SOAR 2023

STATE *of* ADAPTATION REPORT

Tomorrow belongs to the people who prepare for it today.

African Proverb.

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FOREWORD

The 2023 State of Adaptation report illuminates Africa's remarkable progress in climate change adaptation across pivotal sectors, including agriculture, water, health, and ecosystems, providing a nuanced perspective on both achievements and impending challenges. Within the context of climate change adaptation, the report underscores the critical role of strategies, policies, and actions in mitigating adverse impacts, particularly in safeguarding agriculture, food security, and other vital sectors.

Africa has demonstrated its commitment through essential measures, including the adoption of Nationally Determined Contributions (NDCs) and the formulation of National Adaptation Plans (NAPs), serving as foundational documents for urgent adaptation actions. These measures not only acknowledge the looming threat of climate change but also integrate it into overarching strategies aimed at enhancing the resilience of its people, economies, and ecosystems, commanding acceleration in implementation.

The report delves into diverse approaches, ranging from concrete adaptation measures combined with capacity building to climate information services, early warning systems, risk management, insurance, research and development, policy integration, institutional frameworks, and finance and investment. It emphasizes the integration of climate change elements into overarching economic strategies, reflecting a holistic approach to adaptation. Finally, it identifies emerging trends in adaptation strategies, with a particular emphasis on resilience across key sectors.

Acknowledging the economic and livelihood impacts of climate change, the report underscores the significance of social protection programs in enhancing resilience. Successful programs in eastern and southern Africa serve as valuable models, advocating for the integration of climate risk management into social protection programs to ensure long-term resilience.

Addressing the challenges faced by Climate Information Services (CIS) in Africa, the SOAR 2023 emphasizes the need for comprehensive climate risk management. Holistic integration of CIS into adaptation, climate resilience, disaster risk reduction, and disaster risk reduction efforts is crucial for informed decision-making in the face of evolving climate risks.

Despite commendable progress, the report draws attention to the significant underfunding of climate finance needs in developing countries, with Africa facing a pronounced gap. Challenges, including governance issues, technical infrastructure risks, and financial obstacles, underscore the importance of strategic tapping into diverse funding sources to meet the adaptation finance gap and build resilience.

The State of Adaptation Report 2023 not only serves as a reflection of the progress made but also issues a compelling call to action. Urgent and coordinated efforts at national, regional, and international levels are deemed imperative to effectively address the escalating climate crisis. The report advocates for a unified continental voice, proposing the restructuring of international climate finance mechanisms and the integration of technology needs into national development plans. Emphasizing the need for increased finance for implementing adaptation and digital technologies for SMEs, the report underscores the importance of regional cooperation for technology advancement.

The recommendations articulated in the report collectively form a roadmap for future climate change response actions, focusing on a Loss and Damage Mechanism, community engagement and participation, knowledge sharing through case studies, and partnerships with NGOs and civil society organizations.

We believe this report will stand as a guiding beacon, directing Africa toward a sustainable and climate-resilient future.

Amb. Hussein Alfa Nafo

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EXECUTIVE SUMMARY

Africa, a continent blessed with abundant resources, nevertheless grapples with various challenges, among which is climate change. Across the continent, climate change manifests through extreme weather events, impacting the economy and critical sectors, while undermining developmental and social progress. The State of Adaptation in Africa Report 2023, prepared by the Africa Adaptation Initiative (AAI), analyses climate trends and adaptation strategies. It delves into the effects of climate change on crucial sectors such as agriculture, water resources, health, cities and infrastructure. The report evaluates the current state of adaptation efforts, identifies gaps and proposes means to amplify these endeavours. Anchored in the AAI's four key pillars—enhancing climate information services, strengthening the institutional policy framework, supporting concrete adaptation actions on the ground, and mobilizing climate finance and investments—the report aims to guide the AAI's activities in ensuring a resilient and sustainable future for Africa.

The State of Adaptation in Africa Report 2023 sheds light on the climate risks in Africa, underscoring the need for proactive adaptation. It scrutinizes current and projected trends in precipitation and temperature, highlighting an anticipated rise in temperatures across the continent. Temperature fluctuations in eight subregions are projected, ranging from 0.03°C to 6.2°C, contingent on future global socio-economic scenarios. The report emphasizes interconnected challenges across Africa's subregions, spanning agriculture, water resources, public health, biodiversity and coastal communities. This accentuates the need for cohesive efforts and resource allocation to effectively mitigate the multifaceted impacts of climate change.

The economic and livelihood repercussions of climate change in Africa are profound, leading to a decline in economic growth. Global financial conditions, supply chain disruptions, reduced demand for exports and the far-reaching effects of the COVID-19 pandemic all contribute to these challenges. The report establishes a foundation for comprehending the extensive impacts of climate change on various sectors, and underscores the significance of adaptive strategies and climate-resilient policies. In particular, Africa's informal sector, constituting 85.8 percent of employment on the continent, bears the brunt of climate change impacts. Businesses and activities in this sector often operate in climate hazard-prone areas, leading to disruptions in transportation and commodity flows. Women, particularly in rural areas, are disproportionately vulnerable to the economic impacts of climate change. Furthermore, climate change amplifies transboundary economic effects in Africa, affecting critical sectors such as agriculture and fisheries. Reductions in rice crop yields due to climate-induced shocks exacerbate food insecurity in importing nations. The report comprehensively outlines the impacts and risks of climate change in crucial sectors including agriculture, water, health and biodiversity across Africa.

The State of Adaptation in Africa Report 2023 underscores the urgency of implementing adaptive measures grounded in science, equity and resilience, to safeguard Africa's sustainable development and overall well-being. Adaptation emerges as a linchpin for Africa's development, given its vulnerability to climate challenges and the observed economic repercussions across various sectors. Key considerations in adaptation strategies include addressing agriculture dependency, water scarcity, threats to the health sector, biodiversity and ecosystems, and conflict and displacement risks.

At different governance levels, policies and plans are incorporating climate change priorities to cultivate resilience. Noteworthy examples of adaptation current efforts encompass the utilization of drought-tolerant crop varieties, the promotion of conservation agriculture, sustainable land management practices and the strengthening of agricultural extension services. Improved climate information services are crucial for robust early warning systems in agriculture. Risk assessment and management, including insurance schemes, are being developed to protect farmers from climate-induced losses.

Research and development have aimed at fostering climate-resilient practices in the health sectors. The integration of policies across sectors and

the diversification of livelihoods are crucial components for effective climate change adaptation. These endeavours collectively contribute to building adaptive capacity and enhancing the continent's ability to withstand and respond effectively to the impacts of climate change.
Nevertheless, various barriers, encompassing technological, financial, institutional, information, socio-economic and market-related challenges, must be systematically addressed to ensure robust support for climate adaptation measures within African agriculture.

Building capabilities in climate information services and early warning systems is essential to facilitate informed decision-making and bolster the resilience of farmers. A comprehensive examination of climate adaptation efforts in Africa reveals significant challenges and gaps, including limited financial resources, insufficient technical capacity, data and information deficiencies, inadequate policy frameworks, and multiple pressures on sectors and ecosystems. To enhance the implementation of climate adaptation, countries are urged to go beyond existing opportunities by incorporating adaptation into mainstream strategies, fortifying ecosystem-based adaptation strategies, exploring innovative funding mechanisms and fostering stronger collaboration.

Effective biodiversity and ecosystem adaptation in Africa necessitates community engagement, capacity-building, sustainable practices, research, monitoring and policy coherence. Innovative funding mechanisms such as green bonds, payment for ecosystem services, biodiversity offsetting, conservation impact bonds and debt-for-nature swaps play a crucial role in supporting adaptation efforts. Collaborative efforts involving Governments, the private sector, non-governmental organizations and international organizations are indispensable for the successful implementation of these funding mechanisms.

Social protection programmes, public works initiatives and unconditional cash transfers prove effective in building resilience against climate-related shocks. Integrating climate risk management into social protection programmes contributes to long-term resilience. Local adaptation strategies, including water conservation and the cultivation of drought-resistant crops, are pivotal for addressing climate change challenges encountered by rural communities. Challenges in addressing climate change impacts in Africa involve the mobilization of adaptation finance and grappling with institutional barriers.

Comprehensive climate risk management is imperative due to the variations in climate change risks and impacts across the continent. Climate Information Services play a vital role in informing decision-making, fostering climate-smart decisions, and supporting adaptation and resilience-building.

Recommended actions to build resilience and protect African economies against climate change include incorporating climate resilience into macroeconomic planning, leveraging social protection, supporting the informal sector, embracing regional cooperation, enhancing data and awareness, strengthening climate insurance, investing in adaptation, diversifying adaptation financing, and addressing funding gaps. Urgent and concerted efforts are required at national, regional and international levels to prioritize adaptation measures and secure a sustainable and climate-resilient future for Africa. Clear international signals, restructuring climate finance mechanisms, integrating technology needs, mobilizing finance for adaptation, investing in digital technologies, and strengthening regional integration and collaboration, are recommended for future actions. Further emerging recommendations for future climate change response involve establishing a loss and damage fund, promoting community engagement and participation, and facilitating knowledge-sharing.

INTRODUCTION

Africa stands as a continent rich in both human and natural resources, presenting a unique opportunity to address the Sustainable Development Goals and aspirations. However, it also grapples with a myriad of challenges such as wars, food insecurity, energy crises, desertification, water scarcity, health issues, biodiversity loss, environmental degradation, reduced economic growth, and pandemics and their aftermath. These challenges are compounded by the pervasive influence of climate change, magnifying existing risks and reshaping the continent's landscape with frequent and intensified natural disasters such as storms, droughts, wildfires, floods and landslides.

Between January 2021 and September 2022, over 54 million Africans experienced the detrimental impacts of climate change, with eastern Africa facing pronounced droughts and floods affecting more than 33 million individuals. Northern Africa, on the other hand, grappled with damaging floods and wildfires. Over the past decade, extreme weather events linked to climate change have been responsible for many fatal disasters on the continent, resulting in a continuous transformation of its landscape and natural systems. Climate change emerges as the predominant challenge for Africa, affecting over 55 percent of its workforce employed in climate-sensitive sectors, particularly agriculture. Rain-fed agricultural enterprises dominate the continent, leading to a 34 percent decline in crop yields since 1961, the highest among global regions. The impact of climate change on hydrology is profound, causing significant changes in river discharge (−50 percent to +50 percent) and cascading effects across sectors, causing water scarcity and endangering lives, livelihoods and environmental sustainability.

Africa, with a population exceeding 1.4 billion, is the world's second most densely populated continent. Despite a marginal decrease in population growth, projections suggest a trajectory towards 2.5 billion by 2050. Notable socio-demographic characteristics include rapid population expansion, elevated fertility rates, a young median age, rising life expectancy, sizeable households and widespread poverty. Elevated fertility levels, averaging around four children per woman, drive population increases. Many African countries contribute to the world's fastest-growing populations, with South Sudan and Burundi demonstrating high growth rates in 2021. Nigeria, with over 200 million people, and predictions indicating it could surpass 400 million by 2050, is the most populous country. Despite a low median age of around 20 years in 2020, Africa records the lowest global life expectancy at birth, averaging 64 years, primarily due to inadequate health care.

In 2022, approximately 460 million Africans lived in extreme poverty, struggling on less than US$1.90 per day. Socio-economic dynamics vary, with persistent challenges of poverty, inequality and limited access to essential services. The Human Development Index for Africa in 2020 averaged 0.548, reflecting a mix of sectors in the economy, with emphasis on industrialization and economic diversification according to the African Union's Agenda 2063.

The informal economy, comprising informal employment, self-employment and small-scale businesses, plays a vital role. However, climate change exacerbates existing vulnerabilities, necessitating an urgent acceleration of climate adaptation efforts, matching the extent of the continent's challenges.

The State of Adaptation in Africa Report 2023 stands as a dedicated effort by Africans, for Africans, prepared for the attention of African Heads of State, the African Group of Negotiators, decision makers and policymakers, and other relevant African climate and development stakeholders to inform on progress on adaptation on the continent and raised momentum for expedited focus on implementation. It presents a thorough analysis of current and projected trends in precipitation,

temperature and climate-related indices, offering insights into the potential impacts on socio-economic activities across the continent. Utilizing regional classifications, the report takes into account the spatial and temporal heterogeneity of precipitation in diverse African regions and considers distinct geographical characteristics. This nuanced approach aims to enhance the understanding of the varied impacts of climate change on the continent.

From examining economic implications and critical sector vulnerabilities to exploring adaptation strategies and financial landscapes, the State of Adaptation in Africa Report 2023 serves as a guiding light, illuminating not only the challenges, but also the imperative need, for proactive and strategic measures to ensure a resilient and sustainable future for Africa.

The report is structured as follows:

Section I: Climate Risks in Africa. This introductory chapter not only assesses current and projected climate trends in Africa, but also highlights the imperative of adaptation within the context of the continent's development. It investigates potential impacts on socio-economic activities, considering precipitation, temperature and climate-related indices. This chapter serves as a crucial foundation, emphasizing the challenges posed by climate change and the necessity of integrating adaptive strategies into Africa's ongoing development initiatives.

Section II: Economies and Livelihoods: This chapter strategically explores the detrimental impacts of climate change on both the economy and livelihoods in Africa. Emphasizing the pressing and immediate need for substantial investment in adaptation measures, it examines socio-economic challenges posed by climate change.

Section III: Climate Change Impacts, Risks, and Vulnerability in Africa's Critical Sectors: This section covers a detailed overview of observed impacts, projected risks and notable vulnerabilities in critical sectors such as agriculture and food security, water, health, and biodiversity and critical ecosystems. The analysis emphasizes the intricate dynamics and potential challenges facing each sector within the context of climate change.

Section IV: Cities, Settlements, and Key Infrastructure: considering the impacts of climate change on African cities and their crucial infrastructure, this chapter draws from academic literature, reports, and case studies. It contributes to a nuanced understanding of the relationship between climate change and urbanization in the African context.

Section V: Adaptation Strategies: Exploring how Africa is actively responding to the impacts of climate change across its key sectors, this pivotal session not only examines existing adaptation measures but also identifies crucial gaps and opportunities for scalability.

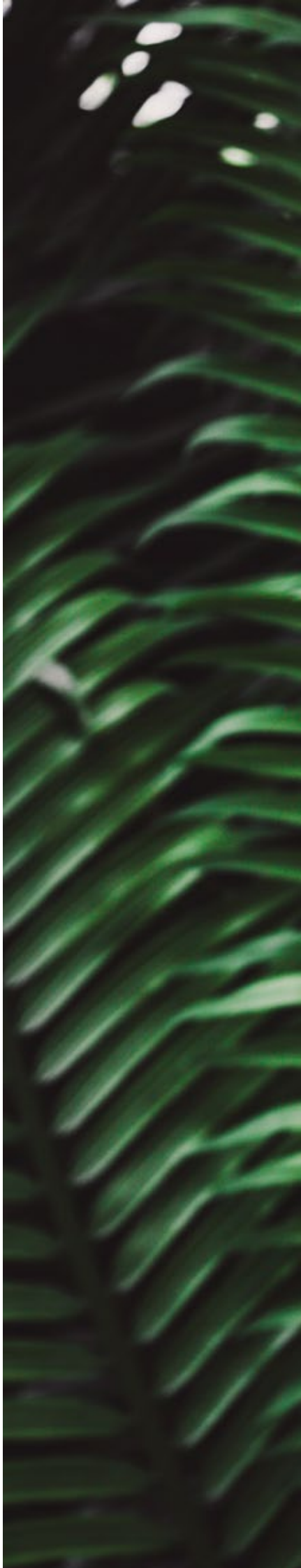
Section VI: Climate Information Services : This section focuses on a particular adaptation measure, specifically the climate information services, aimed at assisting African countries in mitigating the human and economic impacts associated with climate risks and disasters.

