms were reviewed. Project documents and websites were examined to characterise interventions based on their activities, applied technologies/innovations, community engagement efforts, and reported impacts.

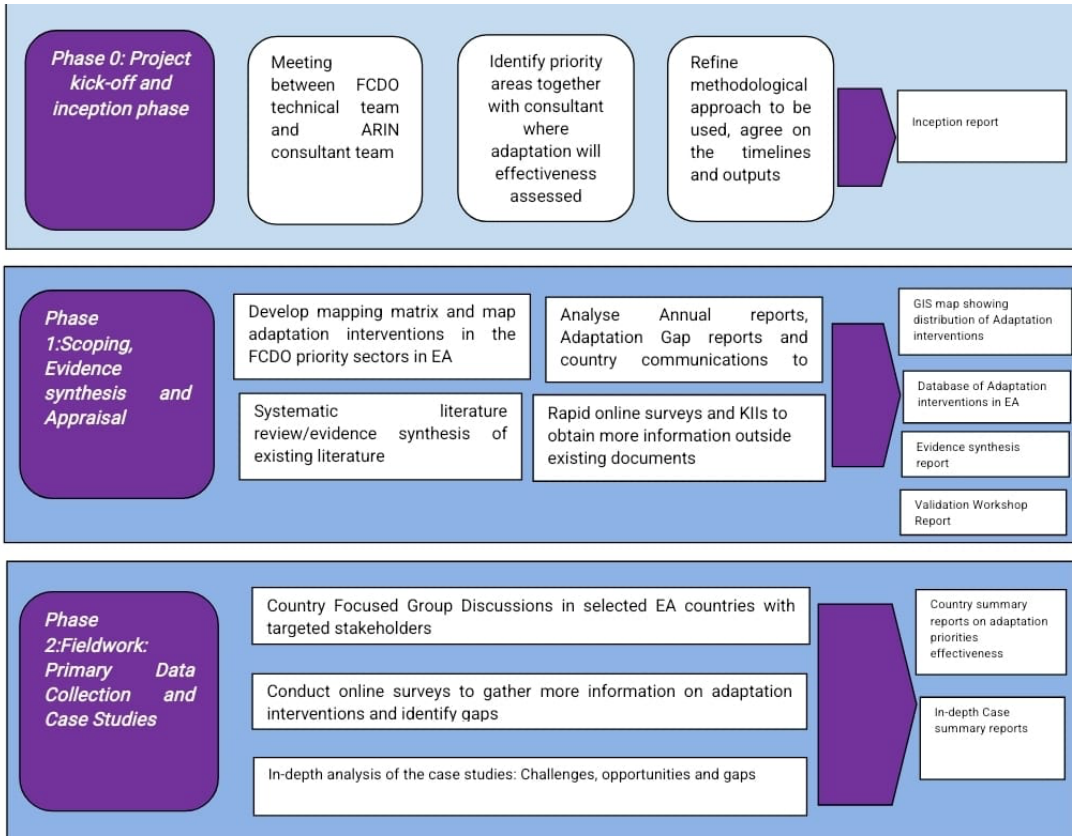


Figure 3: Data Collection Framework

To further understand the evidence surrounding intervention effectiveness, a systematic review of both published and relevant policy documents was conducted. This review identified the current state of evidence for different practices and existing knowledge gaps requiring further research attention. A virtual regional consultative workshop held on 28 February 2024 validated the preliminary intervention mapping and evidence synthesis. These scoping activities in Phase 1 will inform the empirical study to be undertaken separately in Phase 2 of this work

3. RESULTS

3.0 RESULTS

3.1. Adaptation Interventions in East Africa

This section presents the key findings of the scoping study. Priority sectors are identified as sectors where investments have the highest potential for building adaptive capacity and resilience to climate change. The section first outlines some of the region's main climate risks, before detailing some potentially promising interventions/innovations drawing on the evidence.

3.1.1. Climate Risks and Impacts on Different Sectors.

Climate risks refer to the potential for climate change to create adverse consequences for human or ecological systems. This includes impacts on lives, livelihoods, health and well-being, economic, social, and cultural assets and investments, infrastructure, service provision, ecosystems, and species (Selvaraju, 2012). Extreme and erratic weather events have been observed in East Africa, manifesting as high average temperatures and rainfall variability (Ackerl et al., 2021; Steynor et al., 2021). The impacts of these extreme events on key livelihood and economic sectors such as agriculture, water, health, energy, and natural resources are widely documented.

Agriculture accounts for up to 40% of the gross domestic product (GDP) on which East African economies depend, impacting the livelihoods of 65% of the region's population (Adhikari et al., 2015). Over 70% of the region's population are small-scale farmers reliant on rainfed agriculture for their livelihoods, with 40% of GDP derived from agriculture (Adhikari et al., 2015). The sector is vulnerable to climate risks due to rising temperatures and increasing precipitation variability (Richardson et al., 2022). According to the Drought in East Africa Report (2022), the severe impact of prolonged droughts on soil moisture and crop yields leads to annual and seasonal crop failures among rural small-scale farmers in the region. The report further estimates that approximately 70 million people in East Africa are exposed to drought risks due to frequent failed rainy seasons. Successive failures in the rainy season from 2018 to 2022 have particularly affected agricultural productivity and food and nutritional security in arid and semi-arid regions, as well as the highlands of Kenya, Ethiopia, Sudan, Uganda, and Somalia (UNFCCC, 2020). Due to this drought, 23 million people in Kenya, Ethiopia, and Somalia faced famine, while another 2.3 million people were internally displaced in Somalia, Ethiopia, and Kenya, resulting in a record 264,000 climate migrants (refugees).

A severe locust invasion occurred during this period, the worst in 25 years for Ethiopia and Somalia, and 70 years for Kenya. The locust invasion devastated crops, impacting agricultural livelihoods and food availability across the region. The prevalence of such insects and other vectors is linked to changing temperatures and precipitation patterns, further affecting the health of vulnerable populations.

Major East African water sources, such as Lakes Edward, Albert, Kivu, Victoria, Tanganyika, and Malawi, have experienced temperature rises of between 0.2 and

0.7°C, affecting water quality and availability and exposing an increasing number of people to water stress. The Mara River Basin, flowing between Kenya and Tanzania, is increasingly facing water resource stress due to high water demand and urbanisation (Roy et al., 2018). Increased water resource stress affects water availability and quality for domestic use and poses further risks to agricultural productivity and nutritional well-being for both rural and urban households (Ackerl et al., 2021).

Sea level rise is occurring in the coastal zones and cities of Kenya, Somalia, and Tanzania (World Bank, 2015), posing a risk of flooding in low-lying cities, notably Mombasa and Dar es Salaam (World Bank, 2021). Floods in urban areas destroy infrastructure, roads, and health facilities, contaminate water, and have been linked to an increase in vector-borne diseases such as cholera and malaria. In rural areas, floods cause livestock deaths and crop losses, destruction of homes, soil erosion, and land degradation. Where deforested slopes become waterlogged, disasters such as landslides and deaths are common (Richardson et al., 2022).

The most important economic and livelihood sectors in East Africa are therefore highly vulnerable to climate change. Averting these climate risks and building the resilience of people and infrastructure is crucial for the region's sustainable growth (Kumamoto & Mills 2014; GCA, 2019; Richardson et al. 2022). Several adaptation interventions are already in place to address these risks, as discussed below.

3.1.2 Characterising Adaptation Interventions in East Africa

Figure 4 shows the characterisation and spatial distribution of interventions identified across the nine (9) countries. A total of 242 adaptation projects were identified, with the highest number of projects located in Kenya (n=55), followed by Uganda (n=46), while South Sudan had the fewest projects (n=6) (**Figure 5).** This imbalance may be influenced by donor interests, political stability, and governance issues, affecting the mobilisation, design, and implementation of projects. These disparities could trigger climate-induced migration, as people move from underserved countries to those with more interventions, potentially jeopardising the overall effectiveness of adaptation efforts.