Section VII: Finance and Investment for Adaptation in Africa: Offering a concise overview, this session examines the finance and investment status across key sectors, including Agriculture and Food Security, Water resources, Health, Biodiversity, and Ecosystems. The report also outlines the financial needs to address climate change impacts on the overall economy and climate information systems and services across the continent.

Section VIII: Future Outlook: The final section underscores the urgent need for proactive adaptation to current climate-related issues. Beyond this, it provides recommendations for future actions to better harness adaptation efforts in Africa, ensuring a sustainable and resilient future for the continent.

This report offers a comprehensive assessment to address the intricate challenges posed by climate change across the continent. Within the subsequent chapters, a thorough exploration of specific sectors and

strategic approaches provides invaluable insights and recommendations for policymakers, stakeholders and communities alike. By implementing adaptive measures grounded in science, equity and resilience, we possess the collective power to safeguard Africa's sustainable development, preserve its unique ecosystems and ensure the well-being of its diverse populations. Confronting the undeniable reality of a changing climate, the State of Adaptation in Africa Report 2023 stands as a beacon of hope, guiding us towards a future where Africa is more climate-resilient, prosperous and equitable for all.



CLIMATE RISKS IN AFRICA.

Facing Climate-Driven Hardships: Addressing Critical Risks and Impacts Amid Changing climate and Demographics and Socioeconomic Realities."

1.1. Evidence in Africa of Changing Climates

This section presents a comprehensive examination of both current and projected trends in precipitation, temperature, climate-related indices and their potential impacts on socio-economic activities within Africa. The assessment employs a set of regional classifications (Figure 1) tailored for precipitation analysis on the continent. Notably, these classifications diverge from the Intergovernmental Panel on Climate Change (IPCC) macro-regions classes in the Sixth Assessment Report. This departure is intentional, recognizing the potential limitations of the latter in capturing the nuanced characteristics of precipitation in regions marked by significant spatial and temporal heterogeneity.

This heterogeneity is evident in variations such as the different annual precipitation cycles between northern and south-central Africa, or the distinctive patterns along the coast of the Gulf of Guinea or the western Sahel. Additionally, regions with specific geographical features, such as the Ethiopian Highlands or Gulf of Guinea, merit a more nuanced approach. For temperature assessments, the analysis utilizes a distinct set of regions (Figure 2), aligning with the methodology applied in the current study. This tailored approach aims to enhance the precision of the analysis by accounting for the specificities of temperature patterns across various geographical areas within the continent. It is worth noting that the foundation of this analysis rests on the findings of prior works, including but not limited to Almazroui and others (2020) and Dosio and others (2021). These seminal works provide a robust basis for our examination, and in this section we succinctly summarize their key findings. This approach not only ensures a solid grounding for our analysis, but also acknowledges and builds upon the valuable contributions of these esteemed researchers.

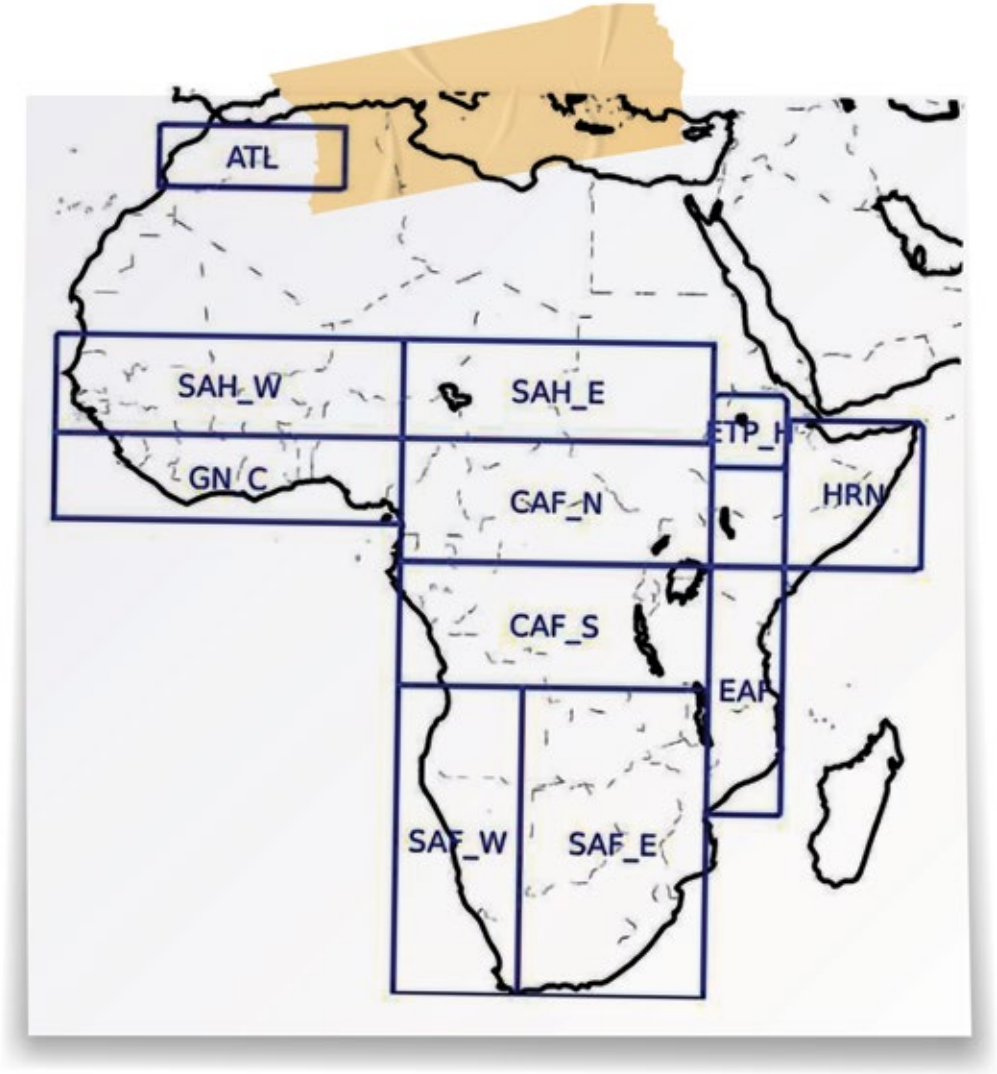


Figure 1: *Subregions used for precipitation characteristics in the State of Adaptation in Africa Report 2023.*

1. Projected changes in temperature

The assessment of anticipated temperature changes in Africa until the close of the 21st Century involved the use of 27 climate models, spanning two periods: 2030–2059 (near future) and 2070–2099 (far future), with reference to the baseline period of 1981–2010. This evaluation encompassed eight regions across the entire continent, incorporating its smaller subregions (see Appendix 3). The findings indicate a discernible increase in temperatures across Africa in both the near and far future, relative to historical periods. Projections suggest a magnification of this warming trend as we approach the end of the century, particularly under scenarios featuring higher greenhouse gas emissions. The anticipated decadal average temperature rises range from 1.4°C to 4.4°C for the near future across all three climate change scenarios (Shared Socioeconomic Pathway [SSP]1, SSP2 and SSP5). Temperature increases between 1.0°C and 6.2°C are forecasted for the final decade of the future period.

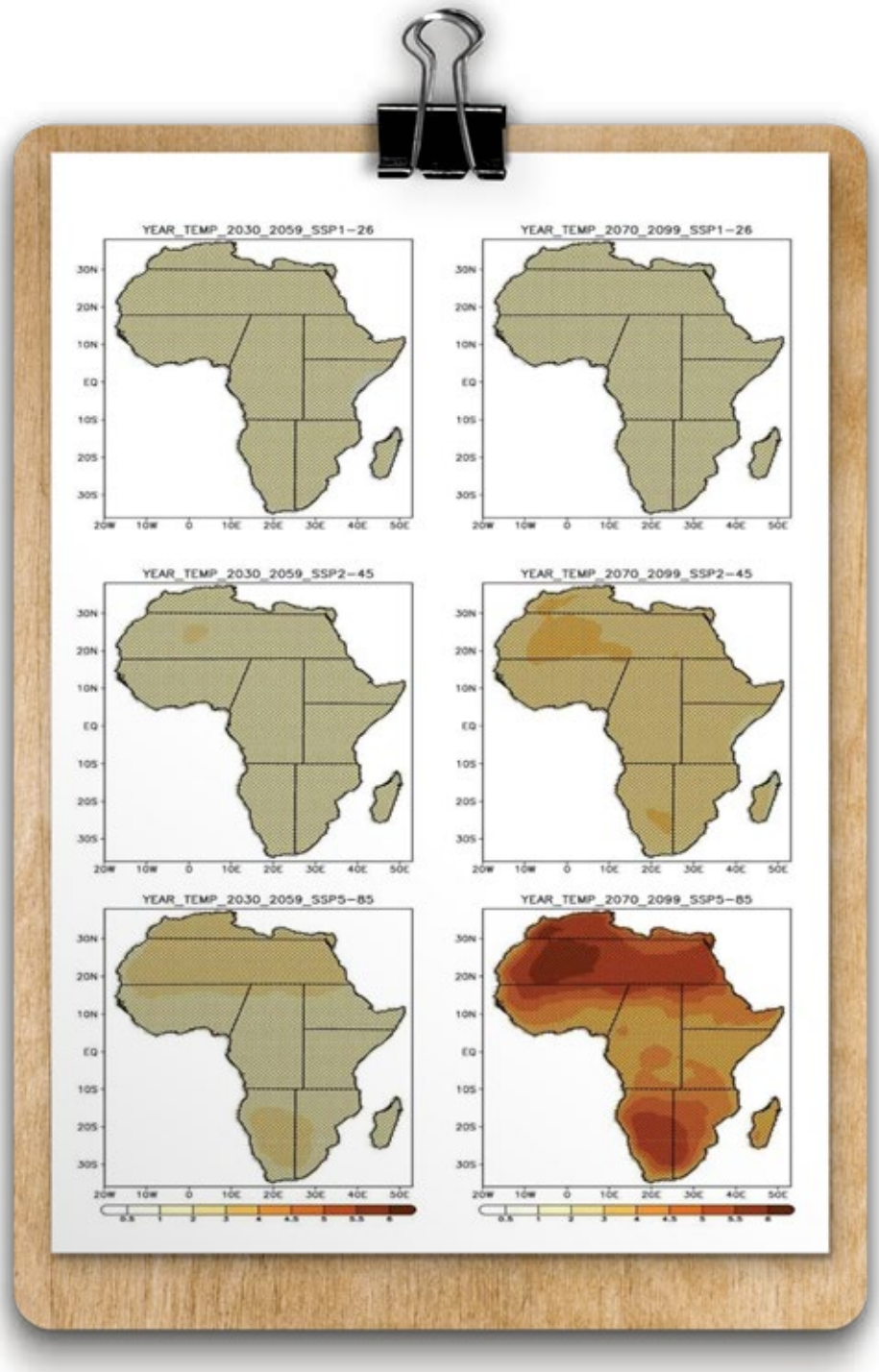


Figure 2: *Future changes in mean annual temperature (°C) over Africa under three scenarios (SSP1-2.6, SSP2-4.5, SSP58.5) for the two time periods (2030–2059 and 2070–2099) as compared with the reference period (1981–2010).*

Note: The backslash and forward slash represent the grid boxes having significant and robust change, respectively, while hatching represents the grid boxes having both significant and robust change. Significance is defined based on a two-tailed Student t-test, while robustness is achieved when 66% of all models project a climate change signal in the same direction.

Source: Almazroui and others (2020).

Table 1: *Future changes in mean annual temperature (°C) and precipitation (%) over Africa for two future time slices (2030–2059 and 2070–2099) with reference to the base period (1981–2010).*

Scenario	2030 - 2059					2070 - 2099				
	Median	LMV	HMV	66% LMV	66% HMV	Median	LMV	HMV	66% LMV	66% HMV
SSP1-2.6	1.24	0.76	2.02	0.96	1.70	1.39	0.74	2.38	0.93	1.85
SSP2-4.5	1.46	1.03	2.29	1.22	1.76	2.32	1.78	3.81	1.84	2.98
SSP5-8.5	1.77	1.08	2.65	1.58	2.29	4.36	2.90	6.37	3.23	5.51

Note: *The lower median value (LMV) and the higher median value (HMV) represent the full range, while 66% LMV and 66% HMV represent the 66% likely range for the models used.*

Table 2 provides a concise overview of Africa's projected temperature changes across its eight subregions throughout the 21st Century, encompassing smaller parts within these regions. See Appendix 1 for further information.

Table 2: *Projected trends in the mean annual temperature (°C) for the period 2030–2099*

Scenario	AFRICA	NAF	SAH	WAF	CAF	CEAF	NEAF	SWAF	SEAF
SSP1-2.6	0.03	0.04	0.03	0.04	0.05	0.03	0.04	0.04	0.04
SSP2-4.5	0.23	0.26	0.27	0.24	0.23	0.22	0.23	0.27	0.23
SSP5-8.5	0.62	0.69	0.74	0.60	0.54	0.49	0.57	0.68	0.59

North Africa (NAF): *Notably, the subregions in NAF bordering the Mediterranean Sea are anticipated to face the most pronounced impact from temperature changes, rendering them climate change hotspots. Depending on future scenarios of global socio-economic changes, NAF's temperature is projected to fluctuate at decadal scales, ranging from 0.04°C to 1.69°C for all three scenarios in the first decade of the near future, escalating to 1.2–6.0°C in the final decade of the far future.*

Sahara (SAH): *In SAH, renowned as one of the hottest and driest places globally, temperature variations are expected based on different greenhouse gas emissions and socio-economic pathways. Decadal temperature increases are anticipated to range from 0.03°C to 0.74°C in the first decade of the near future, escalating to 1.1–6.2°C in the last decade of the far future.*

West Africa (WAF): *Within WAF, decadal temperature increases are predicted to fall between 1.0°C and 1.8°C in the first decade of the near future, contingent on the greenhouse gas emission scenario. For the last decade of the far future, increases are projected to range from 1.2°C to 5.8°C in this region.*

Central Africa (CAF): *In CAF, decadal temperature increases are forecasted to range from 0.05°C to 0.54°C in the first decade of the near future, with subsequent increases of 0.8–5.2°C predicted for the last decade of the far future.*

North East Africa (NEAF): *NEAF is expected to experience decadal temperature increases ranging from 0.04°C to 0.57°C in the first decade of the near future, with projected increases of 1.2°C–5.3°C in the last decade of the far future.*

Central East Africa (CEAF): *The temperature in CEAF is projected to rise from 0.03°C to 0.49°C in the first decade of the near future, expanding to 0.5°C–4.9°C in the last decade of the far future.*

South West Africa (SWAF): *In the 21st Century, SWAF is anticipated to experience heightened temperatures, presenting varied possibilities of greenhouse gas emissions. Predictions include decadal increases ranging from 0.04°C to 0.68°C in the first decade of the near future, and from 1.0°C to 6.2°C in the last decade of the far future.*

South-East Africa (SEAF): *SEAF is also expected to undergo temperature increases. Projections include decadal increases ranging from 0.04°C to 0.59°C in the first decade of the near future, and from 1.0°C to 5.4°C in the last decade of the far future.*

Box 1: *Is Africa getting warmer that the other part of the globe?*

The 2022 IPCC report highlights an alarming trend: human-induced global warming is progressing at a significantly faster rate in Africa compared to the rest of the world (Trisos and others, 2022). The report's regional projections point to a concerning forecast for both northern and southern Africa. It anticipates that the average annual maximum temperature in these regions will surpass normal levels by almost 4°C. As global warming reaches 2°C above pre-industrial levels, the scientists behind the report predict a median temperature increase of 3.6°C for these African regions.

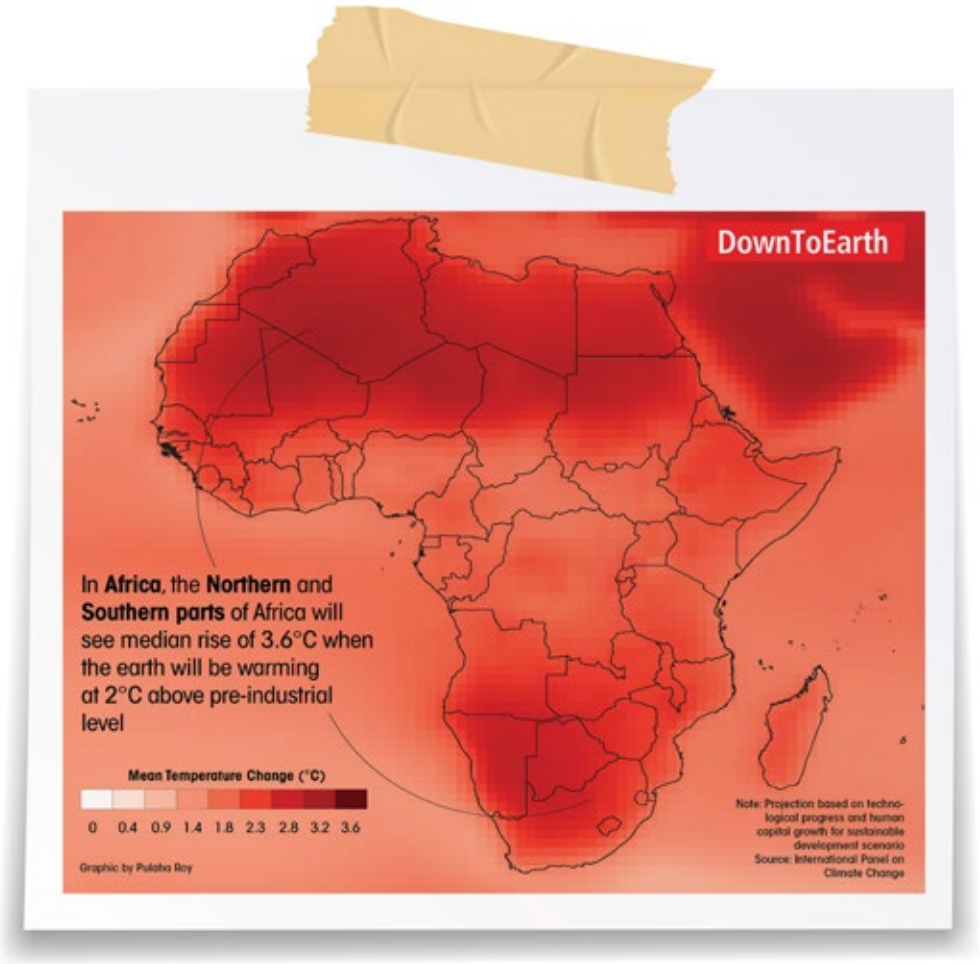


Figure 3: *Projected mean Temperature over Africa*

The analysis highlights that specific regions in north-western Africa are poised to experience an increase of over 2°C in annual minimum temperatures. Additionally, the authors note a projected rise in minimum temperatures in southern Africa, leading to anticipated warmer cold days in the future. In 2021, Africa observed its fourth-warmest April since 1910, registering a temperature anomaly of 1.48°C, as documented by data from the National Oceanic and Atmospheric Administration. The IPCC underscores that with continued global warming, there will be a sustained increase in extreme heatwaves, accompanied by a decline in extreme cold waves, throughout the 21 st Century.

2. Projected Changes in precipitation

This section relies on data derived from a range of climate models, encompassing Coupled Model Intercomparison Projects CMIP5, CMIP6, CORDEX and CORE, to scrutinize anticipated alterations in precipitation indices under diverse emission scenarios. The primary objective is to discern commonalities and disparities among these models. During the December-January-February season (see Appendix 5), a consistent uptick in seasonal mean precipitation is observed over the Horn of Africa and parts of Angola, Kenya and the United Republic of Tanzania across all model ensembles. Nonetheless, nuanced distinctions emerge, particularly in central Africa, where CMIP5 and CMIP6 models foresee an increase, CORDEX models indicate marginal change, and CORE simulations predict a notable decrease. Botswana, Namibia and western South Africa are anticipated to undergo drying trends, with CORE simulations showcasing the most substantial changes. Comparable patterns persist for other seasons, including March-April-May, June-July-August and September-October-November, exhibiting variances in wetting and drying trends across diverse regions and seasons. Despite disparities in seasonal mean precipitation, there is a higher degree of consensus regarding alterations in other indices, such as the Simple Daily Intensity Index, the number of wet days and the duration of meteorological drought. CMIP6 ensembles stand out for providing more accurate and aligned precipitation projections, enhancing our understanding of the evolving climate dynamics.

NAF: *In NAF, a substantial increase in future precipitation is anticipated, particularly under high-emission scenarios. However, the low-emission scenarios display less consistent trends. Projections for the 21st Century indicate significant rises in precipitation. For the near term, expect increases of 14.2, 16.9 and 24.5 percent for low-, middle- and high-emission scenarios respectively (see Figures 4 and 5).*

SAH: *SAH is poised to witness varying year-to-year rainfall in the 21st Century, marked by notable fluctuations (Appendix 5). In the high-emission scenario, a forecasted increase in precipitation is noted towards the century's end. Projected precipitation changes for different emission scenarios range from 11.3 to 15.6 percent in the long-term period, with a likely range spanning from −5.7 percent to 89.7 percent, depending on the scenario (Appendices 4 and 5).*

WAF: *Throughout the 21st Century, WAF experiences significant precipitation fluctuations, displaying a wide range of possibilities with no clear trend. Projected precipitation changes under different scenarios range from 8.1 to 14.2 percent in the near and long terms, with potential changes spanning from −3.6 percent to 47.3 percent depending on the scenario (Appendices 4 and 5).*

CAF: *In terms of precipitation, CAF exhibits a clear increasing trend under high-emission scenarios, with weakly increasing trends under low-emission scenarios. Over the near and long term, the projection indicates a rise in precipitation of 9.4 percent to 16.6 percent under different scenarios, with a likely range for these changes ranging from 3.8 percent to 35.8 percent, depending on the specific scenario (Figures 4 and 5).*

NEAF: *Notably, NEAF sees a significant increase in precipitation in high-emission scenarios, while other scenarios lack a consistent trend. Over the 21st Century, the region is expected to experience a robust overall increase in precipitation, ranging from 14.2 to 24.5 percent in the near and long terms. However, there is some uncertainty, with a likely change range spanning from 4.2 to 42.6 percent, depending on the scenario (Appendices 4 and 5).*

CEAF: *Projected precipitation changes in CEAF vary under different scenarios, with estimates indicating an increase of 6.9–9.2 percent in the near and long term. However, there is a range of possibilities, with likely changes spanning from −0.5 percent to 18.9 percent, depending on the specific scenario (Appendices 4 and 5).*

SWAF: *Similarly to NAF, SWAF experiences a significant decrease in projected precipitation in the 21st Century, especially under high-emission scenarios. Precipitation is projected to decrease by approximately −2.4 to −5.4 percent in the near and long term, with a likely range from −6.0 percent to −1.2 percent in different scenarios (Appendices 4 and 5).*

SEAF: *Similarly to SWAF, SEAF also witnesses a substantial decrease in projected precipitation during the 21st Century. Over the near and long term, precipitation is expected to decrease by approximately −2.4 to −4.0 percent, with a likely change range from −6.3 percent to 0.0 percent, depending on the scenario (Appendices 4 and 5).*

1.2. Potential impacts of current and projected changes in climate on Africa

Climate change-induced shifts in temperature across the continent are disrupting the diverse ecosystems and landscapes of Africa (United Nations Human Settlements Programme [UN-Habitat], 2022). As observed and predicted temperature changes intensify, various plant and animal species, adapted to specific environmental conditions, face challenges. The escalating temperature increases may create new environmental conditions, posing survival difficulties for species once well-suited to local environments. This shift can lead to declines in some species and the dominance of others better suited to the altered conditions (Masson-Delmotte and others, 2021). Consequently, these changes in species composition trigger disruptions in habitats and species interactions, resulting in extensive biodiversity losses (UN-Habitat, 2022). Such disruptions have far-reaching implications for the availability of natural resources, impacting livelihoods in a continent where a majority of the population relies on nature-based resources and economies, particularly in impoverished rural communities (Masson-Delmotte and others, 2021).

The agricultural sector in particular should prepare for heightened occurrences of extended periods of extreme heat and intense rainfall, especially in coastal regions, excluding south-western Africa, under 1.5°C and 2°C global warming scenarios (Mutengwa and others, 2023). This aligns with the anticipated increase in heatwaves and more frequent hot spells, primarily between 15°S and 15°N on the African continent. The effects become even more pronounced under the 3°C global warming scenario (Masson-Delmotte and others, 2021). To address these challenges, it is advisable to cultivate crop varieties capable of withstanding prolonged exposure to high temperatures and heavy rainfall (Weber and others, 2023). A Ricardian analysis conducted for 11 African countries revealed that, on average, a 1°C temperature rise could lead to a 6 percent reduction in net revenue per hectare (Seo and Mendelsohn, 2008).

However, the impacts of climate change extend beyond productive sectors, leading to substantial economic losses, particularly through climate-induced natural disasters in Africa and worldwide (Matata and others, 2018). The distribution of these losses varies among income groups, with low-income countries accounting for a disproportionate share of deaths but a smaller proportion of economic losses (Steiner, 2019). Vulnerable groups, including poor farmers, pastoralists, marginalized communities and impoverished urban residents, bear a disproportionate burden of environmental degradation. Pollution, soil erosion, deforestation, biodiversity loss and water scarcity contribute to their vulnerability due to heavy reliance on natural resources for livelihoods (Steiner, 2019; Birkmann and others, 2022). In recognition of this, enhancing theresilience of impoverished communities is a key target for African countries in Agenda 2030 (Steiner, 2019).

Approximately 500,000 square kilometres of land are lost annually in Africa due to factors such as soil erosion, salinization, pollution and deforestation (United Nations Environment Programme [UNEP], 2016).
This land degradation is driven by a growing population, rapid urbanization, demand for firewood and unsustainable farming methods. Projections indicate that by 2050, 56 percent of Africa's population will reside in urban areas, contributing to the expansion of cities and unsustainable agricultural practices, further deteriorating freshwater sources and coastal and marine ecosystems (Steiner, 2019).

Extreme daily rainfall and prolonged heatwaves are crucial indices for the infrastructure sector. In the 1.5°C and 2°C global warming scenarios, a moderate rise in extreme daily rainfall and more frequent, longer-
lasting heatwaves is predicted in African coastal regions between 15°S and 15°N. These impacts intensify significantly in the 3°C global warming scenario, extending from coastal areas into the continent's interior. In response, infrastructure preparations for increased power grid demands and upgrading unpaved roads are essential in these regions (Weber and others, 2018).

Small islands in Africa face multifaceted impacts from climate change, including rising sea levels, coastal erosion, heat stress, reduced agricultural productivity, freshwater resource risks, extreme weather events and ocean acidification. These challenges have economic and social consequences, affecting sectors including tourism and agriculture, as well as threatening health and well-being (Pörtner and others, 2019; United Nations Development Programme [UNDP], 2020; UNEP, 2021a). Many African small island nations are actively engaged in adaptation efforts, encompassing strategies such as shoreline protection, reforestation and sustainable water management (UNEP, 2021a).

Projected temperature increases in Africa's subregions pose interconnected challenges across public health, water resources, agriculture, biodiversity and coastal communities. Coordinated efforts and resource allocation are imperative to adapt and mitigate the effects of climate change in these regions (Masson-Delmotte and others, 2021).

1.3. Adaptation necessity for Africa's development

Adaptation emerges as a critical imperative for Africa's development, given the continent's vulnerability to severe climate challenges such as soaring temperatures, shifting rainfall patterns, extreme weather events and rising sea levels (Masson-Delmotte and others, 2021). The economic repercussions of climate-related events across all sectors emphasize the pivotal role of adaptation in bolstering economic resilience and curbing vulnerability to climate risks (African Development Bank [AfDB], 2023).

Key points underscoring the significance of adaptation include:

Agricultural Dependency: A substantial portion of Africa's population relies on agriculture for their livelihoods, making the implementation of adaptation strategies crucial to safeguard and enhance agricultural systems (Campbell and others, 2023).

Water Scarcity: Climate change exacerbates water scarcity in many African regions, highlighting the need for adaptation to secure access to clean water for various purposes (Masson-Delmotte and others, 2021).

Health Sector Threats: The health sector faces imminent threats from climate-induced vector-borne diseases, heat-related illnesses, and malnutrition, necessitating effective adaptation to safeguard the well-being of Africa's population (Egerton and others, 2023).

Biodiversity and Ecosystems: Africa's distinctive ecosystems and biodiversity are in peril due to climate change, emphasizing the urgency of adaptation measures to protect vital ecosystem services such as pollination, water purification, and carbon sequestration (Masson-Delmotte and others, 2021).

Conflict and Displacement Risks: The potential for climate-induced conflicts and displacement poses a threat to regional stability and security, underlining the instrumental role of adaptation efforts in reducing the risk of such conflicts and mitigating their humanitarian consequences (Ali and others., 2023).

In this context, adaptation is not only a necessity but a linchpin for Africa's sustainable development, safeguarding its people, economies, and ecosystems in the face of escalating climate challenges.

Climate Change Impacts on Economies and Livelihoods in Africa.

2.1. Climate Change Impacts on African economies and livelihoods

As introduced in the previous chapter, climate change stands out as one of the most critical challenges in the 21st century, and its impact is particularly severe in Africa. The continent's susceptibility arises from factors such as vulnerability, lower income levels, heavy reliance on climate-sensitive sectors, and limited adaptive capacity. Consequently, many African nations find their economic conditions significantly influenced by these challenges.

In the aftermath of a robust recovery from the detrimental effects of COVID-19, African economic growth experienced a decline, estimated at 3.8% in 2022, down from the 4.8% recorded in 2021. This downturn is attributed to various factors, including tightened global financial conditions, supply chain disruptions exacerbated by global events like Russia's invasion of Ukraine, subdued global growth resulting in reduced demand for African exports, and the ongoing repercussions of the COVID-19 pandemic. Adding to these challenges is the escalating impact of climate change and extreme weather events, acting as risk multipliers.

The interconnectedness of this chapter with other sectoral chapters is essential for constructing a comprehensive understanding of the comprehensive impacts of climate change. By contextualizing the economic implications of climate change, this chapter lays the foundation for understanding how various sectors, such as agriculture, water, and ecosystems, are interconnected and affected by these economic disruptions. It establishes the backdrop against which the significance of adaptive strategies and climate-resilient policies in these sectors becomes evident. Essentially, the insights from this chapter form the basis for a comprehensive framework that addresses the multifaceted and interrelated challenges brought about by climate change in Africa.

Delving into a thorough analysis of the adverse effects of climate change on the economy and livelihoods in Africa, this chapter emphasizes the urgent need for investment in adaptation. This shift has evolved from being a mere option to an imperative priority, crucial not only for preserving economic growth but also for ensuring food security, sustaining employment, and safeguarding livelihoods as African nations grapple with the intricate and interconnected challenges posed by climate change.