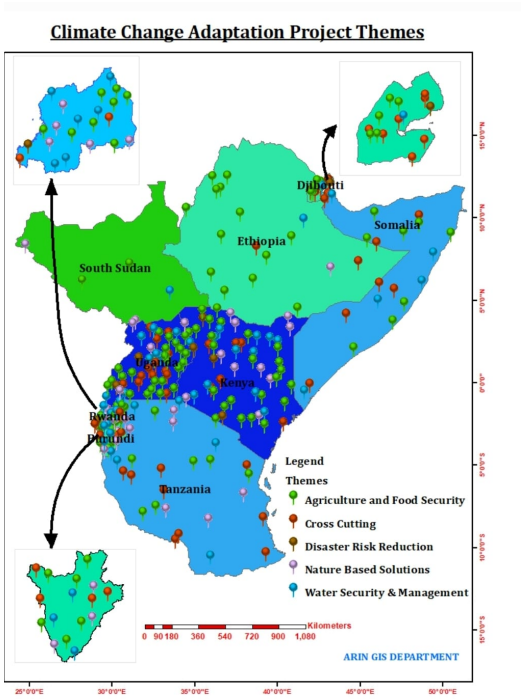


Figure 4: Spatial distribution of the a) total identified Adaptation Projects and b) per thematic areas (n=292).

Interventions identified were predominantly focused on agriculture and food security (35.9%), and water security and management (21.1%). A similar trend was observed in the number of studies retrieved in the literature review (n=235). The implementation period of most projects ranged from 1 to 13 years, with over 50% of interventions having a duration of one year or less.

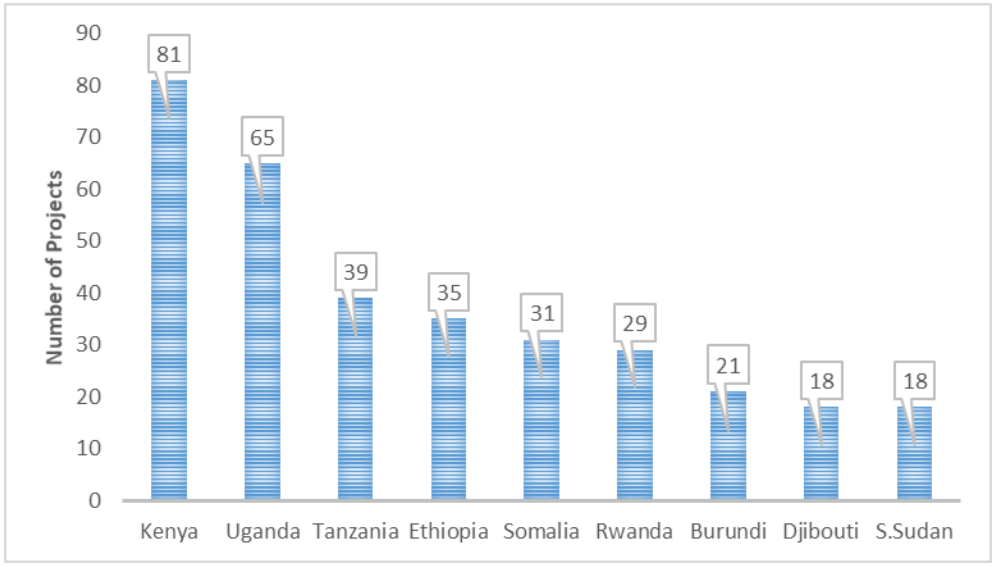


Figure 5: Number of adaptation projects per country

Currently, the main multilateral funders are the UNFCCC Adaptation Fund, Green Climate Fund (GCF), Global Environment Facility (GEF), and Multilateral Development Banks, including the World Bank and African Development Bank (AfDB). The main

bilateral donors of adaptation projects are JICA, USAID, FCDO, BMZ, IKI, and GIZ. The majority of funding (90%) for interventions is in the form of grants, with less than 5% considering equity. This reliance on public funds indicates limited private sector involvement in adaptation financing.

The current mean annual project budget is £4,032,614, with wide variation—the smallest project has an annual budget of £21,787, while the largest is £60,108,259 per project. **Figure 6** shows the variation in project costs per country, with the widest range in Tanzania and the lowest in Burundi.

Grant funding often incentivises benefit transfers and non-market transactions. This approach can discourage the development of innovative business models that attract private financing for promising technologies. Consequently, transitioning adaptation interventions from project-based initiatives to sustainable business models remains challenging, hindering long-term effectiveness. Short project implementation periods (typically five years or less) exacerbate this issue. Efforts are underway to mobilise private sector financing and investments for adaptation through multilateral development banks and flagship programmes such as the African Development Bank's Adaptation Accelerator Programme. While promising, this requires investing in institutional preparedness and capacity building to facilitate the adoption of private financing for promising practices.

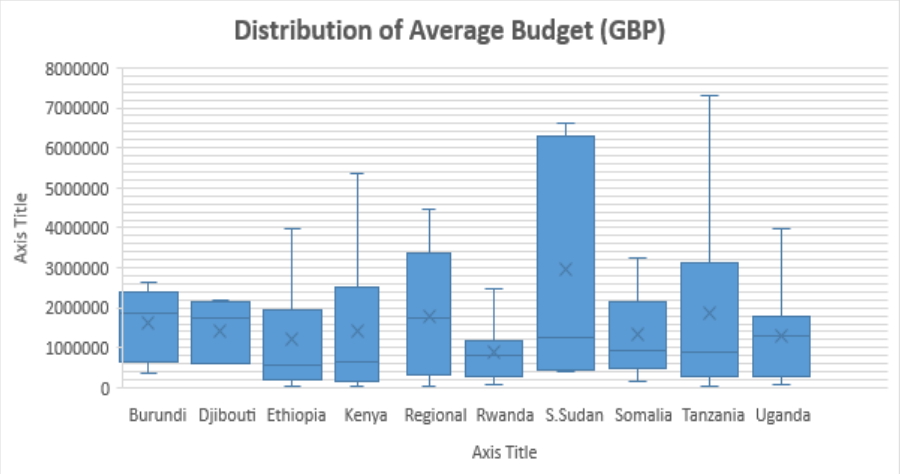


Figure 6: Box Plots of Average Annual Project Budget per Country

3.2 Adaptation Priorities in Policy

The National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) were reviewed to identify priorities and assess their alignment with current risks and interventions. Table 1 summarises the identified priority sectors. Agriculture and food security, as well as water security and management, are the most commonly highlighted sectors in these policy documents. While some alignment exists between policy sectors and climate risks, notable gaps remain. For instance, disaster risk

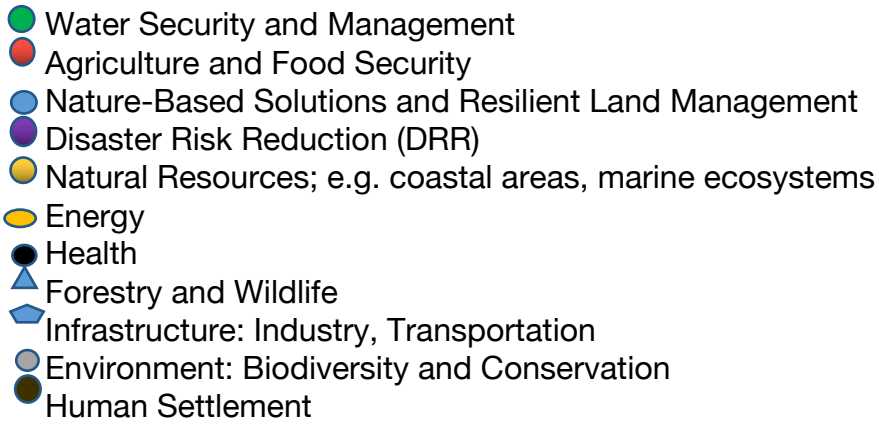
reduction measures are crucial for addressing flooding and other risks in Uganda and Rwanda (Knapen et al., 2006; Richardson et al., 2022), yet these actions are often overlooked in national policies.

Similarly, Burundi, Uganda, Rwanda, Djibouti, and Somalia omit human settlement and infrastructure from their policies, while Uganda, Rwanda, South Sudan, and Ethiopia do not include natural resource management (NRM) despite its significant role in their economies and livelihoods. Nature-based solutions (NbS) and resilient land management are mentioned only in the NAPs and NDCs of Kenya and Uganda, while health is excluded from those of South Sudan and Djibouti. These discrepancies indicate potential policy impediments for adaptation interventions in sectors not covered by the policy agenda. The prominence of agriculture and food security as a priority sector across all East African countries' policies reflects the sector's crucial role as a major livelihood and economic driver, heavily dependent on ecosystem services.

While sectoral considerations may be similar across countries, the specific activities, technologies, and innovations adopted differ contextually. For instance, in agriculture and food security, activities such as irrigation, intensive agriculture, animal husbandry, drought-resistant species introduction, integrated water resource management, and early warning systems are tailored to specific ecologies, communities, and landscapes.