1. Observed impacts and projected risks of climate change for African economies and livelihoods

African nations are grappling with severe climate-related challenges, including droughts, floods, and rising sea levels, resulting in significant short-term economic setbacks and impeding overall development progress. The macroeconomic costs associated with these adverse effects are notably higher in Africa compared to other regions of the world (Kalkuhl, M. and L. Wenz, 2020).

Recent studies, including the IPCC's Sixth Assessment Report released in 2022, indicate that the economies of African countries are highly sensitive not only to climate-related disasters, but also to year-to-year changes in climatic variables. The IPCC's projection suggests a potential median loss of 1.5 percent of annual gross domestic product (GDP) in developing countries due to global warming, with a substantial impact on sub-Saharan Africa (Pörtner and others, 2022).

A growing body of scientific literature has focused on modelling and assessing the potential impacts ofclimate change on African economies. For example, a study by Baarsch and others (2020) used a panel model to evaluate the historical impact of rainfall and temperature variations on income levels and convergence trends in Africa. The research revealed that climate variability caused average annual losses of 10–15 percent of GDP per capita over the 30-year period of 1986–2015. Consequently, the average GDP per capita of African nations currently stands at 13.6 percent below what it would have been without the climate warming attributed to human activities since 1991.

Barrios et al. (2010) demonstrated that if total rainfall had not declined between 1960 and 2000, the gap between African GDP and that of the rest of the developing world would be 15–40% smaller today, with the most significant impacts in countries heavily dependent on agriculture and hydropower.

The AfDB's economic analysis report on climate-induced historical losses in African countries further highlights significant economic losses over the 1986–2005 period. Many countries experienced average annual reductions in GDP per capita growth ranging from −15 to −10 percent, emphasizing the impact of limited adaptation to year-to-year fluctuations in precipitation and temperature patterns (Baarsch and others, 2019).

The findings align with Baarsch and others (2020), indicating that the majority of African countries experienced average annual losses, induced by climate variability, ranging from −15 to −10 percent in GDP per capita growth over the 1986–2015 period. The cumulative reduction

over this 30-year period could range from 5 to 15 percent, depending on the GDP per capita growth baseline. While the specific mechanisms through which climate variability impacts economic growth were not exhaustively detailed in the econometric analysis and modelling of Baarsch and others (2020), several hypotheses were formulated. These potential channels include an economy's structure and employment patterns, or the distribution of the population between rural and urban areas. The structure of an economy emerges as a significant determinant of the extent of losses experienced by countries. Countries with abundant natural resources, robust service sectors or diversified economies fared comparatively better, while the majority of African countries, historically heavily reliant on agriculture, faced more adverse effects from climate-related losses in the historical period.

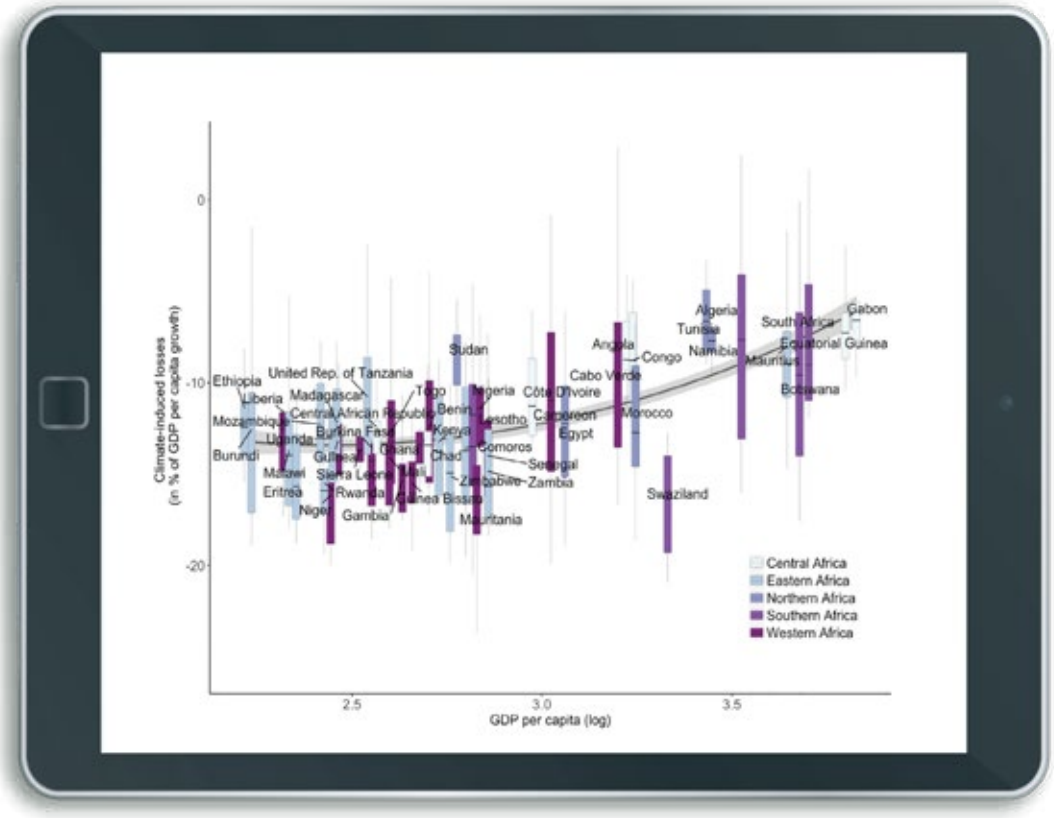


Figure 4 : *Annual climate-induced (precipitation and temperature combined) losses in the period 1986–2005 measured in %age of GDP per capita growth.*

Source: Baarsch et al (2020)

Macroeconomic evidence underscores that climate change disproportionately affects agriculture in sub-Saharan Africa, given that it employs 55–62 percent of the region's workforce. Rising temperatures have a more pronounced impact on agricultural GDP compared to non-agricultural GDP, as highlighted by the IPCC in 2022 (Pörtner and others, 2022).

These climate impacts directly translate into consequences for livelihoods, particularly in regions heavily dependent on agriculture, livestock and fisheries. These sectors, being exceptionally sensitive to climate change, face significant challenges. A growing body of evidence emphasizes the vulnerability of local livelihood resources to climate-related hazards such as droughts, rising temperatures and floods, directly undermining people's capacity to secure food and generate income. Between 2005 and 2020, Africa experienced flood-induced damage exceeding $4.4 billion, with eastern and western Africa facing the most substantial impact. Notably, Lagos reported unprecedented economic losses estimated at $200 million due to floods in 2011. In southern Africa, the highest flood-related costs occurred during the period from 2000 to 2015.

In term of future risks projection, Birkmann and others (2022) have stated that climate change is expected to have adverse effects on economic growth in Africa when compared to a hypothetical scenario where there is no additional climate change, and current levels of adaptation remain unchanged. Depending on the future socio-economic scenario, this could increase global inequality and leave some African countries poorer than at present. Estimations have shown that in the absence of adaptation measures, a 3°C temperature increase will reduce Africa's GDP by 3 percent by 2050 and 8.6 percent per year after 2100, compared to only 3.8 percent if climate change is limited to the 1.5°C target set in the Paris Agreement (AfDB, 2023a).

GDP per capita deviation risk projections made by Baarsch and others (2020) in two different warming scenarios (Representative Concentration Pathway [RCP]2.6, low warming; and RCP8.5, high warming) for Africa show that the changes in precipitation and temperature will have an adverse impact on GDP per capita growth across all African regions. Among these regions, western and eastern Africa are expected to be the most affected, with a median reduction in GDP per capita exceeding 10 percent in the high warming scenario by 2050.

In contrast, the northern, southern and central African regions are projected to be the least affected, with deviations anticipated to remain below 10 percent compared to the baseline, and below 5 percent in the case of central African countries. Notably, high warming scenarios would be particularly detrimental to African economies, as the regional median macroeconomic risks are nearly double those of the low warming scenario by 2050. While the macroeconomic risks stemming from climate-related disasters and climate change exhibit a relatively similar level between 2010 and 2030, it is worth noting that

the risk measured in the high warming scenario is already higher than that in the low warming scenario.

In a high warming scenario for African countries, the total economic costs of climate change, including adaptation costs and residual damages, is expected to exceed those of a low warming scenario (Baarsch and others, 2019). They are estimated to be at least one third higher, and could double in eastern Africa (Figure 5). The AfDB (2023) estimates that climate change-related losses to the continent's economy could range from $289.2 billion to $440.5 billion.

Figure 5 : *Total net damages for five African regions.*

Note: Residual damages, anticipatory adaptation investments and reactive adaptation costs are given in 2050 for each region for a scenario holding global warming below 2°C, and a scenario exceeding 2°C by 2050 and heading towards above 4°C by 2100, as percentage of regional GDP in 2050.

Source: Baarsch and others (2019).

> *In the moment of crisis, the wise build bridges, and the foolish build dams.*
>
> African Proverb.

Against the backdrop of African nations contending with existing debt burdens, the escalating frequency and persistence of climate change impacts stand poised to heighten macroeconomic volatility, thereby undermining the long-term growth prospects of these countries. This escalating risk presents a formidable challenge to sustainable development. Compounding this challenge is Africa's position as the world's fastest-growing population, projected to account for approximately 40% of the global population by 2100. This demographic surge intensifies the urgency to implement effective strategies addressing climate-induced disruptions in agriculture and ensuring food security.

In tandem with these pressing challenges, evidence suggests that by 2030, climate change is forecasted to push 39.7 million Africans into extreme poverty under a baseline scenario of delayed and non-inclusive growth. Recent research establishes a significant positive statistical association between increasing temperatures and poverty. A 1°C rise is correlated with a 4.6% reduction in per capita consumption expenditure and a 2.8 percentage point increase in poverty rates in sub-Saharan countries. Flood shocks, regardless of the considered measures, yield negative impacts on total expenditure, resulting in a 35% decrease in total and food per capita consumption and a 17 percentage point increase in extreme poverty. The potential for price spikes further exacerbates household poverty, with anticipated substantial food price hikes by 2080-2099, especially under challenging mitigation and adaptation scenarios (SSP3 and RCP8.5). Countries like Chad, Niger, and Sudan are anticipated to experience the most significant price increases, reaching up to 120%.

Furthermore, climate hazards and extreme events act as primary mechanisms for the destruction of household assets, impeding the ability to invest in new assets and leading to reduced productivity.

These challenges are further compounded by socio-cultural norms perpetuating gender disparities in agriculture. Women, often overseeing smaller plots of land characterized by poorer soil quality, contend with limited access to crucial agricultural inputs such as fertilizers, advanced tools, and improved seed varieties. Lower educational attainment among women in agriculture, coupled with reduced benefits from extension services and support provided by governmental and non-governmental entities, exacerbates this situation. Recognizing and addressing these gender-specific vulnerabilities should constitute a vital component of any strategy aimed at fostering resilience and assisting communities in adapting to the climate impact on livelihoods in rural Africa.

2. Economic impacts and vulnerabilities

Impacts on key economic sectors

Climate change is having profound and distinct impacts on various sectors of Africa's economy, affecting key stakeholders such as households, producers, governments, and external entities. This includes crucial industries like agriculture, mining, manufacturing, and services, particularly tourism.

In households, rising food prices due to decreased agricultural productivity strain budgets and worsen food insecurity. Producers, especially in agriculture, face challenges with reduced yields and income loss, necessitating adaptive farming practices. Governments experience increased demands for assistance following climate-induced disasters, challenging resources and disaster response mechanisms. External entities, including international aid organizations, are under heightened pressure to provide support amid growing climate-related challenges.

In the mining industry, increased water scarcity disrupts operations and poses challenges to resource extraction. Services, particularly tourism, suffer from changing weather patterns that impact destination attractiveness, leading to decreased revenues, especially in tourism-dependent regions. Agriculture witnesses a substantial 34% reduction in productivity growth since 1961, resulting in critical implications for staple crops and disruptions in the supply chain, affecting both local and international markets.

The industrial sector, especially those reliant on agricultural raw materials, faces disruptions, exemplified by a 40% drop in tea leaf harvest in Kenya due to erratic rainfall and extreme temperatures. Micro, small, and medium-sized enterprises (MSMEs), crucial for African economies, experience substantial revenue declines, impacting livelihoods and contributing to broader economic instability.

The tourism industry sees decreased revenues due to prolonged droughts and extreme heat events, disrupting travel plans and deterring potential tourists. Adverse climate events like Cyclones Idai and Kenneth cause infrastructure damage, disrupt essential services, and impede economic activities, particularly in vulnerable communities.

Overall, climate change poses multifaceted challenges, necessitating targeted adaptation and resilience strategies for households, producers, governments, and industries. A comprehensive approach is essential to address these implications and promote sustainable development in the face of evolving climatic conditions.

Impacts and vulnerabilities of the informal sector

The influence of climate change on Africa's informal sector represents a crucial yet frequently overlooked aspect when evaluating the overall ramifications of climate extremes. Despite being frequently excluded from GDP-based projections, these impacts can be substantial and exert a detrimental effect. The informal sector, constituting a significant 85.8% of all employment in Africa, plays a substantial role in African economies and encompasses small to medium-sized enterprises highly vulnerable to climate extremes.

Numerous businesses and activities within the informal sector are situated in areas particularly prone to climate hazards, such as low-lying coastal regions or sloped terrains. Construction workers, domestic workers, street vendors, and transport workers, for example, often encounter challenges in operating during climate shocks due to disruptions in transportation and commodity flows. These interruptions carry economic consequences, impacting both businesses and individuals within the informal sector.

Moreover, a primary challenge faced by those involved in the informal sector is their limited capacity to adapt to climate-related risks. The deficiency in adaptive capacities means that during extreme events like flooding, landslides, or waterlogging, they frequently struggle to recover their assets and rebuild their livelihoods.

It's crucial to recognize that women are disproportionately represented in the less well-remunerated segments of the informal economy, rendering them particularly susceptible to the economic impacts of climate change within this sector. This exacerbates existing gender disparities. In rural Africa, impoverished households, especially those led by women, bear a more substantial burden in dealing with climate-related challenges, impacting them more profoundly. A significant portion of the informal workforce in these areas comprises women, who unfortunately also face a higher likelihood of unemployment compared to men, as emphasized by the International Labour Organization.

Transboundary economic effects of climate change

Climate change introduces a complex dimension to transboundary challenges, amplifying existing tensions and exerting additional pressure on livelihoods across borders in Africa. Disruptions or damages to regional infrastructure, stemming from extreme climate events or environmental shifts, can set off cascading economic impacts, disrupting crucial sectors like agriculture and fisheries. These disruptions extend beyond regional trade, impacting resource-dependent industries and influencing fish stocks, agricultural trade, and energy generation. Moreover, the interconnected nature of economies and shared resources across borders means that climate-induced disruptions, such as trade bans due to livestock diseases, have a ripple effect across the entire region. This emphasizes the imperative need for cooperative strategies to effectively address these challenges.

Climate change heightens transboundary risks, emphasizing the essential role of regionally coordinated efforts to enhance resilience and mitigate its far-reaching consequences on economies and livelihoods.

Transboundary trade risks emerge as a focal point in many of Africa's regions, such as West Africa, where national policies, particularly regarding food imports and exports, prioritize these concerns. Several countries, including Senegal and Nigeria, heavily depend on food imports to meet domestic demand. Reductions in rice crop yields in source countries, attributed to climate-induced shocks, have resulted in increased prices and food insecurity in importing nations. Climate-related events like droughts and locust plagues frequently trigger food commodity imports, elevating the need for food aid. Furthermore, the global projection of a potential 51% decrease in rice production by 2100 due to temperature rises and extreme weather events intensifies the urgency to address these transboundary trade risks.