Table 1: Priority Sectors in the NDCs and NAPs per Country (Source: Illustration done by ARIN)

S/N	Country	Priority Sectors										
1	Burundi	●				●	●	●				
2	Kenya	●	●	●	●	●	●	●	▲	⬟	●	
3	Uganda	●	●	●				●	▲			
4	Rwanda	●	●					●	▲			
5	Djibouti	●	●			●			▲			
6	South Sudan	●	●		●		●			⬟	●	●
7	Tanzania	●	●			●	●	●	▲	⬟		●
8	Ethiopia	●	●					●	▲	⬟		
9	Somalia	●	●		●	●		●			●	



Notes: Rwanda and Uganda face significant risks such as floods and landslides but lack adequate disaster risk reduction (DRR) measures, human settlement, or infrastructure considerations within their NDCs and NAPs. South Sudan and Djibouti do not prioritize health in their respective policy documents. (Source: Information derived from an assessment of sectoral priorities in NDCs and NAPs in Rwanda and Uganda [Refer to page 96, MET, flooding and Lake Victoria - Box 8])

3.3 Characterising Evidence on Effectiveness of Adaptation Interventions

The review identified 235 studies, of which 112 met the inclusion criteria. The distribution of reviewed studies mirrored the distribution of interventions, with the highest number from Kenya (20%, n=22) followed by Uganda (13%, n=15). Burundi and Somalia had the fewest reviewed studies (3%, n=3 and 1%, n=1 respectively) **(Figure 7**).

Thematic areas receiving the most attention in the reviewed studies were agriculture and food security, nature-based solutions (NbS), and water security and management. Health was the least studied sector. Some studies addressed multiple sectors and their interconnections (**Figure 11**). Research interests varied across countries. Studies in Kenya, Uganda, Burundi, and Tanzania primarily focused on agriculture and food security, while those in Ethiopia and Rwanda examined the linkages across sectors. Somalia had a particular focus on disaster risk reduction (DRR) with fewer studies on other sectors.

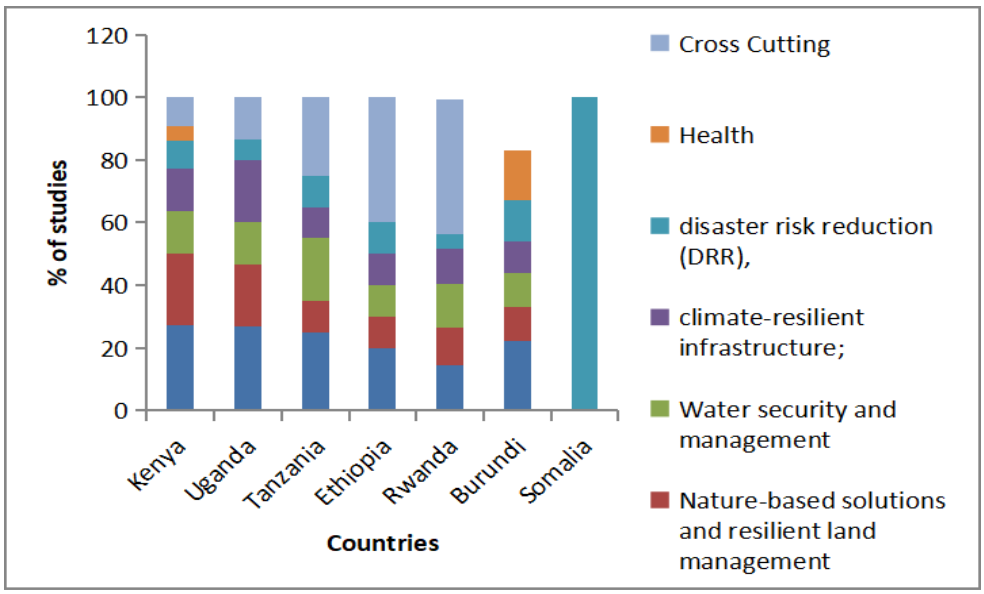


Figure 7: Illustration of Thematic Interventions

Studies on agriculture have primarily focused on climate-smart agriculture (CSA) practices, which include a range of activities such as livestock management, crop management, sustainable land management (SLM), and climate information services. These services are crucial for guiding farmers on optimal planting times and other important decisions to enhance crop yields.

Interventions related to water security and management include integrated water management (IWM), water governance and planning, and the application of indigenous knowledge systems and local knowledge to water adaptation (see Table 2). Hydrological modelling and simulation to predict future scenarios and inform planning and policy reviews or changes were also identified. The impacts of water security on livelihoods were cited in most studies, highlighting gaps that need to be addressed to enhance community resilience (Table 4).

In the Nature-based Solutions (NbS) theme, key intervention types include forest ecosystems, integrated urban management, nature-based solutions for livelihood management, and mainstreaming ecosystem-based adaptation into policies. Kenya had more studies conducted in these areas compared to other countries (see Lokidor et al. 2023 and Kalantari et al. 2018).

Flood risk reduction and early warning systems, as well as hydrological modelling, were among the key interventions identified within the Disaster Risk Reduction (DRR) theme.

Overall, the review of the evidence reveals that some countries, such as Somalia and Burundi, as well as certain thematic areas, are less studied. This indicates an evidence gap that could impede a comprehensive understanding of the effectiveness of various interventions in these contexts. Nonetheless, there are pertinent lessons from the available evidence that can be used to inform future interventions across the region.

Table 2: Adaptation Intervention per Thematic Area

S/N	Thematic Area	Adaptation Interventions Activity	Selected References
1	Agriculture and Food Security	-Climate-smart Agriculture (CSA) e.g. agroforestry, inter-cropping, crop rotation -Livestock Management -Crop Management -Financial Investment -Sustainable Land Management (SLM) -Community and Livelihood Resilience -Climate Information Services	Bayala et al., 2012, Zougomere et al., 2021, Recha et al., 2022, Radeny et al., 2029, Kuyah et al., 2023
2	Water security and Management	-Integrated Water Management -Water governance and Planning -Indigenous Knowledge System -Hydrological Modelling	Banda et al 2022, Moges et al., 2013
3	Nature Based Solutions (NbS)	-Ecosystem-based Adaptation (EbA) -Integrated urban Management -NbS for flood management -EbA Mainstreaming into policies	Viguola et al., 2015, Musonda et al., 2015, Locateli et al., 2015
4	Disaster Risk Reduction	-Flood risk reduction in urban settlement -Early Warning Systems -Information climate services -Risk and Governance -Hydrological Modelling -Drought Risk Adaptation -Urban development plans and policies	Ackerl et al., 2023, Steynor et al., 2023, Giller et al., 2015, Hartman et al., 2022
5	Climate Resilient Infrastructure	-Urban Governance and Planning -Early warning system (EWS)	Charisa et al., 2016, Nabutola, 2006

3.4 Analysis of the Effectiveness of Interventions

This section examines the effectiveness of interventions in East Africa, exploring how well they achieve specific outcomes, including improved well-being (e.g., crop yield), efficiency (value for money), equity, justice, transparency, and accountability. It also analyses the effectiveness of different adaptation interventions, including practices, technologies, and behaviours. Particular focus is placed on technologies, capacity building, financing, as well as policy and planning interventions within each theme/sector. The section concludes with a discussion on considerations for prioritising these interventions and provides a summary.

3.4.1 Agriculture and Food Security

Most interventions aimed at improving agriculture and food security fall under the umbrella of climate-smart agriculture (CSA) initiatives.

Technological, Practices, and Behavioural Interventions through CSA: The Food and Agriculture Organisation (FAO) defines Climate-Smart Agriculture (CSA) as an agricultural approach that tackles food security and climate challenges simultaneously. It contributes to three goals: sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change, and reducing and/or removing greenhouse gas emissions (mitigation) where possible (FAO, 2013). Studies evaluating the effectiveness of CSA interventions in East Africa and elsewhere have primarily focused on assessing the extent to which CSA meets these goals. CSA covers a broad range of practices, technologies, and behaviours, including but not limited to improved livestock management, crop management, sustainable land management (SLM), agroforestry, conservation agriculture, and crop rotation.

The evidence suggests that CSA achieves at least two of its intended objectives: increasing agricultural productivity and food security, while also enhancing adaptive capacity and resilience. A systematic review and meta-analysis of CSA practices in Tanzania and Uganda by Lamanna et al. (2016) found positive outcomes for both productivity and adaptation indicators across all considered CSA practices. These practices included inter-cropping, agroforestry, tree management, crop management, soil management, water management, nutrient management, post-harvest management, and livestock diet management.

In Ethiopia, Gezimu et al. (2023) found that CSA practices, such as planting drought-tolerant crop varieties, adjusting planting dates, and cultivating diverse crops, led to increased food security. Furthermore, research in Isiolo, Kenya (Quandt, 2020), Siaya and Vihiga counties in western Kenya (Kuyah et al., 2019), and the Eastern Arc Mountains (EAM) of Tanzania (Mkonda et al., 2017) highlighted the significant potential of agroforestry, a CSA intervention, to enhance adaptation to climate change within the agricultural sector. Specifically, agroforestry contributes to increased farm profitability by diversifying and improving output per unit area within tree/crop/livestock systems, protecting against the detrimental effects of wind or water flow, and introducing new products that contribute to the financial diversity and flexibility of farming enterprises (Nguyen et al., 2013).

Long-term agronomic experiments in Ethiopia's drylands have demonstrated that conservation agriculture[3] (CA), another CSA intervention, can increase grain yield compared to conventional agriculture (Araya et al., 2016). This practice is particularly relevant in East Africa due to its high rainfall variability. CA promotes adaptation to climate variability in both high and low-rainfall areas (Below et al., 2010; Kabirigi et al., 2015). Social experiments comparing adaptation outcomes between participating

[3] Conservation agriculture is based on three basic principles: the lowest possible soil disturbance, permanent organic cover, and crop diversification (FAO, 2015)

and non-participating social units (individuals, households, villages) corroborate findings from agronomic experiments. These studies confirm similar positive outcomes from CSA. For example, Alem et al. (2015) found that the system of rice intensification increased maize yields and water use efficiency in Tanzania. Additionally, Thorlakson & Neufeldt (2012) confirmed that agroforestry improved farm productivity, off-farm income, wealth, and farm environmental conditions in Nyando district, Kenya. In Uganda, Kato et al. (2010) concluded that practices like irrigation, fertilizers, improved fallow, crop residues, mulching, and trash lines increase crop production and reduce production risk by mitigating the effects of climate change and variability. Regarding economic feasibility, Akinyi et al., 2022 examined various CSA practices[4] in five Sub-Saharan African (SSA) countries, including Kenya and Ethiopia. They found that CSA practices were profitable across all countries, as measured by net present values, internal rates of return, and benefit-cost ratios, with payback periods ranging from 1-2 years.

Accordingly, integrated approaches that combine several Climate-Smart Agriculture (CSA) practices provide higher value for money and should be encouraged (Mutenje et al., 2019). However, there is limited evidence on effective models for integrating CSA practices. Key areas lacking research include the economic viability of integrating various CSA practices, with current studies not sufficiently addressing how different practices can be economically combined to enhance their overall impact. Additionally, further research is needed to evaluate the socio-technical feasibility of integrated CSA practices, including understanding how different communities and stakeholders interact with and benefit from these practices. There is also a gap in research on incorporating indigenous knowledge into CSA practices, as local expertise could potentially enhance the effectiveness and sustainability of these interventions. Furthermore, research should explore how CSA practices advocating for natural regeneration can be effectively linked with modern agricultural technologies such as intensification and mechanisation. This integration is crucial for addressing urgent food security gaps and creating a more robust and adaptable agricultural system

Capacity-Building Interventions: Capacity-building interventions aim to equip farmers with the knowledge and skills necessary to appreciate and adopt new agricultural practices and technologies (Kirina et al., 2022; Beal et al., 2021; Kalimba & Culas, 2020; Juvvadi et al., 2013). Although the review identified limited causal evidence on the impact of these interventions, some promising examples exist. For instance, Farmer Field Schools (FFS) provide training to communities, including women and children, on climate-resilient technologies such as drought-resistant crops and agroforestry techniques. The Mwangaza Field School in Tanzania is a notable example of this approach. It offers training and self-learning opportunities within FFS fields, helping farmers gain knowledge on practices such as breaking hard pans, using organic fertilisers, and becoming trainers themselves (Omwenya et al., 2011).

[4] CSA practices evaluated included the use of improved seed, weeding, alternate wetting and drying in rice cultivation, selecting proper harvesting dates, proper storage bags during harvest, proper management of storage facilities, minimum tillage, mulching, crop rotation and intercropping.

Another study employed a social experiment methodology, comparing participating and non-participating households to assess the impact of capacity-building interventions delivered by the Global Climate Change Alliance's (GCCA+) project in Tanzania. These interventions included financial and business education, Farmer Field Schools (FFS), and extension services for the uptake of Climate-Smart Agriculture (CSA) technologies. While the project increased training opportunities and information access for participating households, the study found no significant increase in income or assets (livestock, market access). This lack of impact is likely due to the project ending before participants could fully translate acquired knowledge into action (Gaworek-Michalczenia et al., 2022). Additionally, limited local leadership hindered the development of socio-technical synergies between introduced technologies and local farming systems (Kirina, 2022; Ogunyiola et al., 2022; Atela, 2012).

Putting acquired skills into practice requires sustained support, local leadership, and long-term investments beyond project lifespans. These are key enablers that are often missing from project designs. More experimental studies are needed to bridge the gap between acquired skills and practical application.

Financing: Studies on financing practices have primarily focused on the types of financing available, advocacy for specific options, and governance structures. Social protection programs, such as weather-indexed crop insurance, asset restocking (including direct livestock provision), and cash transfers (Davies et al., 2009), are crucial financing mechanisms within the Climate-Smart Agriculture (CSA) space.

Evidence from Kenya's Hunger Safety Net Programme (HSNP) and Cash Transfer for Orphans and Vulnerable Children (CT-OVC) programmes demonstrate the effectiveness of cash transfers. These programmes enable individuals to meet basic needs during droughts and crop/livestock losses, while also enhancing credit access and savings (Merttens et al., 2013). Assessing cases in Kenya, Uganda, and Ethiopia, Ulrichs et al. (2016) highlight that these programmes significantly contribute to people's capacity to absorb the negative impacts of climate-related shocks and stresses on their livelihoods.

Furthermore, a social experiment in Ethiopia found that the Productive Safety Net Programme (PSNP) – a major social protection scheme – decreased household vulnerability to climate-induced shocks. This programme enabled people to diversify their livelihoods away from rain-fed agriculture, which is highly susceptible to climate change (Weldegebriel, 2016). Index-based insurance was also shown to mitigate climate change impacts in Ethiopia by encouraging increased household farm investments (Belissa, 2019).

There is growing advocacy for scaling up market-based approaches to financing adaptation, including Payment for Environmental Services (PES) schemes (FAO, 2010). While suggestions exist to link carbon credits from Climate-Smart Agriculture (CSA) to PES schemes, evidence on how PES supports adaptation remains limited. Some studies even suggest limited impacts of PES projects on well-being and income (Nantongo et al., 2024; Duchelle et al., 2018). Nonetheless, further research

is needed on how to strengthen the adaptation benefits of PES in CSA actions, including exploring sectoral synergies between agriculture, forests, and land. The Community Markets for Conservation (COMACO) Landscape Management Project in Zambia, which promotes sustainable agriculture and forest conservation, exemplifies this approach.

Devolved financing**,** another approach under study, focuses on strengthening local structures to improve access to funding for local farmers. The County Climate Change Fund (CCCF) in Kenya, now scaled out nationally through the Financing Locally Led Climate Action (FLLOCA) program, serves as an example. The CCCF facilitates the flow of climate finance to county and local governments and empowers local communities by enabling public participation in managing and using climate funds.

Studies indicate that the CCCF model delivers livelihood benefits necessary for building resilience to climate change. It also provides better value for money compared to nationally managed funds, as direct benefits from investments far exceed the costs of implementing the CCCF mechanism. Furthermore, the model enhances the inclusion and participation of local communities while improving accountability and transparency in planning and implementing adaptation interventions (Adeninyi, 2023; Crick et al., 2019).

Therefore**,** early evidence suggests that devolved financing models may be effective based on both outcome-based indicators (e.g., costs, benefits, well-being, resilience) and process-based indicators of effectiveness (e.g., justice, equity, transparency, and inclusion). However, further rigorous evidence from experimental and longitudinal causal studies is required to build a stronger case for these models.