There is no beauty but the beauty of action.

African Proverb.

SECTION III

Climate Change Impacts, Risks, and Vulnerability in Africa's Critical Sectors

In the following section, the State of Adaptation in Africa Report 2023 provides a comprehensive overview of the observed impacts, projected risks and notable vulnerabilities linked to critical sectors in Africa, covering the sectors of agriculture and food security, water, health, and biodiversity and critical ecosystems. The analysis delves into the intricate dynamics and potential challenges confronting each sector within the context of climate change, emphasizing the diverse and complex nature of the impacts across the African continent.

3.1. Agriculture & Food Security

Climate-related hazards to agriculture in Africa bear a considerable impact on and food security affecting food production, distribution and overall availability. The IPCC highlighted three significant climate-related hazards for Africa in its Sixth Assessment Report, one of which is decreasing food production from crops, fisheries and animals. The term "key risks" refers to potentially severe dangers linked with harmful anthropogenic involvement in the climate system (Pörtner and others, 2022). The key risk related to agriculture and food security ranges is already assessed as moderate based on current levels of global warming, meaning that negative impacts have already been detected and can be attributed to climate change. This level of risk is associated with reductions in agricultural productivity, such as a 5.8 percent mean reduction in maize productivity (Trisos and others, 2022). At 1.5°C global warming, this risk transitions to high risk with projected impacts including:

- 9% declines in maize yields in West Africa.
- 20 - 60% declines in wheat yields in Southern and Northern Africa.
- Declines in coffee and tea yields in East Africa.
- Declines in sorghum yields in West Africa.
- Over 12% decline in marine fisheries catch in West Africa (Trisos and others, 2022)..

The risk transitions to very high risk at 2°C which includes projected impacts such as 10–30 percent declines in marine fisheries catch potential in eastern and southern Africa, and more than 30 percent for western Africa. Impacts also include dramatic declines in yield for wheat, rice and maize, and 40 percent loss in rangeland productivity, as well as severe heat stress for livestock (Trisos and others, 2022).

1. Observed impacts and projected risks.

Kemoe and others (2022) indicate that the toll of extreme weather events which destroy crops and disrupt transportation of food highlight Africa's challenges and the urgency of introducing policies to protect livelihoods and save lives. Temperature increase is accelerating, extreme weathers are worsening food insecurity, displacement and conflicts, agricultural productivity is decreasing, losses and damages are rising, adaptation financing is insufficient, and early warnings must reach everyone. For example, as shown in Figure 6, the rate of temperature increase in Africa has been accelerating in recent decades with climate-related events becoming more severe with high levels of fatalities and losses. Annual food imports are expected to continue to increase. Africa's loss and damage costs due climate change are projected to range between $290 billion and $440 billion in 2°C and 4°C warming scenarios respectively (World Meteorological Organization [WMO], 2022). Overall, climate change is intensifying food insecurity in Africa, harming ecosystems and economies, fuelling displacement and migration, and stalling progress by interacting with multiple other stressors and shocks, including inequality, conflicts, the

COVID-19 pandemic and degrading natural resources (Kray and others, 2022a; WMO, 2022). These trends are expected to continue and cost of inaction to keep rising if the gap in adaptation finance is not closed and appropriate adaptation action actions are not urgently taken by African countries. Some of the observed impacts and projected risks are discussed in more detail below.

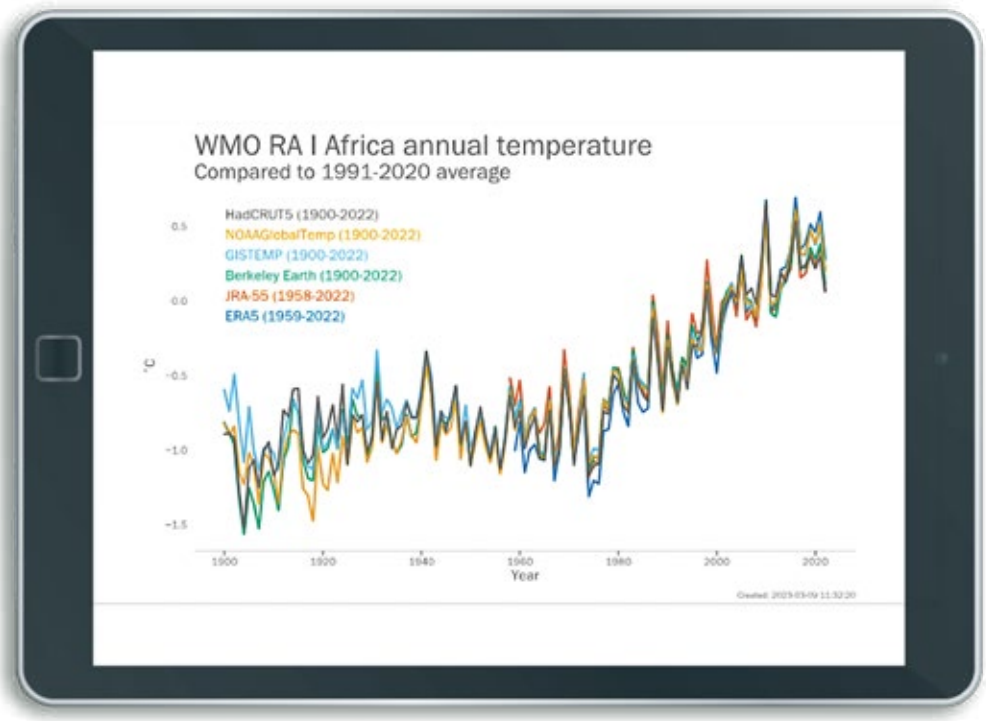


Figure 6 : *Trends in average annual temperatures in Africa compared to 1991–2020 average.*

Source: Adapted from WMOrganization, (2022)

Reduced agricultural productivity: In Africa, observed impacts of climate change on agriculture and food security include a reduction in productivity growth of 34% since 1961, and significant declines in crop yields (5.8% for maize, 2.3% for wheat, and up to 5.1% for sugar cane) (Trisos and others, 2022). Many African regions, especially sub-Saharan Africa, depend heavily on rain-fed agriculture. Shifts in the timing, intensity, and duration of rainfall can lead to prolonged droughts or flooding, affecting crop yields and livestock productivity. In many African regions, planting dates for crops are aligned with the onset of rains. Delays in the onset or early cessation can disrupt the entire cropping calendar, leading to reduced yields or total crop failures (Trisos and others, 2022). Under a 3°C warming scenario, Africa is expected to lose up to 60% of growing areas for beans and 30% for maize and banana by 2050. Short-duration, high-intensity rainfall events can cause soil erosion, nutrient leaching and flooding, which damages crops and decreases soil fertility. Elevated temperatures and altered precipitation patterns can reduce yields of staple foods like maize, millet, and wheat. This is particularly concerning in areas that already experience low yields. Excessively high temperatures, especially during flowering, can lead to sterility in many crops, reducing grain yields. (Baptista and others, 2022; Carleton, 2022; Kemoe and others, 2022; Kray and others, 2022a; Pörtner and others, 2022; Scholes, 2022).

Loss of livestock: The IPCC reports that livestock systems in Africa are already being affected by climate change, primarily through reductions in fodder quality and availability, reduced water resources availability, and livestock pests and diseases (Trisos and others, 2022) Livestock systems, particularly pastoralism, are directly dependent on the availability of water and pasture. Climate change will continue to impact fodder quality and availability as rangeland net primary productivity in West Africa is projected to decrease by 42% under 2°C global warming, and by 46% under 2.4°C global warming. It is expected to decrease by 37% in Southern Africa, 32% in North Africa, and by 5% in both Central and East Africa (Trisos and others, 2022). Droughts can lead to inadequate pasture, affecting livestock health and increasing mortality. Also, heat stress can reduce meat and milk production. Figure 7 below depicts the projected increase in heat stress for cattle under the 1.5°C and 3.75°C global warming scenarios (Bahta, 2022; Pörtner and others, 2022; Scholes, 2022; Trisos and others, 2022).

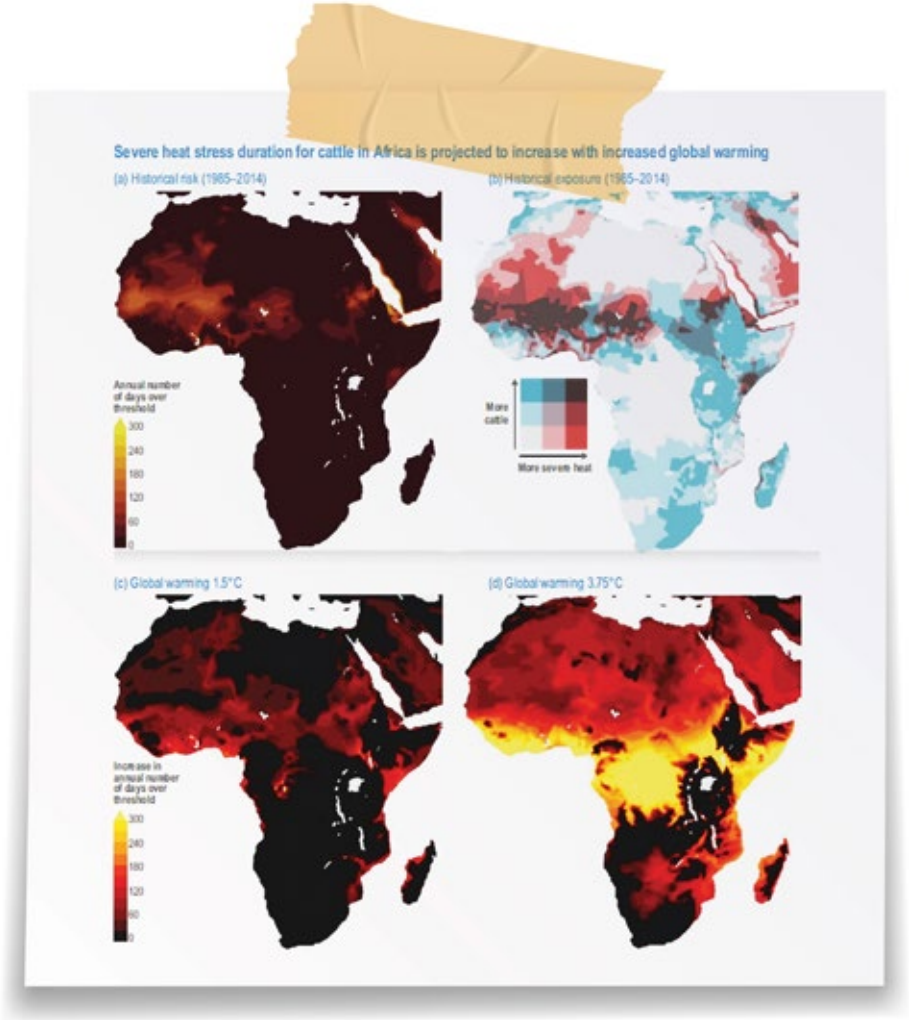


Figure 7 : *Projected heat stress for cattle in Africa under different global warming scenarios*

Note: (a) Number of days per year with severe heat stress in the historical climate (1985–2014); (b) Historical cattle exposure to severe heat; (c, d) Projected increase in the number of days per year with severe heat stress for a global warming level of 1.5°C and 3.75°C

Source: Trisos and others,(2022).

Water scarcity: Extreme variability in rainfall and river discharge has been experienced across Africa and has had largely negative impacts on water-dependent sectors such as agriculture and food security (Trisos and others, 2022). Changes in the distribution, intensity, and frequency of rainfall, coupled with increasing evaporation rates, can decrease the availability of water for irrigation. Many African regions, especially in the eastern and southern parts, are prone to droughts which can severely impact crop yields and livestock. With global warming up to 3°C global warming, droughts are projected to increase between 3- and 20-fold (Trisos and others, 2022). Water sources are projected to diminish or become more unpredictable, there can be increased competition for resources, leading to potential conflicts. Diminished rainfall can reduce the recharge rates of aquifers, which many farmers rely on for irrigation and over-extraction of groundwater for irrigation can lead to increased soil salinity, affecting crop growth (Kemoe and others, 2022; Pörtner and others, 2022).

Pests and diseases: The IPCC reports that pests and diseases are responsible for approximately 10 – 35% in yield losses in many crops. Recent locust outbreaks are attributable to climate change (Trisos and others, 2022). Rising temperatures and changing rainfall patterns can expand the range and increase the prevalence of many pests and diseases, affecting both crops and livestock. For instance, an increase in temperatures might expand the range of certain pests like the Fall Armyworm, which has devastated maize crops across Africa, and pests that survive in hotter and more variable conditions might be hardier, potentially leading to increased pesticide resistance. Increased humidity can exacerbate post-harvest losses by promoting conditions suitable for pests like weevils. The IPCC estimates that climate change could increase pest-driven losses by up to 50%. Warmer conditions can favor the proliferation of vectors like mosquitoes, which can transmit livestock diseases such as Rift Valley fever. (Baptista and others, 2022; Pörtner and others, 2022; Trisos and others, 2022).

Soil degradation: Estimates show that soil degradation affects 46 % of Africa's land area impacting at least 485 million people or 65 % Africa's population and representing an annual cost of approximately USD 9.3 billion. Land degradation and climate change exacerbate each other and affect food security, biodiversity and livelihoods. Changes in precipitation and increased temperatures can exacerbate soil erosion, salinization, and desertification. For example, rising temperatures can accelerate the decomposition of organic carbon in soils, reducing soil fertility; desertification and changing land use patterns can reduce the biodiversity in the soil, impacting soil structure and health; and excessive rainfall can lead to soil acidification, which affects nutrient availability for crops. This reduces the amount of arable land available for farming. It is known that soil erosion rates increase with increasing mean annual rainfall and vegetation cover is key in preventing soil loss through water and wind erosion (Africa Group of Negotiators Experts Support, 2020). For instance, in Nigeria total soil loss due to water erosion is estimated at 30 million tons per year, and in Ethiopia about 1 billion tons of top soils are lost per year due to soil erosion. It is projected that more than 50 percent of cultivated agricultural are in Africa could

be unusable by 2050 and the continent could become unable to feed even 25 percent of its population by 2025. Availability of livelihood safety nets will also be reduced by climate-related land degradation. The World Bank estimates that land restoration, including soil restoration, would cost $3.4 billion and the estimated cost for inaction is $26.8 billion.

Shifts in agro-ecological zones: Changing weather patterns can lead to shifts in agro-ecological zones, affecting the crops that can be grown in various regions. This could require farmers to adapt by switching to new crops or farming practices. Warming temperatures are affecting the optimal altitude ranges for coffee and tea cultivation, key export crops for countries like Kenya and Ethiopia. Many African communities rely on freshwater and marine fisheries. These systems are sensitive to temperature changes and water quality. And in coastal areas, rising sea levels and increased salinity can impact coastal agricultural zones (Food andAgriculture Organization of the United Nations [FAO], 2022; Pörtner and others, 2022).

Economic impact: Reduced agricultural outputs can lead to increased food prices, which can particularly hurt urban populations and the poorest rural inhabitants who are net food buyers. Additionally, reduced productivity can lead to loss of employment for those involved in agricultural production, processing, and distribution. An increase in global temperatures to 3°C 2030 would lead to catastrophic results such as a reduction of the income of the poorest 40% of Africans by 8%, and undernourishment of 350 million Africans. Those relying on agriculture in North Africa are expected to see a 5-20% reduction in their economic welfare depending on the degree of global warming, while the figure in Sub-Saharan Africa is 5% – 10%. Furthermore, crop failures can strain local credit systems as farmers may struggle to repay agricultural loans (FAO, 2022; Kemoe and others, 2022; Kray and others, 2022b; Pörtner and others, 2022; Trisos and others, 2022).