Policy and Planning: Policy, planning, and governance mechanisms play a crucial role in shaping the successful implementation of adaptation strategies. A robust study by Nkonya et al. (2015) examined the effectiveness of policy interventions using case studies from four Sub-Saharan African (SSA) countries, including Uganda and Kenya. This research explored the impact of sustainable land management policies on climate risk management. In Uganda, the study focused on the effects of government decentralisation and land tenure system reforms. In Kenya, it examined policies supporting agricultural research and development, along with creating an agricultural market environment that incentivises farmers to adopt sustainable land and water management practices. The findings revealed that policies implemented in both countries contributed to the development of stronger local institutions, ultimately leading to improved community resource management.

Future adaptation programming should emphasize collaboration between key stakeholders, including local government authorities. This collaboration is critical for establishing information-sharing platforms to facilitate the exchange of resources and knowledge. A successful example is e-Soko, an agricultural information service operating in Kenya, Tanzania, Uganda, and Rwanda. Through mobile phone applications, SMS, and online platforms, e-Soko provides farmers, traders, and consumers with access to market prices, weather information, and agricultural best

practices. This service enhances market efficiency by reducing information asymmetry (Tenge et al., 2014). Similarly, the Kenya Climate Data and Information Management System (KCDIMS), developed by the Kenya Meteorological Department, serves as a centralized repository for climate data, information, and tools.

While gaining prominence recently, institutional support from relevant government departments, including agricultural extension officers, remains inadequate in East African countries. Such support is crucial for fostering livelihood diversification among farmers (Tesfaye et al., 2015; William et al., 2012). Karim et al. (2017) identified that institutional support for livelihood diversification remains insufficient and varies across the region. Effective and complementary institutions are essential to facilitate scaling-up efforts. These institutions can mitigate challenges faced by farmers, reduce adoption barriers, and enhance the sustainability of scaling processes, ultimately leading to a greater societal impact from CSA practices and technologies.

Overall, increasing food security requires policy shifts and mainstreaming adaptation considerations into national and regional policies. Policy shifts can be achieved through modifying government or institutional policies to encourage the adoption and implementation of climate-smart agricultural practices. This can involve integrating CSA considerations into national agricultural policies and strategies alongside strengthening climate information services. These services can provide farmers with timely and accurate weather forecasts, climate projections, and other relevant climate information. For instance, Ethiopia and Kenya have developed broad cross-sectoral policies for green and resilient economies (Radeny et al., 2022). However, on-the-ground agricultural strategies and programs often fail to adequately address the realities of climate change.

Although East African countries have established policies and institutions for environmental management and climate change issues, several gaps remain in mainstreaming climate change considerations into sectoral plans and programmes. Even where mainstreaming does occur, it is often not effectively implemented due to financial constraints (Liwenga et al., 2014). Most agriculture, food, and nutrition sector policies in East African countries require more deliberate and proactive mainstreaming, facilitated by collaboration among stakeholders and local government authorities (Amwata et al., 2020; Mungai et al., 2020).

3.4.2 Water Security and Management

Water is the primary conduit through which climate change affects people, ecosystems, and economies globally (Sadoff & Muller, 2009). The 2022 Drought in East Africa report underscores the criticality of water security, revealing that approximately 16.2 million people in the Horn of Africa lack access to clean water. Addressing water insecurity is thus a crucial early adaptation measure, offering immediate relief to vulnerable and marginalized communities while contributing to the Sustainable Development Goals (SDGs) and building resilience against future climate risks. Effective water management remains a significant challenge across East Africa.

Adoption of Practices, Technology and Behaviour:

Integrated Water Management (IWM): IWM is a coordinated approach to managing water, land, and related resources to maximise economic, social, and ecological processes, ensuring benefits are distributed equitably and sustainably (Allan et al., 2013). This approach is a crucial adaptation strategy for addressing water insecurity caused by droughts or flooding (Allan et al., 2013; Cameron and Katzschner, 2017). According to Leal Filho et al. (2022), the most frequent actors responding to water scarcity within East Africa and sub-Saharan Africa include individuals or households (32%), local governments (15%), and national governments (15%). The most common types of responses are behavioural and cultural (30%), technological and infrastructural (27%), ecosystem-based (25%), and institutional (18%).

Water management practices adopted in East Africa include micro-irrigation schemes such as small motorized pumps, drip kits, treadle pumps, and rope and washer pumps (Nakuwaka et al., 2018). These technologies are replacing the less efficient flood irrigation, which is associated with water wastage (Nakuwaka et al., 2018). Micro-irrigation schemes are adaptable, as they can be adopted in various smallholder farmer contexts with minimal procedural requirements like approval processes. They are also water-saving, delivering water directly to the plant root zone, thereby minimizing evaporation and runoff losses compared to flood irrigation. Additionally, these schemes are manageable, as they often require less technical expertise and lower investment compared to large-scale irrigation projects (Fujiie et al., 2011; Pavelic et al., 2013).

Rainwater Harvesting: Rainwater harvesting during the rainy season can ease water supply difficulties and save water costs during dry periods (Mati et al., 2006). Initiatives include in situ rainwater harvesting, where farmers adopt techniques like *fanya juu trenches* to capture and store rainwater on their land, improving resilience to climate variability (Kibassa, 2013), and rooftop harvesting, where communities collect rainwater from rooftops using techniques like hanging cloths for collection and drainage (Ahamada, 2018). For example, Dar es Salaam in Tanzania has the potential to harvest approximately 5,000,000 m^3 of rainwater annually from buildings (Mati et al., 2006). Additionally, collecting and storing runoff through constructed wetlands can support rain-fed agriculture, which is crucial in countries like Rwanda, where 90% of agriculture relies on rainfall (Billman, 2014).

Integrated Water, Energy, Food, and Ecosystem (WEFE) Interventions: The Water, Energy, Food, and Ecosystem (WEFE) Nexus, put forward by the World Economic Forum (WEF) in 2011, recognizes the need for a holistic approach to address the interrelated challenges of water, energy, food, and environmental security in the context of climate change and sustainable development. The WEFE nexus provides a framework for understanding interactions between human activities and the environment, promoting coordinated management and use of natural resources across sectors (de Andrade et al., 2020). It identifies interlinkages, trade-offs, and synergies between water, food, energy, and forests, previously considered separately.

A study by Okumu et al. (2024) highlighted the crucial role of institutions, such as rules, regulations, and agencies, in managing the established water-food-energy ecosystem interlinkages and fostering synergies along the value chain in the Mt. Kenya catchment. The study emphasizes the urgent need to address food, water, forest, and energy security alongside climate change to achieve sustainable development goals in the region, especially given its heavy reliance on agriculture for livelihoods. WEFE practices offer promising multi-sectoral benefits but require further investigation in East Africa due to limited data and transdisciplinary research (Mperejekumana et al., 2024).

Financing: Investment in innovative financing models is crucial for improved water security and management. Public-private partnerships and water funds modelled on The Nature Conservancy (TNC) offer promising avenues. This model involves investing in "green" (natural) and "grey" (built) infrastructure upstream, with recouped investments coming from reduced water treatment costs, among other benefits. It promotes sustainable water management, community participation, and multi-sectoral and transboundary cooperation.

For example, the Upper Tana-Nairobi Water Fund invests in interventions like tree planting, riparian buffer zones, and teaching farmers terracing techniques. These initiatives create a more reliable water supply, a healthier freshwater ecosystem, and improved livelihoods for farming families (Schmitz, 2020).

Areas With Potential for Further Investment

Integrated institutional arrangements and governance that support the engagement of different stakeholders, particularly communities to make decisions, is key. Overall, integrated water management approaches like WEFE, which address water challenges across sectors, are promising investment areas. This requires integrated institutional arrangements and governance that support stakeholder engagement, particularly involving communities in decision-making.

Kenya's legal framework provides a good example. The Water Act of 2002 and the 2016 amendment to the Constitution's Water Act envision community participation through Water Resource Users Associations (WRUAs) (Baldwin et al., 2015). A case study by Jawuoro et al. (2017) highlights the effectiveness of WRUAs in Kiserian (Kajiado County) in improving water security and management through river desilting, tree planting, and riverbank stabilisation.

Another successful example is a project funded by the Austrian Development Cooperation and facilitated by the International Union for Conservation of Nature (IUCN) in the Habarow-Saka catchment, Garissa County. Through stakeholder engagement (including WRUAs, NGOs, and government officials), the project developed an Adapted Sub-Catchment Plan (ASCMP) and bylaws to support sustainable land and water resource management and community drought resilience (Nyachieo, 2016). However, Mwendwa (2014) points out that lack of coordination, capacity building, and political interference can hinder the effectiveness of WRUAs in water governance.