Climate change poses significant threats to agriculture and food security across diverse regions of Africa. From droughts and erratic rainfall patterns to shifting pest dynamics and temperature extremes, these diverse regions exhibit distinct vulnerabilities. Table 1 below provides a high-level summary of some of the impacts that climate change will have on the different regions in Africa.

Table 3: *Summary of regional impacts of climate change on agriculture and food security*

North Africa	Crop productivity: Cereal crops, mainly wheat and barley, face potential yield reductions due to heat stress and changing precipitation patterns. These staple foods underpin the region's food security. Olive production: negative impacts are expected in the production systems. Irrigation: North Africa's agriculture, especially in Egypt along the Nile, relies significantly on irrigation. Changes in river flow due to changing precipitation patterns in its catchment can impact agriculture. Salinization: As sea levels rise, coastal aquifers risk increased salinization, jeopardizing freshwater supplies for irrigation and drinking.
West Africa	Rainfall uncertainty: The onset of the rainy season is crucial for cropping calendars. Changes or unpredictability can lead to either early planting, resulting in crop failure, or delayed planting, resulting in reduced yields. Cocoa production: Countries like Côte d'Ivoire and Ghana are leading cocoa producers. Changes in temperature and humidity can affect cocoa yields and quality. Sorghum yields: Declines in the region of 2% - 5% depending on the degree of global warming. Livestock: Transhumance patterns (seasonal livestock movement) can be disrupted by changing availability of pasture and water, impacting herd health and community relationships.
Central Africa	Forest-dependent livelihoods: Many indigenous communities rely on forests for food, medicines, and livelihoods. Deforestation, exacerbated by changing climate patterns, threatens this dependence. Cassava and yams: Vital staple crops can be impacted by changing rainfall patterns and new pest and disease profiles. River systems: The Congo River Basin, a lifeline for many, can see changes in flow patterns, impacting agriculture, fisheries, and transportation.
East Africa	Lake ecosystems: Lakes like Victoria, Tanganyika, and Malawi support millions through fishing. Changes in lake temperatures and nutrient upwelling can disrupt fish populations. Maize and beans: These are staple foods in the region. Reduced rainfall and increased temperature can lead to significant yield drops. Tea and coffee: negative impacts are projected on the production systems, including on suitable areas for production, and yield. Disease patterns: Rising temperatures can expand the range of diseases like coffee rust, which affects coffee plants, or Maize Lethal Necrosis Disease.
Southern Africa	Maize: A primary staple that's temperature-sensitive, especially during flowering. Even slight temperature increases can reduce yields significantly. Grape production: Countries like South Africa have significant wine industries. Changes in temperature and precipitation patterns can alter grape quality and production. Water resources: The region has seen crises like the Cape Town water shortage. Such events can directly impact irrigation-dependent agriculture.

2. Vulnerability of agriculture and food security in Africa.

Climate variability and the increased frequency and severity of weather extremes brought on by climate change present a number of problems: they exacerbate risk and impacts, affect all aspects of food security and nutrition, disproportionately affect the social groups that are already in precarious situations, and put additional strain on water, land and ecosystems (Kray and others, 2022b). Across Africa, may groups such as female farmers, cocoa farmers, pastoralists, coastal farmers, rural and forest communities, have higher vulnerability to climate change. This is due to low adaptive capacity, acute levels of poverty, socio-economic status, gender, age and ethnicity and the limited facilities to adapt to the changing climate conditions (Trisos and others, 2022).

Agriculture in Africa heavily depends on rainfall and is mostly subsistence in nature (Hlophe-Ginindza and Mpandeli, 2020; Trisos and others, 2022).The heavy reliance on rain-fed agriculture makes the continent's food systems highly sensitive to the changing conditions of precipitation and rising temperatures. (Ofori, Cobbina and Obiri, 2021; Pörtner and others, 2022).

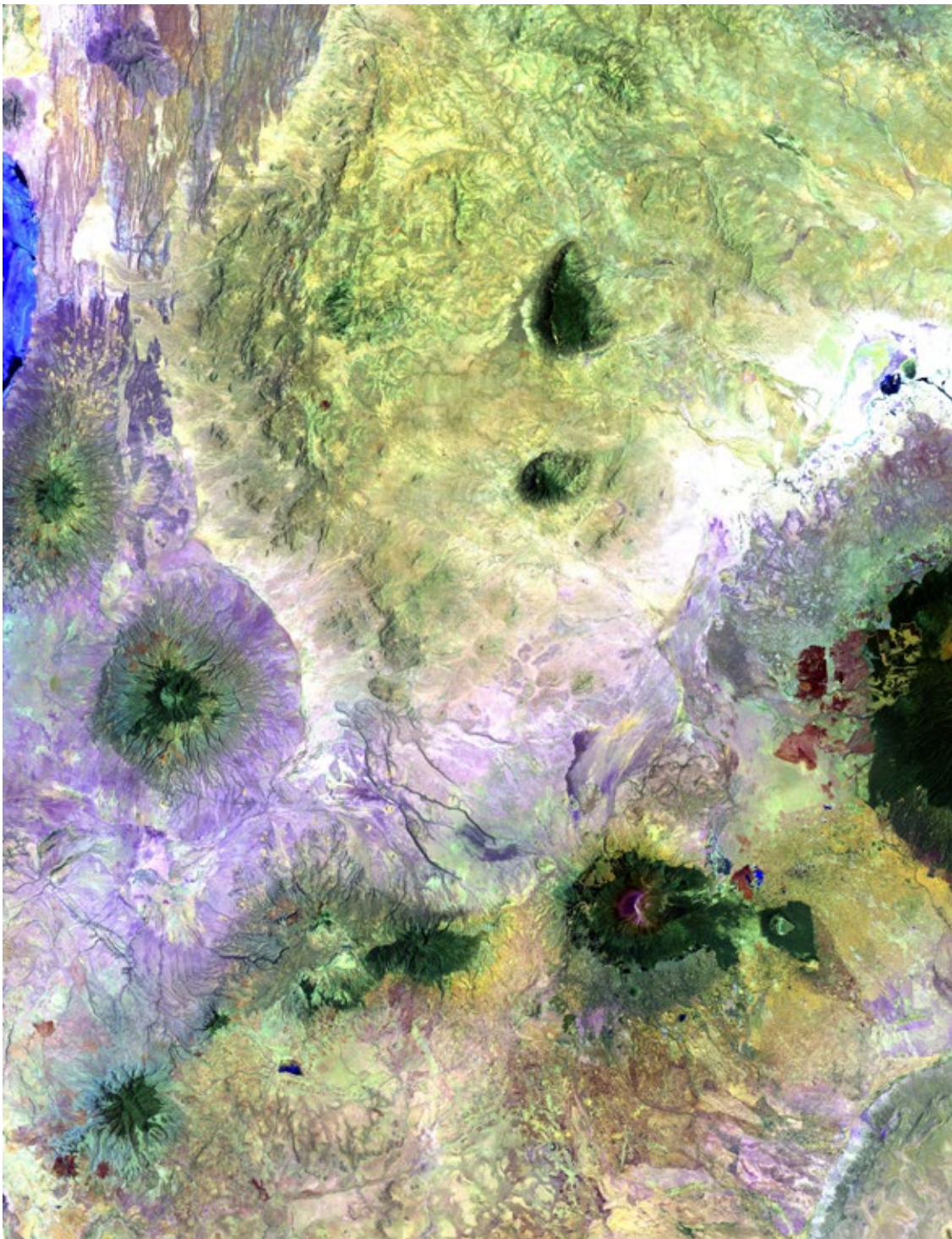
As stated above, agriculture accounts for over 65% of employment, 35 – 40 % of the GDP, and 50 percent of exports (FAO, 2022). For those living in rural poverty, the agriculture sector acts as a safety net. Since drought and floods occur more frequently and intensely in many locations, communities across the continent are becoming more vulnerable (World Health Organization [WHO], 2023).

Non-climatic stressors aggravate food insecurity in many parts of the continent (Trisos and others, 2022). Africa's dependence on increasing level of food imports, increasing food prices due to strong important demand and tightening export stocks, fertilizer and fuel crisis, rising debt, extreme weather including drought, on-going conflicts are issues that add to Africa's vulnerability (Adesina, 2022; Kray and others, 2022b). Over 80 percent of Africa's basic food imports come from outside of the continent. Food imports are expected to almost triple from US$43 billion in 2019 to US$110 billion in 2025 and food security is expected to decline by 5-20 percent with each flood or drought (Kray and others, 2022b).

Agriculture already struggles to sustainably meet the demands of a population that is getting bigger and more urbanized while still producing enough raw materials, bioenergy, processed goods, and services to support healthy diets (FAO, 2022, Trisos and others, 2022). The recent advancements achieved in supporting sustainable rural livelihoods and combating hunger and malnutrition are already being undermined by climate change, among other factors (FAO, 2022). In addition, the interconnected effects of biodiversity loss (including ecosystem degradation, extinction of species, and erosion of genetic resources and competition for access to natural resources) have an impact on agriculture and related livelihoods in the short and long

terms (Benton, 2021).

To adapt to climate change, smallholder farmers are increasingly using and being exposed to a group of agrochemicals that are harmful to ecosystems and humans, with inadequate equipment, knowledge and technical support (Isgren, Andersson and Carton, 2020; Opiyo, 2021). The pesticides used by farmers in parts of sub-Saharan Africa belong to a group of chemicals called endocrine disruptor compounds and include dichlorodiphenyltrichloroethane (DDT) and insecticide banned decades ago. In terms of contamination of food, Isgren et al (2020), found evidence that smallholder pesticide use exposes local consumers to risk in many parts of sub-Saharan Africa. The use of agrochemicals may impact intra-African trade international trade as it might lead to non-compliance with quality standards, including sanitary and phytosanitary compliance, thus constraining exports.



3.2. Water Resources

Water is an indispensable natural resource, critical for human health and well-being, biodiversity and ecosystems sustenance (Miller and others, 2021; Papa and others, 2023). The United Nations World Water Development Report 2023 and the African Water Vision 2025 places water as a key climate connector and at the pinnacle of climate change adaptation (CCA), capable—if not well-managed—of hindering much-needed socio-economic development in Africa (United Nations Economic Commission for Africa, African Union and AfDB, 2003; United Nations, 2023).

Climate change affects the spatio-temporal availability of water. Section I clearly contextualizes the extent and impact of climate change in the different regions of Africa. Large portions of the African continent are warming at rates which are twice the global average, leaving many people at risk (Global Center on Adaptation [GCA], 2021), and putting societies and economies across the continent in harm's way by menacing water availability (Bakhtary, Tucker and Fleckenstein, 2021).

While parts of Africa have relatively high water availability and huge hydro-potential, uneven distribution of the available water implies that some regions on the continent are experiencing low water availability and security (Caretta and others, 2022). Changing rainfall patterns, decrease in rainfall, increase in evapotranspiration, and decrease in run-off and streamflow, all associated with climate change, can be considered the physical drivers accounting for water scarcity on the African continent. Total available water in Africa can be masked by variabilities in water access and utility, as water scarcity is determined by more than just physical amounts of bulk water, but also broader developmental dimensions such as governance, institutions, gender equality, poverty, security, education and health (Leal Filho and others, 2022a).

Observed and projected hydrological records reveal that freshwater resources on the continent are vulnerable to climate change (Banze and others, 2018). One third of Africa's population faces water scarcity (Bakhtary, Tucker and Fleckenstein, 2021). Meattle and others (2022) reported that over 300 million Africans do not have access to clean drinking water, and more than 700 million still do not have access to adequate sanitation.

1. Observed impacts and projected risks.

The impact of climate change on water resources in Africa is unequivocal, and exacerbates existing challenges such as poverty, food insecurities, gender inequalities, conflicts, infrastructure and financial limitations. The most important manifestation of the impacts of climate change in Africa is through water (GCA, 2021). Africa is considered the second driest region in the world, exhibiting synchronous physical and economic water scarcity (Tuyishimire and others, 2022).

The impacts of climate change are manifesting in variability in water availability across Africa aggravated by limited, uneven water resources distribution and poor infrastructure. According to the Sixth IPCC report, climate change intensifies the existing stress on Africa's water resources (Caretta and others, 2022). The increasing frequencies and intensities of extremes, attributed to climate change, are reducing water security in many locations and communities in Africa. This hinders sustainable development efforts (Pörtner and others, 2022) among the most vulnerable people on the African continent, who contributes the least to greenhouse gas emissions but are among the most threatened by climate change (AfDB, 2023b). The intensity of water scarcity experienced on the continent is threatening the livelihoods and well-being of people and leading to a range of adaptive responses (Leal Filho and others, 2022a).

Recurrent droughts influenced by climatic variability and change, and other underlying challenges is leading to inequities in access to water and sanitation in Africa (Bakhtary, Tucker and Fleckenstein, 2021). Sustainable Development Goal 6 speaks to access to potable water and sanitation—three in five Africans, or more than 411 million people, do not have access to safe drinking water, and more than over 700 million live without access to good sanitation (African Union, 2023; UNDP, 2023). Many African national Governments are far from being on track to provide these basic human necessities (UNDP, 2023).

Africa is recording an increasing trend in temperature across all its regions (northern, eastern, western, central, southern and Indian Ocean Island countries) between the period 1901–1930 to the period 1991–2021 (WMO, 2022). Large contrasting geographical distribution in precipitation are being observed in the different regions of Africa, with the north-west experiencing extensive reduction, the north-east an increasing trend, the western region a delayed onset, central with large increases, the eastern region with increasing trend, and the southern end of the continent experiencing a larger deficit in precipitation (Trisos and others, 2022; WMO, 2022). A rate of 4mm per annum sea level rise are recorded along the African coastline, leading to increases in the frequencies and intensity of coastal flooding in many low-lying cities, and resulting in groundwater intrusion and salination (WMO, 2022).

Climate change impacts on the spatial and temporal availability of water, and will thus have major consequences for water-dependent livelihoods and developments. As alluded to by Papa and others (2022), the combined effect of climate change, environmental pressures and anthropogenic activities are impacting on the availability of freshwater resources, which are becoming major areas of concerns on the African continent. A combination of increasing water consumption, drought and extreme heatwave events will give rise to increasing water demand and exacerbate prevailing water challenges, on a continent with a vast number of transboundary basins prone to conflict. Projected sea level rise by 2030 is expected to expose more than 116 million people on the continent to associated risks (WMO, 2022).

As also outlined in Figure 8, climate-induced changes in weather patterns are impacting on hydrological processes, affecting the intensity and magnitude of precipitation, thereby influencing water availability, leading to water stresses and exacerbating water scarcity and pollution in Africa. Adapting to the effects of climate change through water management is therefore expected to improve water supply, health and livelihood (AfDB, 2023b).

2. Vulnerability of water resources

Many countries in Africa are confronted with a range of challenges, limiting their ability to extend services to rural and vulnerable populations exposed to climate change-related risks. Environment-dependent livelihoods such as small-scale agricultural activities are particularly vulnerable to changes in water access and availability (United Nations, 2023). Low adaptive capacity and high vulnerabilities predominantly expose Africa to climate change hazards. Social and economic inequalities are also exacerbated by climate change impacts and associated risks in developing regions such as Africa. Development-constrained regions have high vulnerability to climatic hazards, such regions are concentrated particularly in western, central and eastern Africa, where poverty prevails. Reported recent comparative global assessments of climate change related vulnerabilities based on differences in terms of exposure and risks reveal global hotspots of human vulnerability in these parts of Africa, followed by regions in central America and Asia (Pörtner and others, 2022).