Other promising areas include scaling climate-smart Water, Sanitation, and Hygiene (WASH) programmes alongside food security, nutrition, and health interventions that benefit vulnerable groups, particularly women and girls who often bear the burden of water collection. Ethiopia's "One WASH National Program" (OWNP) serves as a good example. The OWNP uses a single plan, budget, and report for the WASH sector, fostering collaboration among key ministries committed to improving WASH services in communities.

Additionally, investing in accurate data collection and robust tracking and reporting frameworks is also critical. Deploying remote sensing and artificial intelligence for water quality and quantity monitoring can enhance preparedness for future risks. These advancements, along with early warning systems, can help communities adapt to shifting demographics and changing lifestyles in both rural and urban areas (see also Sakic et al., 2022).

3.4.3 Nature-Based Solutions and Resilient Land Management

Nature-based Solutions (NbS) are approaches that leverage the services of nature and healthy ecosystems to protect people and safeguard infrastructure and biodiversity.[5] Nature-based solutions (NbS) have been implemented in all countries within the region. These interventions hold significant potential for climate change

[5] https://iucn.org/our-work/nature-based-solutions

adaptation, biodiversity protection, local livelihoods, food and nutrition security. The NbS measures can provide adaptation benefits across multiple sectors (water, energy, agriculture, among others) while reducing substantial amounts of greenhouse gas.

Adoption of Practices, Technology and Behaviour

Agroforestry: Agroforestry, a dominant NbS intervention in East Africa, focuses on improving biodiversity while ensuring resilient and sustainable food production for vulnerable communities. This approach has led to several positive environmental outcomes, such as stable landscapes, reduced surface runoff, mitigated impacts of floods, and favourable microclimate conditions. Agroforestry also contributes to improved soil quality, higher retention of soil moisture (critical for high-yield crops and food security), addressing adverse effects of climate change through carbon sequestration, increased biodiversity, and improved adaptive capacity and resilience among smallholder farmers (Kuyah et al., 2016; Fuchs et al., 2022; Atela et al., 2017).

Examples of successful NbS applications include soil conservation through contour hedgerows in the highlands of Kenya (Angima et al., 2000) and Rwanda (Bucagu et al., 2013); riverbank stabilisation in Ethiopia (Nigatu et al., 2020); bunds in Rwanda (Cyamweshi et al., 2021); and water harvesting structures in Kenya (Droppelmann and Berliner, 2003) and Ethiopia (Abdelkdair and Schultz, 2005). These benefits underscore the value of NbS technologies in offering cross-cutting benefits for ecosystem-dependent sectors such as water, energy, food, and biodiversity. Further exploration of this potential in practice is recommended.

Ecosystem-Based Approach: Integrated ecosystem approaches aimed at restoring degraded ecosystems, such as ecosystem-based adaptation (EbA), have also been utilised. Innovations such as constructed wetlands in Rwanda have been reported to support and promote rain-fed agriculture, particularly in areas where conventional drainage systems are absent, such as informal settlements and refugee camps, where monitoring is frequently done (Mulligan et al., 2020).

Most EbA interventions require strong local leadership and capable governance by community institutions to enhance effective actions and strengthen the people-ecosystem nexus in sustainable ways. However, the limited technical and financial capacities of these local institutions can hinder the management of EbA-related activities, such as the protection of springs and earth dams (Agol et al., 2021). For instance, poorly implemented or managed water resources infrastructure may not effectively store sufficient water for extended periods. Omwenga et al. (2019) highlight the importance of including EbA provisions in sub-national adaptation plans and policies, using the example of the Mt. Elgon Ecosystem.

Nature-based solution against floods: Traditionally, NbS have been part of rural livelihoods, where forests and water bodies provide resources like energy and water. However, with the increasing prevalence of disasters in urban areas, NbS adoption to combat floods in these settings is rising (Lokidor et al., 2023). Urbanisation and expansion of informal settlements have exposed urban centres to flood risks. For

example, over 70% of Tanzania's population resides in informal settlements (Owusu et al., 2021).

Nature-based Solutions (NbS) initiatives not only help build community resilience to flooding but also provide more effective ways to manage runoff, fostering community cohesion. Successful examples include detention ponds to alleviate urban runoff in Dar es Salaam's Metropolitan Project (Mguni et al., 2016) and flood mitigation plans by NGOs to install drains in informal settlements in Kampala (Tukahirwa et al., 2010). Stronger community engagement can enhance the effectiveness of these initiatives, supporting their replication, scaling up, and institutionalisation.

Areas With Potential for Further Investment

Overall, nature-based solutions have the potential to provide multiple, cross-cutting benefits across sectors. These benefits include improved water supply, promotion of urban agriculture, and enabling inclusive decision-making and flexibility (Debele et al., 2019; Debele et al., 2023). Cases from Dar es Salaam, Kampala, and Nairobi showcase these benefits, with NbS interventions mitigating floods and even supporting urban agriculture. For example, Lwasa et al. (2014) highlight projects in Dar es Salaam (Tanzania) and Kampala (Uganda) where urban agriculture slowed runoff and addressed flooding. The Mikoko Pamoja project on the Kenyan coast demonstrates effectiveness in mitigating floods, restoring degraded areas, and improving livelihoods.

However, these promising NbS activities are yet to be fully integrated into planned or ongoing urban development upgrades in East African cities. Atela et al. (2015, 2013) suggest leveraging opportunities presented by existing Community Integrated Development Projects (CIDPs) and plans. This approach could enhance the effectiveness and adaptation of NbS interventions by ensuring adaptation is built into wider development plans, attracting necessary public support (political and financial).

Despite the mentioned benefits, choosing the type of NbS to adopt requires careful site-specific and area-specific considerations (Lechner et al., 2020). This necessitates evaluating local/scientific knowledge, sociocultural factors, technical requirements, environmental practicality, and the political context (Billman, 2014).

The analysis indicates that most NbS studies focus on addressing water security, food security, climate change, human health, and disaster problems holistically, rather than in isolation (combined instead of jointly). This highlights the need for more transdisciplinary studies to explore potential synergies between these sectors. These studies can inform the integration of NbS into other policies and strategies. Additionally, NbS can be more effective when integrated with technology and engineering principles (often referred to as grey infrastructure) for climate regulation, health, housing, and transportation (Dick et al., 2020).

Creating evidence-based visions and scenarios, along with measuring and monitoring implemented actions and strategies, is crucial for a transdisciplinary and integrated approach (Albert et al., 2021). The Seedbio project exemplifies successful collaboration for effective NbS implementation. This project, implemented in the

urban slums of Nairobi and Dar es Salaam, co-developed and built seven project sites, integrating over 17 NbS interventions. The project also fostered a multi-actor regional community of practice, engaging collaborators in Ethiopia, Kenya, Rwanda, Uganda, and Tanzania across various fields like community service, infrastructure, urban planning and management, construction, and risk and resilience management.

Overall, a lack of understanding regarding the performance and requirements of NbS in East Africa exists, primarily due to limited awareness among stakeholders, including policymakers (Lokidor et al., 2023). This can be attributed to the scarcity of monitored data on the performance of different approaches and the limited publication of best-practice case studies within the region (Debele et al., 2019). Raising public awareness is equally important. Lack of public understanding and negative community perceptions can hinder NbS adoption (Wamsler et al., 2020). Additionally, cultural constraints that influence community preferences and expectations can also play a role, as reported by Lechner et al. (2020). In some communities, for example, planting trees and forest management are cultural practices passed down through generations (Naima & Richard, 2016).

3.4.4 Disaster Risk Reduction (DRR)

Disaster risk reduction (DRR) is critical for adapting to climate change by reducing vulnerability and increasing resilience to extreme weather events (IPCC, 2012; Nyandiko, 2020). Floods and droughts are frequent climate risks in East Africa, linked to the ripple effects of climate change (Bahal'Okwibale, 2018; Richardson et al., 2022). Sea level rise, particularly along low-lying coastal zones, and landslides in Rwanda and Uganda, have caused significant losses and damage to vulnerable communities. Several DRR practices have been implemented in various East African contexts.

Adoption of Practices, Technology and Behaviours: Advancements have been made in climate services through forecast generation, creating more accurate weather forecasts; co-production of climate services, collaborative development of climate information products; capacity building, equipping communities to understand and utilise climate information; and communication of climate information, effectively disseminating weather forecasts and advisories.

A study by Gudoshava et al. (2024) confirms that numerous East African countries have established initiatives to disseminate climate information, including mobile phone SMS database systems. For instance, Tanzania's Farm SMS (Kijazi et al., 2021), Kenya's Plant Village (offering both text and television-based advisories), Rwanda's Radio Learning Clubs (Funk et al., 2023), and Ethiopia's Digital Agro-Climate Advisory Platform (Seid et al., 2020) are notable examples.

Capacity Building: Capacity gaps in data collection, analysis, and interpretation significantly hinder the ability to provide accurate and timely climate services for DRR response and preparedness (Gudoshava et al., 2024). Limited availability and accessibility of high-quality socioeconomic data further impede the development of effective impact-based forecasts. Additionally, communicating and disseminating

climate information to end-users remains a challenge, particularly for vulnerable communities with limited access to information.

Despite these challenges, there are successful examples of capacity building for DRR. A project in Tanzania has demonstrably enhanced stakeholder capacities through various initiatives. These include transboundary tabletop exercises on disaster risk response, training of trainers on mental health and psychosocial support in disasters, mentorship programmes for disaster response volunteers that integrate gender, vulnerable group needs, and cultural diversity into DRR, convening DRR coordination working groups, and awareness-raising sessions on Community-Based Disaster Risk Management (CBDRM) for at-risk communities.

Policy and Planning: Recognizing the severity of these challenges of disasters, the East Africa Community Partner states have opted for a coordinated and proactive approach to managing disasters in the region (Kamau, 2013). The EAC Partner states enacted the East African Community Disaster Risk Reduction and Management Act of 2013. This Act aims to protect the rights of climate migrants, whether within the partner states or between and among them and to enhance institutional capacity. This, in turn, is expected to strengthen the adaptive capacity of vulnerable communities against climate risks. Consequently, the Act seeks to coordinate and mainstream adaptation intervention efforts by stakeholders in the region, thus avoiding duplication of efforts and minimizing maladaptation.

Uganda's current DRR Strategic Plan showcases the potential for joint risk assessments, highlighting a promising avenue for collaborative action. Nevertheless, limited funding and low political commitment remain significant challenges, often leading to a reactive approach focused solely on response rather than preparedness (Omoyo et al., 2022). This hinders the crucial potential of DRR to contribute to risk-informed solutions and achievement of the Sustainable Development Goals (SDGs).

Areas With Potential for Further Investment

There has been insufficient attention paid to the identification, reduction, and management of other connected disaster risks including pandemics and climate, which require not just reactive measures but also preparedness for future risks (Chen et al., 2021). To address this, there is a need for effective climate solutions anchored on collaborative efforts across governments, local communities, experts, and other local stakeholders (Aylett, 2015; Broto, 2017). A study conducted in Magomeni Suna settlement in Tanzania on flooding in urban settlements noted that to enhance household adaptation to flood hazards, policy measures towards enhancing social networks and community actions for flood adaptation are necessary. There is also a need to enhance multi-institutional involvement as well as promote local livelihoods to improve household adaptation to floods (John, 2020). An example is the Spatial Planning Area approach in Nairobi which has been held up nationally and internationally as a progressive example of community-informed, government-led slum upgrading and resilience building.

By convening multiple sectors and stakeholders to create locally driven community plans, the SPA process fosters a collaborative environment for innovative DRR

initiatives. Similarly, the Building Climate Resilience for the Urban Poor (BCRUP) program, a joint venture between the Kenyan government and United Cities and Local Governments (UCLG), employs a multi-sectoral approach to risk mapping and resilience planning across 12 African countries. These locally rooted and collaborative endeavours empower local leadership but necessitate investments in capacity building to produce policy-relevant knowledge for affected communities. Leveraging emerging digital infrastructure to enhance DRR and future sustainable development offers significant potential for DRR stakeholders (Atela et al., 2021).

3.4.5. Climate Resilient Infrastructure

East African urban areas face several challenges related to the financing of urban infrastructure projects including strain on central and local government funding due largely to insufficient public funds and misappropriation by relevant authorities (Nabutola, 2006). This is further compounded by the lack of technical know-how that is essential for the design and implementation of resilient infrastructure to service the mounting city requirements and rising demand because of the increasing population (Chirisa et al., 2016). Some of the factors that can make African cities more resilient include the presence of robust urban infrastructure, good governance, and legal framework, participatory approaches for multi-stakeholder interactions, and replicability of best practices. In terms of opportunities for investments, building resilience in developing country cities will require improving urban infrastructure, creating more effective and pro-poor structures of governance, and building the capacity of individuals and communities to address these new challenges and move beyond them (also see Dodman, 2009). Systematic integration of green infrastructure (GI) concepts in urban planning is an essential approach to tackle major current and future challenges in addition to linking GI to governance and rights-based conceptualization, which will have the potential to unlock more resourceful paths for sustainable, green, and inclusive urban development.

4. CHALLENGES

4.0 CHALLENGES TO IMPLEMENTING ADAPTATION INTERVENTIONS

Despite the ongoing implementation of numerous climate adaptation interventions across East Africa, several significant challenges and needs persist:

- **Limited Understanding:** A comprehensive understanding of specific impacts, vulnerabilities, and potential adaptation options in key sectors (water resources, food security, forests, and energy) is limited (World Bank, 2020). This deficiency impedes the development of targeted and effective interventions tailored to address the region's unique challenges, including bankable adaptation projects and integrated policies (Christiansen et al., 2012).

- **Governance Deficits:** Governance weaknesses and legacies of past reforms (e.g., World Bank Structural Adjustment Programmes) hinder the implementation of various climate change adaptation strategies and programs in East Africa (Kweyu et al., 2023). These include corruption, lack of transparency, inadequate accountability mechanisms, and limited stakeholder engagement in executing interventions. These deficits can hinder efficient resource allocation, impede coordination among relevant institutions, reduce the effectiveness of adaptation interventions, and create an unconducive environment for investments (Tippmann et al., 2013).

- **Missing Metrics:** Clear indicators and metrics to track and report adaptation priority actions are lacking (World Bank, 2020; AFDB, 2018). Integrating adaptation tracking and developing metrics is crucial to assess the impacts of future adaptation investments in the region.

- **Weak Sub-National Capacity:** Sub-national actors often have limited awareness and technical capacity regarding climate change policies and issues, making the devolution of adaptation technologies and financing difficult. This hinders opportunities to build and strengthen local leadership and investment opportunities.

- **Sectoral Silos:** The perception that climate change is solely the responsibility of the Environment Ministry can constrain the engagement of other ministries and collaborative efforts in some projects. This can potentially impact the effective management of bureaucratic procedures, including due diligence, procurement, and reporting (Coalition of Finance Ministers for Climate Action, 2022). This limited understanding can lead to scepticism or reluctance to

engage in collaborative efforts, delay decision-making processes, and hinder the implementation of adaptation investments (Ampaire et al., 2016).

- **Unclear Funding Frameworks:** National frameworks for developing adaptation projects are often unclear regarding the administration and management of funding at both national and sub-national levels. This lack of clarity on project selection priorities and criteria can lead to favouritism or lack of transparency, further undermining the credibility and effectiveness of adaptation investments, since resources available/budgeted for key projects may not be directed to those with the highest potential impact.

- **Lack of Adequate Collaboration:** Limited coordination between government agencies can lead to missed opportunities for collaboration, duplication of efforts, and unclear roles. This can result in wasted resources and hinder progress on adaptation initiatives.

- **Competition over Resources:** Fragmented governance can create competition among agencies and stakeholders for limited resources, further undermining the effectiveness of adaptation investments.

- **Unsuccessful Proposals:** Securing funding for adaptation projects can be challenging due to several factors. Proposals often lack a clear focus on long-term benefits, sustainability, and targeted implementation plans. Additionally, unclear descriptions of expected outcomes and impacts can raise doubts among potential donors. Addressing these issues is crucial to improving proposal success rates and ensuring efficient use of resources for climate resilience initiatives.

- **Knowledge Gaps:** The lack of centralized and up-to-date information on adaptation projects across Africa hinders the development of best practices, data sharing, and effective analysis. Addressing these knowledge gaps is essential for improving the overall coordination and effectiveness of adaptation efforts (Basilio, 2012).

- **Profitability Mismatch:** Adaptation projects often struggle to attract private sector investment due to their focus on environmental and social benefits rather than immediate financial returns. Additionally, the high upfront costs associated with infrastructure development in adaptation projects make them less attractive to conventional investors.