The vulnerability of these regions to the impacts of climate change is linked to their dependence on climate sensitive sectors such as agriculture, by menacing water availability to these sectors. While there are uncertainties in the extent of the impacts of climate change on water resources, the observed and projected impacts on sub-Saharan Africa are expected to be greatest (Ngoran, Dogah and Xue, 2015). This is due to rapid population expansion, poverty, food insecurities and health-related vulnerabilities. In addition, sub-Saharan Africa is confronted with numerous water stresses related to climate change, which are far reaching, with cross-cutting sectoral impacts on health, power generation, food security and socio-economic development increasing the severity of peoples' vulnerabilities (Turyasingura and others, 2022).

Growing population, rapid urbanization, migration, land use and land cover changes, overexploitation, and pollution are pre-existing water challenges in Africa, which are magnified by climate change (Mishra and Verbist, 2021). These and many other factors increase the vulnerabilities of women and children, who play the important role of ensuring household water security. Precipitation and water availability in Africa varies widely, further compounded by the extremely low translation of precipitation to run-off due to high evapotranspiration. The continent has a precipitation-to-run-off conversion of 15 percent, which is the lowest on average for all continents. The influence of

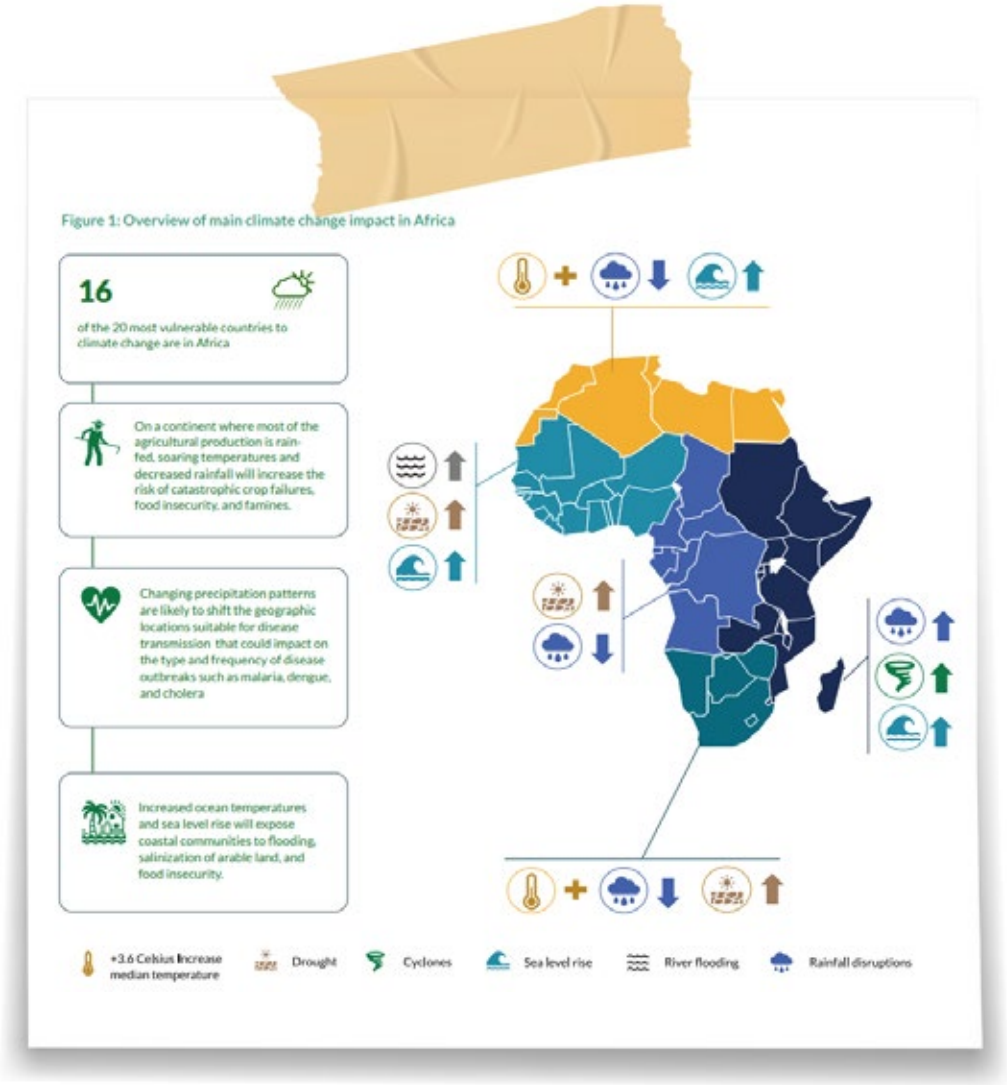


Figure 8 : *Overview of climate change impacts on water resources in Africa.*

Source: Africa NDC Hub. 2021

climate change may further reduce precipitation and expand drylands, on a continent which is already one-third drylands (Bakhtary, Tucker and Fleckenstein, 2021).
The AfDB (2023), in its Climate Change and Green Growth Strategic Framework, identified CCA in the water, sanitation and hygiene (WASH) sector as a key priority area of interventions and implementation. Adaptation in this sector is expected to improve water management, supply and quality, and to protect health and livelihoods. Integrated governance, watershed management, increasing sanitation services, improved stormwater management and wastewater management are deemed to be critical areas of adaptation implementation. Access to funds and technical expertise to implement the range of identified innovative adaptive solutions to address prevailing and future water issues is urgently required.

As more evidence and understanding of the extent of the impacts of climate change on Africa's water resources emerges, adaptation responses at continental, national and to some extent local levels need to evolve and be accelerated. Commitments towards adaptation in the water sector are already becoming evident in countries' nationally determined contribution (NDC) pledges. This section highlights identified water-related impacts associated with climate change, vulnerability, current adaptation actions, investments and barriers.

Adaptation efforts and some developments are resulting in the reduction of vulnerability across populations which are disproportionately affected (Bakhtary, Tucker and Fleckenstein, 2021). While a range of adaptation actions are being recorded from Africa, some of these responses are from countries receiving support funds to reduce vulnerability. Adaptation efforts on the continent are mostly driven by national Governments, non-governmental organizations (NGOs) and international institutions, with minimal contributions by lower levels of government, and only nominal adaptation cooperations across nations (Ford and others, 2015).

3.3. Health and Public Health Systems

The health sector is a key sector in Africa connected to other crucial sectors, such as the economy, food security and agriculture, WASH, cities, and tackling poverty. It is also among the sectors most affected by climate change, with increased impacts in different regions and countries across Africa. There is also evidence of increased climate action by many African countries, from planning to implementation, with finance and skills transfer in the health sector in order to adapt to climate impacts. This chapter focuses on climate change impacts on and adaptation for human health only.

1. Observed impacts and projected risks.

Human health, safety and well-being in Africa are threatened by a rise in temperature, an increase in sea levels, varying precipitation patterns, and more extreme weather such as floods, storms and prolonged droughts (Trisos and others, 2022; WMO, 2022; Lokotola, 2023). Climate change impacts on health in Africa are mostly increased infectious diseases; heat-related illness and stress, malnutrition, and harm/injuries resulting from wildfires; and displacement (WMO, 2022; Lee and others, 2023; Lokotola, 2023). Although there is insufficient evidence at global scale, mental health impacts due to extreme heating are also observed in several African countries (Trisos and others, 2022). In South Africa, high temperatures are strongly associated with poor mental health and suicide (Kim and others, 2019). Figure 9 summarizes the impacts of climate change in Africa in relation to other regions of the world.

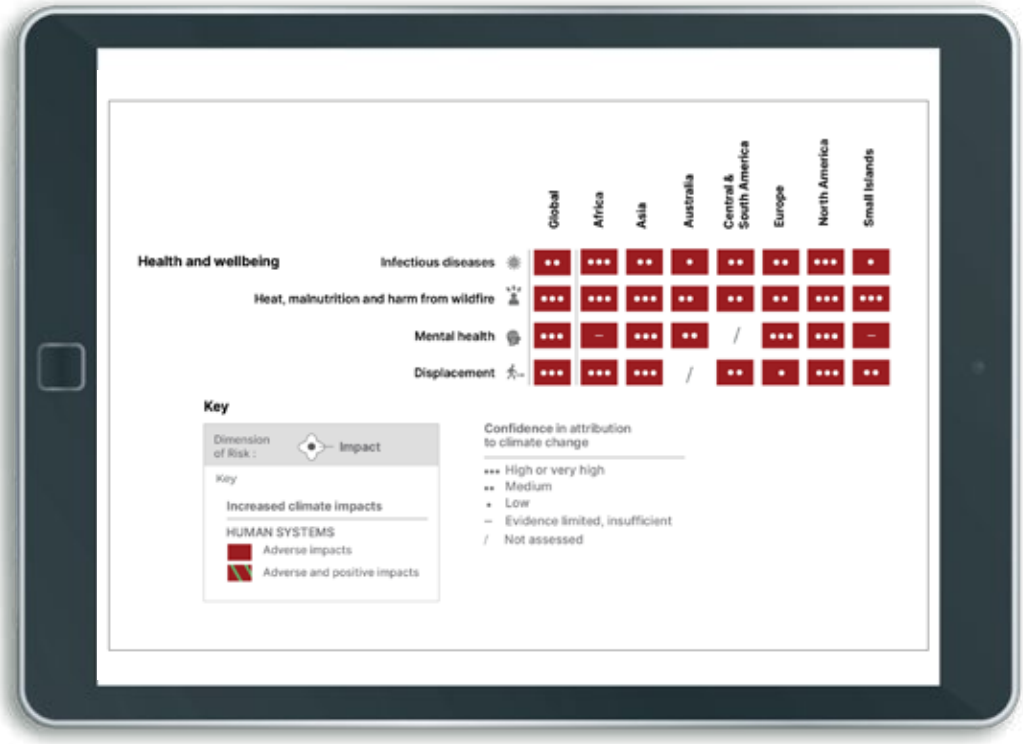


Figure 9: *Observed impacts on health and wellbeing attributed to climate change at global and regional scales.*

Note: Climate change impacts for Africa are reflected in the second column on the figure. Global assessments focus on large studies, multi-species, meta-analyses and large reviews. Regional assessments consider evidence on impacts across an entire region, and do not focus on any country in particular. The direction of impacts is assessed, and both adverse and positive impacts have been observed.

Source: Adapted from Lee and others (2023).

Heat impacts: Evidence is growing on heat-related illness in Africa as a major climate impact which poses significant threats to humans under future global warming levels. Recorded death rates have been above normal on days with raised temperatures across the regions of Africa, in eastern Africa (Kenya and the United Republic of Tanzania), western Africa (Burkina Faso and Ghana) and northern Africa (Tunisia), most commonly because of cardiovascular disease (Climate and Development Knowledge Network Programme [CDKN] and African Climate and Development Initiative [ACDI], 2022a; CDKN and ACDI, 2022b; CDKN and ACDI, 2022c). Respiratory diseases, stroke and other non-communicable diseases have also been linked with heat in southern and eastern Africa (Trisos and others, 2022). In South Africa, human-induced climate change was implicated for almost 44 percent of heat-related deaths (1991–2018), equating to dozens of deaths per year in many of South Africa's districts (Abiodun and others, 2018).

Exposure to extreme heat directly has increased incidences of violence due to mental problems, as it influences emotional control, aggression and violent behaviour, escalating rates of interpersonal violence with homicides rising by as much as 18 percent in South Africa when temperatures are above 30°C compared with temperatures below 20°C (Chersich and others, 2019; Gates and others, 2019).

Heavy precipitation: the heavy and extreme precipitation in eastern Africa has increased the occurrences of malaria. Over southern Africa, changes in temperature and rainfall are increasing malaria transmission (Abiodun and others, 2018). Tropical cyclones have caused the outbreaks of cholera in eastern, western and southern Africa, in countries such as the Democratic Republic of theCongo, Kenya, Malawi, Mozambique, Nigeria, Somalia, Togo and the United Republic of Tanzania (Moore and others, 2017; Ajayi and Smith, 2019; Cambaza and others, 2019).

Flooding: increased flooding that is attributed to anthropogenic climate change has resulted in outbreaks of infectious diseases such as cholera and typhoid in several parts of Africa. In Nigeria, recent floods attributed to anthropogenic climate change has resulted in thousands of deaths of people due to cholera outbreaks, affecting 32 out of the 36 states (WMO, 2022).

Droughts: Adverse impacts of climate change have intensified the displacement of millions of people in Africa due to extreme, successive years of drought. Climate-induced health emergencies have escalated in Africa, constituting over 50 percent of the recorded public health incidents in the region during the last 20 years (WHO Africa, 2022a). However, African nations can adjust to the hostile effects of climate change, improve community resilience, and progress towards achieving Sustainable Development Goals (SDGs) by adopting effective adaptation measures while safeguarding the well-being of present and future generations. Both projected extreme warming and precipitation impact Africa's health.

Extreme warming: The projected extreme warming will have huge risk to Africa's human health. Above 1.5°C, risk of heat-related deaths rises sharply in Africa, with at least 15 additional deaths per 100,000 annually across large parts of the continent. Several projections show very high risk of human health to occur from 2°C global warming across Africa. Climate change-related illness will strain health care systems and economies in eastern Africa. Above 2.5°C, heat-related deaths reach 50–180 additional deaths per 100,000 people annually in northern, western and eastern Africa, and increase to 200–600 per 100,000 people annually for 4.4°C global warming (Trisos and others, 2022). The number of days projected to exceed potentially lethal heat thresholds per year reaches 50–150 days in west Africa at 1.6°C global warming, up to 200 days in west Africa and 100–150 days in central Africa and parts of coastal eastern Africa at 2.5°C, and over 200 days for parts of west, central and eastern Africa for global warming above 4°C (Mora and others, 2017).

The more vulnerable populations (under 5 and over 64 years old) exposed to heat waves of at least 15 days over 42°C in African cities are projected to increase from 27 million in 2010 to 360 in 2100 for 1.8°C global warming (Trisos and others, 2022). This increases to 440 million for greater than 4°C global warming (Mora and others, 2017). People in the large cities of central, eastern and western Africa will be particularly at risk. Projected rates of heat-related mortality among people in northern Africa who are older than 65 increase by 8–20 fold in 2070–2099, compared with 1951–2005, based on RCP4.5 and RCP8.5 (both at >2°C global warming) (Ahmadalipour and Moradkhani, 2018).

At 2°C, thousands to tens of thousands of additional cases of diarrhoeal disease are projected, mainly in central and eastern Africa (Trisos and others, 2022). Tens of millions of eastern Africans will become exposed to malaria under future warming this century, as the climate suitability for the Anopheles mosquito expands to higher altitudes. Under mid- and high-warming scenarios, eastern African hotspots for malaria prevalence are expected to increase by as early as 2030. Epidemics of dengue and yellow fever are projected to expand further into the Sahel region of western Africa under future global warming scenarios.

Extreme precipitation and flooding: Cholera outbreaks are anticipated to impact east Africa most severely during and particularly after, El Niño-Southern Oscillation events (Moore and others, 2017).

Droughts: Disruptions in water availability caused by droughts will jeopardize access to safe water and adequate sanitation in Africa. Considering the existing water insecurity facing Africa, this will undermine hygiene practices and increase environmental contamination with toxins (Colvin and others, 2016; Howard and others, 2016).