- **Loan Limitations:** While loan-softening mechanisms can incentivize private sector involvement, the limited commercial viability of many adaptation

projects restricts the effectiveness of this approach (e.g., the Ireme Invest facility in Rwanda).

- **Disincentives for the Private Sector:** Several factors discourage private enterprises from investing in adaptation initiatives. These include high risks associated with climate change impacts, lack of clear financial returns, regulatory constraints that may vary by country and influence investment decisions, and limited awareness and guidance on how to participate in and develop adaptation measures.

- **Cost-Sharing Challenges:** African governments face difficulties in sharing the costs of adapting public infrastructure and attracting private sector funding for adaptation purposes (Christiansen et al., 2012; CTI-PFAN, 2012). Regulatory constraints, lack of awareness, and limited guidance on engaging with the private sector further hinder progress. This restricts the financial resources available for adaptation and limits the potential for innovative solutions and technologies.

Concerted efforts are needed to raise awareness, provide guidance on private sector engagement, and develop strategies that incentivize co-investment in adaptation initiatives. Addressing regulatory constraints and fostering collaboration between governments and private enterprises is crucial.

5. RECOMMENDATIONS

5.0 RECOMMENDATIONS

Building on the identified challenges and gaps, the following recommendations outline how adaptation interventions in East Africa can be designed to be more effective and sustainable. The recommendations include both overarching ones and specific ones aligned to the thematic areas of study.

5.1. Overarching recommendations

- **Co-creation and Scaling-Up Frameworks:** Invest in co-creating and co-designing sustainability and scaling-up frameworks for adaptation interventions. This participatory approach with stakeholders, project managers, and communities will foster ownership, enhance local capacity, and ensure interventions are contextually appropriate and sustainable in the long term (**addresses weak sub-national capacity**).

- **Gender-Responsive Interventions:** Integrate gender considerations throughout the project cycle, from gender-disaggregated data collection to evidence generation. This will strengthen the knowledge base on gender and climate change, enabling a better understanding of gender-differentiated vulnerabilities and capacities. This knowledge can inform the design and implementation of gender-responsive adaptation interventions, leading to more targeted and effective strategies (**addresses gaps in understanding specific impacts**).

- Invest in research and data collection approaches to fill knowledge gaps in key priority sectors. This can involve conducting studies, monitoring programs, and data collection campaigns to gather essential data on climate change impacts, sectoral vulnerabilities, and adaptation needs. Encourage collaboration between research institutions, universities, and sector-specific organizations to generate robust data and evidence (**addresses lack of clear indicators/metrics**).

5.2 Specific Recommendations

5.2.1. Agriculture and Food Security

- **Collaborative Stakeholder Engagement:** Foster collaboration between local farmers' groups, NGOs, civil society organizations, and the private sector. This multi-stakeholder approach can influence farmers' perceptions regarding climate change and encourage them to adopt adaptation practices. This collaborative approach will enhance the acceptability, sustainability, and long-term impact of interventions (**addresses limited awareness and stakeholder engagement**).

- **Promote Climate-Smart Agriculture (CSA):** Invest in innovative and integrated farming practices like CSA. These practices will equip farmers to cope with extreme weather events, enhance long-term food security, and promote sustainable livelihoods (**addresses limited adaptation options).**

- **Market Linkages and Modern Practices:** Strengthen linkages between farmers and markets, and promote modern farming practices to increase agricultural productivity, improve household income, and promote sustainable farming. Examples include farmer field school (FFS) programs that provide hands-on training on crop management, pest control, soil conservation, and post-harvest handling, leading to increased productivity and market competitiveness (**addresses limited access to knowledge and resources**).

5.2.2. Water Security and Management

- **Prioritise Water Governance:** Water governance should be a key priority for future investments. Effective water governance ensures the development and management of resilient water systems that can withstand climate change impacts. It also fosters the coordination and integration of various stakeholders for a holistic and integrated response to these challenges. **This approach addresses governance deficits and unclear funding frameworks.**

- **Integrate the WEFE Nexus:** Integrate the Water-Energy-Food Ecosystem Nexus (WEFE) approach into water adaptation investments. This will enhance the effectiveness and sustainability of adaptation efforts by allowing for synergistic planning and decision-making at different levels. It will also enable the identification of interdependencies, trade-offs, and co-benefits among water, food, and energy sectors (**addresses sectoral silos**). For example, implementing water-efficient irrigation techniques that are affordable to small-

scale farmers will conserve water, reduce energy consumption, and enhance food production.

- **Strengthen Monitoring and Evaluation:** Invest in a robust data capture and efficient monitoring and evaluation framework. This will provide reliable and up-to-date information on the progress and impact of water projects to stakeholders and project managers. This information is crucial for informed decision-making and efficient resource allocation throughout the project lifecycle (**addresses missing metrics and fragmented information**).

- **Promote Local Water Security:** Invest in building resilient local systems that use both indigenous and modern methods of farming, water preservation, and conservation to combat climate-induced water insecurity. This is crucial because water insecurity can exacerbate social conflict in semi-arid areas (**addresses limited understanding and weak sub-national capacity**)

- **Leverage Nature-Based Solutions:** Invest in nature-based solutions, particularly ecosystem-based techniques. This includes preserving and restoring natural ecosystems like wetlands and forests, which are essential for controlling water flow, reducing floods, and enhancing water quality. These methods can offer affordable and long-lasting solutions for managing water resources (**addresses limited understanding of adaptation options**).

- **Invest in Data Management and Early Warning Systems:** Invest in data collection and management mechanisms through advanced technologies like GIS, remote sensing, and AI. Additionally, prioritise research into early warning systems for water-related disasters and emergencies. These advancements will further improve the effectiveness of adaptation interventions (**addresses lack of clear indicators/metrics**)

5.2.3. Nature-Based Solutions and Resilient Land Management

- **Mainstreaming NbS:** Integrate NbS into other policies and strategies. This multi-disciplinary approach will help capture the multiple co-benefits of NbS, such as improved biodiversity, soil health, and carbon sequestration, alongside climate change adaptation.

- **Stakeholder Collaboration:** Foster collaboration between local communities, the private sector, governing bodies, and non-governmental organizations in the spirit of "NbS with and for the people." This collaborative approach is critical for ensuring the successful implementation of NbS investments and

building adaptive capacity within communities (**addresses limited understanding and weak sub-national capacity**).

- **Inclusive Decision-Making:** Support and involve all stakeholders in decision-making processes. This includes participation in evidence-based research, integrating grey infrastructure (engineered solutions) where necessary, and advocating for adaptive institutional and policy changes. Financial support from governments and private sector regulators is also crucial for successful NbS implementation. This transdisciplinary and multi-stakeholder approach ensures NbS addresses the needs of all sectors (**addresses governance deficits and sectoral silos**).

- **Research and Development:** Prioritise research that reviews the various terminologies used for NbS across different spatial scales. Additionally, actively engage local communities in the co-design, development, and delivery phases of NbS projects. This will ensure NbS interventions are culturally appropriate, sustainable, and meet the specific needs of local communities (**addresses limited understanding and weak sub-national capacity**).

5.2.4. Disaster Risk Reduction

- **Data-Driven Decision Making:** Invest in robust data collection systems to provide national and international decision-makers with the information needed for informed resource allocation. This data is crucial for assessing progress, measuring the impact of interventions, identifying gaps, refining strategies, and improving the overall efficiency and effectiveness of DRR efforts (**addresses missing metrics and fragmented information**).

- **Policy and Coordination Review:** Conduct evaluations to explore the effectiveness of current DRR policies, coordination mechanisms, risk monitoring, reporting, and advocacy efforts. This will identify areas for improvement and ensure a comprehensive approach to DRR (**addresses governance deficits**).

- **Urban Planning and Design:** Integrate DRR considerations into urban planning and design. This includes investments in resilient housing, critical infrastructure, and land-use management practices to reduce vulnerability to flooding and other climate-related disasters (**addresses limited understanding**).

- **Technological Advancements:** Leverage advancements in remote sensing, geospatial analysis, and artificial intelligence (AI) to enhance risk assessment, early warning systems, and decision-support tools. These technological advancements can significantly improve preparedness and response efforts (**addresses limited understanding**).

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7.0 ANNEXES

Annex 1: Database- Adaptation Interventions
Annex 2: Online-Survey Tool
Annex 3: Adaptation Intervention Indicators
Annex 4: Assessment of the Effectiveness of Selected Adaptation Interventions in East African Countries

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