2. Vulnerability of the health sector

In urban settings, climate change has caused adverse impacts on human health (Lee and others, 2023), yet Africa is one of the continents with the fastest urban population growth, thus increasing exposure. Extreme temperatures, including heatwaves, have intensified in African cities, particularly in northern and southern Africa. In Africa, this is exacerbated by an increase in the population living in concentrated among economically and socially marginalized urban residents, such as those living in informal settlements. Exposure in the health sector in Africa is influenced by vulnerability factors such as geographic location, and demographic, socio-political and economic factors, as some countries and economies reduce exposure because of their health-resilient systems that can sustain climate-related shocks, while others are highly exposed due to weak health systems that suffer the most climate change shocks and hazards. Figure 10 shows the vulnerability and exposure of the health system to climate change risks.

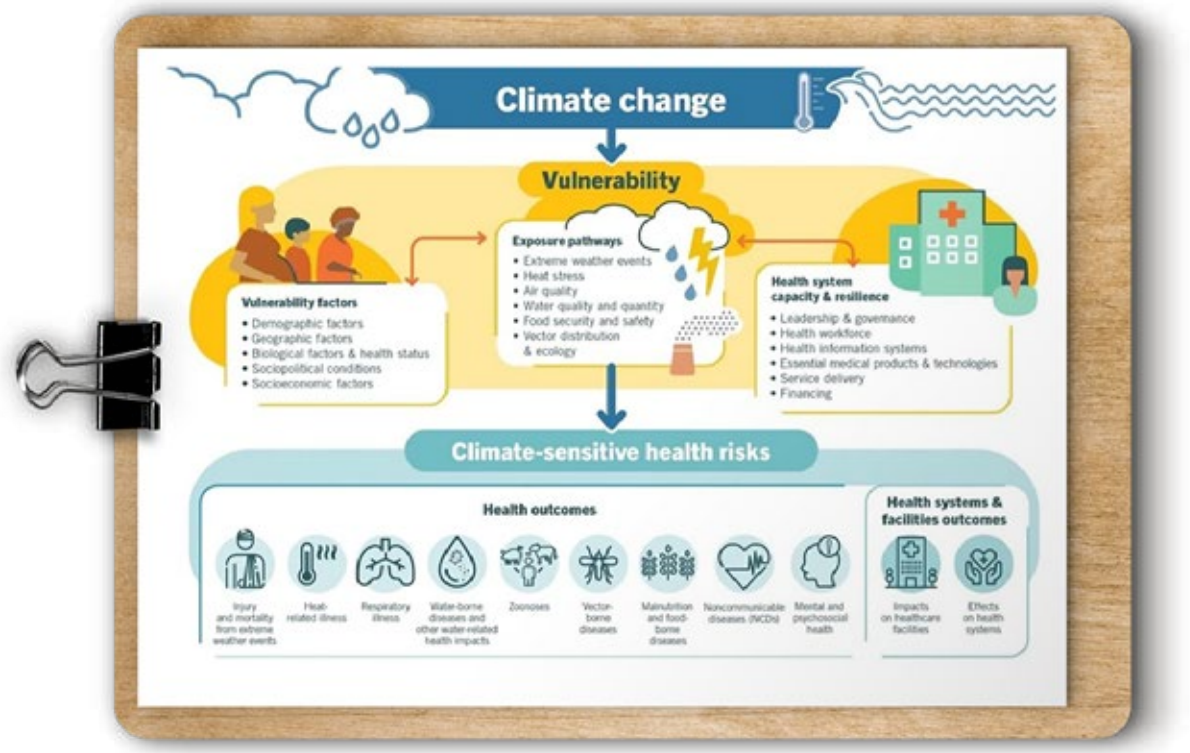


Figure 10: *Health impacts of climate along the exposure pathways and factors contributing to vulnerability.*

Source: Adapted from WHO, (2023a)

Although climate change affects all population groups in Africa, there is high evidence that the most vulnerable are young children (younger than 5), the elderly (over 65), pregnant women, individuals with pre-existing illness, physical labourers, and people living in poverty or affected by other socio-economic determinants of health, thus increasing their risk (Trisos and others, 2022). Climate change is projected to lead to an additional 2.4 million undernourished children under the age of 5 in sub-Saharan Africa by 2050 (World Food Programme, 2021).
The high reliance of Africa's economy on climate-sensitive sectors, such as agriculture, further increases the vulnerability and exposure of the health sector to climate impacts, as changes in agricultural productivity affect food security for many African countries that are already experiencing food insecurity, thus increasing the risk of malnutrition.

Given the high exposure and vulnerability of the health sector in Africa, mortality and morbidity will escalate with further global warming (2°C), placing additional strain on health and economic systems as distribution and seasonal transmission of vector-borne diseases is expected to increase, exposing tens of millions more people, mostly in western, eastern and southern Africa (Trisos and others, 2022).

Box 2: *Traditional and Indigenous medicines and climate change impacts*

African traditional and indigenous medicines (ATIM) play a critical role in providing medicinal resources to millions of Africans—approximately over 80 percent of the African population relies on ATIMs—and are pivotal in achieving universal health coverage for the continent. Several of these medicines are derived from flora and fauna (biodiversity ecosystems) (Tshabalala and others, 2022). In South Africa, approximately 10 percent of South Africa's flora are used for traditional medicines, and 3 percent of these are already on the red list of the International Union for Conservation of Nature and are predicted to be at risk of extinction (Williams and others, 2013). Given the current climate impacts and projected risk discussed above, these ATIMs will likely face the risk of extinction or quality reduction. At 2°C global warming, more than 10 percent of African species are at risk of extinction (Trisos and others, 2022), including the plant and animal species used for ATIMs. Climate change will not only cause extinction, but it will also affect the distribution. The evidence shows that in southern Africa, the B. volubilis and D. elephantipes species (which are critical for ATIMs) are respectively projected to decline and are vulnerable to future climate projections for RCP2.6 and RCP8.5 by 2050 and 2080 (Tshabalala and others,2022). This affects their distribution, thus impacting availability of the medicines to African communities.

Evidence already shows the disappearance of some of these plants in Africa, such as the different herbals used for ATIMs. For example, the Aloe species in the United Republic of Tanzania, which are critical for ATIMs in Africa, are affected by climate change (Abihudi and others, 2020). With the high risk of some plant and animal species facing extinction at 2.5 or 3.0 °C global warming, ATIM is highly likely to face extinction. Projected climate impacts for Africa are considered very high risk for biodiversity, including the risk of local extinction of more than 50 percent of plants, vertebrates and insect species across one fifth of Africa (Trisos and others, 2022). This threatens the herbal plants and animal species used for ATIMs, which will likely have significant effect on achieving 100 percent health coverage for Africa.

In South Africa, increased temperatures and scarcity of rainfall are already negatively impact the availability and accessibility of water, food and traditional medicine (Rankoana, 2022). Future research to establish the impacts of climate change on ATIMs is required, which includes the effects of future climate risk on ATIMs.

3.4. Biodiversity and Ecosystems

The IPCC Sixth Assessment Report identified three key risks for Africa, namely biodiversity loss and ecosystem disruption, mortality and morbidity from heat and infectious diseases, and reduced food production from crops, fisheries and livestock. The risk associated with biodiversity loss and ecosystems disruption is assessed to have reached moderate levels at current global warming (1.09°C), with a projected transition to high risk at 1.5°C global warming, and very high levels of risk projected to be reached at 2°C global warming (Trisos and others, 2022).

At current levels of global warming, observed impacts include repeated mass die-offs of coral reefs, reduced lake productivity, woody encroachment of grasslands and savannahs, and associated impacts on livelihoods (Trisos and others, 2022). At 1.5°C of global warming, more than 10 percent of species are at risk of local extinction, with woody encroachment expected to expand further. At 2°C of global warming, the following risks are projected (Archer and others, 2018; Trisos and others, 2022):

- Destabilization of the African tropical forest carbon sink.
- Local extinctions of more than 50% of plants, insects and vertebrae species.
- Total extinction of approximately 7 – 18% of species.
- Loss of more than 90% of warm water coral reefs.

1. Observed impacts and projected risks.

Climate change is exerting significant and multifaceted pressures on Africa's biodiversity, ecosystems and livelihoods. The continent, renowned for its rich and diverse natural landscapes, is particularly vulnerable to the impacts of a warming planet. Rising temperatures, altered precipitation patterns and extreme weather events are affecting the delicate balance of African ecosystems. This environmental disruption poses substantial risks to the continent's unique flora and fauna, leading to species extinctions, shifts in geographic ranges and the disruption of vital ecological functions (Archer and others, 2018; GCA, 2022; Pörtner and others, 2022).

The repercussions extend beyond the realm of biodiversity. African communities are intricately connected to their environment, relying on the functions and services provided by ecosystems for their livelihoods (Archer and others, 2018; Pörtner and others, 2022). Agriculture, water resources and traditional knowledge are intertwined with the continent's natural systems. Climate-induced challenges, such as altered rainfall and the increasing frequency of droughts, impact agricultural productivity, food security and water availability, exacerbating existing vulnerabilities and potentially leading to conflicts over resources. The complex interplay of climate change, biodiversity, ecosystems and livelihoods in Africa calls for a comprehensive understanding and strategic action to address these pressing challenges (Hussain, 2023).

Loss of biodiversity: Observed impacts of climate change include the death of many of Africa's oldest and largest baobabs, loss of grassland and savannah ecosystems due to woody encroachment, and associated declines in species that depend on grassland and savannah ecosystems. Coral reefs have experienced mass bleaching and mortality over the past 20 years, and mangroves have declined in many areas of the continent including in Mozambique which has seen a decline of 48% (Trisos and others, 2022).

Changes in climate create opportunities for invasive species to thrive in new areas. These invasive species can outcompete native species, leading to a decline in native biodiversity (Archer and others, 2018).

Shifts in species demography, ranges and abundance: Climate change is causing bird ranges to contract to higher elevations, physiological changes in many bird species and declines in fynbos plant diversity. Anchovy, hake, sardines, rock lobster and seabirds have all experienced shifts in their distribution (Trisos and others, 2022).

Many species in Africa are expected to face shifts in their geographic ranges as they seek more suitable climates. This can lead to changes in local ecosystems, potential loss of native species and increased competition with invasive species. Many species are moving to higher altitudes and latitudes in search of more suitable climates. While some species may be able to adapt by shifting their ranges, this can disrupt established ecosystems and lead to competition with other species (Archer and others, 2018; Pörtner and others, 2022).

Habitat transformation, loss and fragmentation: In terrestrial ecosystems across the continent there has been an observed expansion of woody plants into grasslands and savannahs. Warming of inland lakes has led to loss of fisheries. In coastal areas, climate change is impacting negatively on mangroves (with observed southward shift of mangrove species in southern Africa), seagrasses and coral reefs (Trisos and others, 2022).

The changing climate can result in the alteration and loss of critical habitats in Africa, affecting diverse ecosystems such as forests, savannahs, wetlands and coastal regions. Habitat fragmentation can isolate populations and reduce genetic diversity. For example, in arid and semi-arid regions of Africa, reduced rainfall and increased desertification can lead to the loss of important habitats for both flora and fauna. Changes in temperature and precipitation can lead to shifts in ecosystems. For example, some areas may become unsuitable for certain vegetation types, leading to habitat loss, as well as isolating species and reducing genetic diversity (Archer and others, 2018; Pörtner and others, 2022).

Altered ecosystem services: Ecosystems in Africa provide a wide range of services to people, including food, clean water and climate regulation. Climate change can disrupt these services, impacting human well-being, especially in rural and resource-dependent communities (Archer and others, 2018; Pörtner and others, 2022).

For example, climate change can lead to shifts in precipitation patterns and temperature, which can affect agricultural productivity, crop yields and the availability of food, leading to food shortages and increased food prices. In coastal ecosystems including mangroves and coral reefs help protect coastlines from erosion and storm surges. Rising sea levels and more frequent and severe storms due to climate change can weaken these protective functions, increasing the vulnerability of coastal communities (Chandwani and others, 2022). Many crops in Africa depend on pollinators such as bees, butterflies and other insects. Climate change can disrupt pollinator populations and their activities, affecting agricultural yields (Archer and others, 2018; Pörtner and others, 2022).

Altered fire regimes: Climate change is associated with an increased risk of wildfires, which can have detrimental effects on African ecosystems, particularly in savannas and grasslands, and the species they support.

Ocean and coastal impacts: Rising sea levels and ocean acidification can affect marine ecosystems along Africa's coasts, including coral reefs, mangroves, and fisheries. In marine ecosystems, particularly in the coastal regions of Africa, rising sea temperatures can lead to coral bleaching. Coral reefs are highly diverse ecosystems, and bleaching can harm both the corals themselves and the species that depend on them (Chandwani and others, 2022).

Biodiversity and health: Changes in the distribution of disease vectors, such as mosquitoes, can impact human health and may also affect wildlife populations (Archer and others, 2018).

Loss of cultural and traditional knowledge: Indigenous communities in Africa often have deep knowledge of local ecosystems. Climate change can disrupt traditional practices and the transmission of this knowledge, potentially leading to the loss of valuable insights for ecosystem management and conservation (Kupika and others, 2019).

Evidence shows that there is an urgent need not only for climate adaptation for biodiversity conservation but also for identifying and implementing adaptation measures that help communities adapt to climate change, protect and sustain biodiversity (Africa Biodiversity Collaborative Group, 2023).

2. Vulnerability of ecosystems and biodiversity

Climate vulnerability, as defined by the IPCC, refers to the extent to which a system is prone to and incapable of effectively coping with the adverse impacts of climate change, encompassing climate variability and extremes. Africa, according to the IPCC (2022), has been identified as one of the continent's most susceptible to climate variability and change, with anticipated temperature increases surpassing those in other regions of the world. Climate models indicate a median temperature rise between 3°C and 4°C across the entire continent and all seasons by the close of this century, representing approximately 1.5 times the global mean response.

This heightened vulnerability is illustrated in Appendix 7 which shows the widespread and substantial increase in biodiversity loss with every 0.5°C increase above the current (2001-2020) level of global warming, as highlighted by Trisos et al. (2022). The projections underscore the urgent need for comprehensive strategies to address the escalating impacts of climate change on Africa, emphasizing the multifaceted challenges posed by rising temperatures and their cascading effects on biodiversity.

Africa is well known to have diverse climates that are considered to be the most variable in the world on seasonal and decadal time scales, which makes the region's ecosystems most susceptible to climatic events (GCA, 2021).

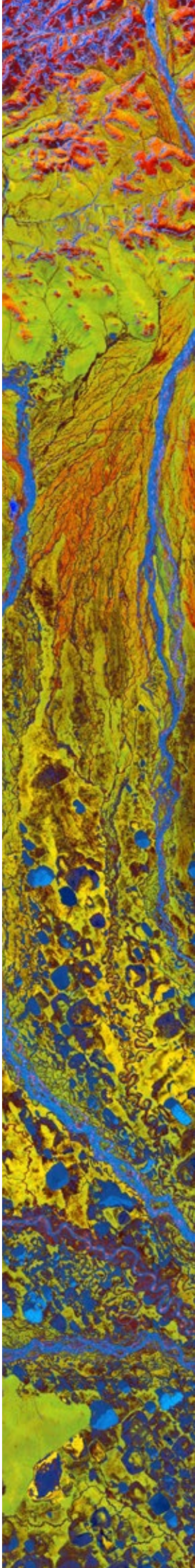
Drought-prone areas are likely to be more vulnerable to climate change than the more humid areas. Many of these climatic changes may have devastating effects where they add to existing stresses such as water scarcity, food insecurity and climatic variations (Archer and others, 2018; Boone and others, 2018; Kapuka and others, 2021; GCA, 2021; Pörtner and others, 2022). In addition, uncertainty regarding the direction and magnitude of changes in precipitation, river flows and lake levels poses as a challenge for adaptation to climate change (Archer and others, 2018; Pörtner and others, 2022).

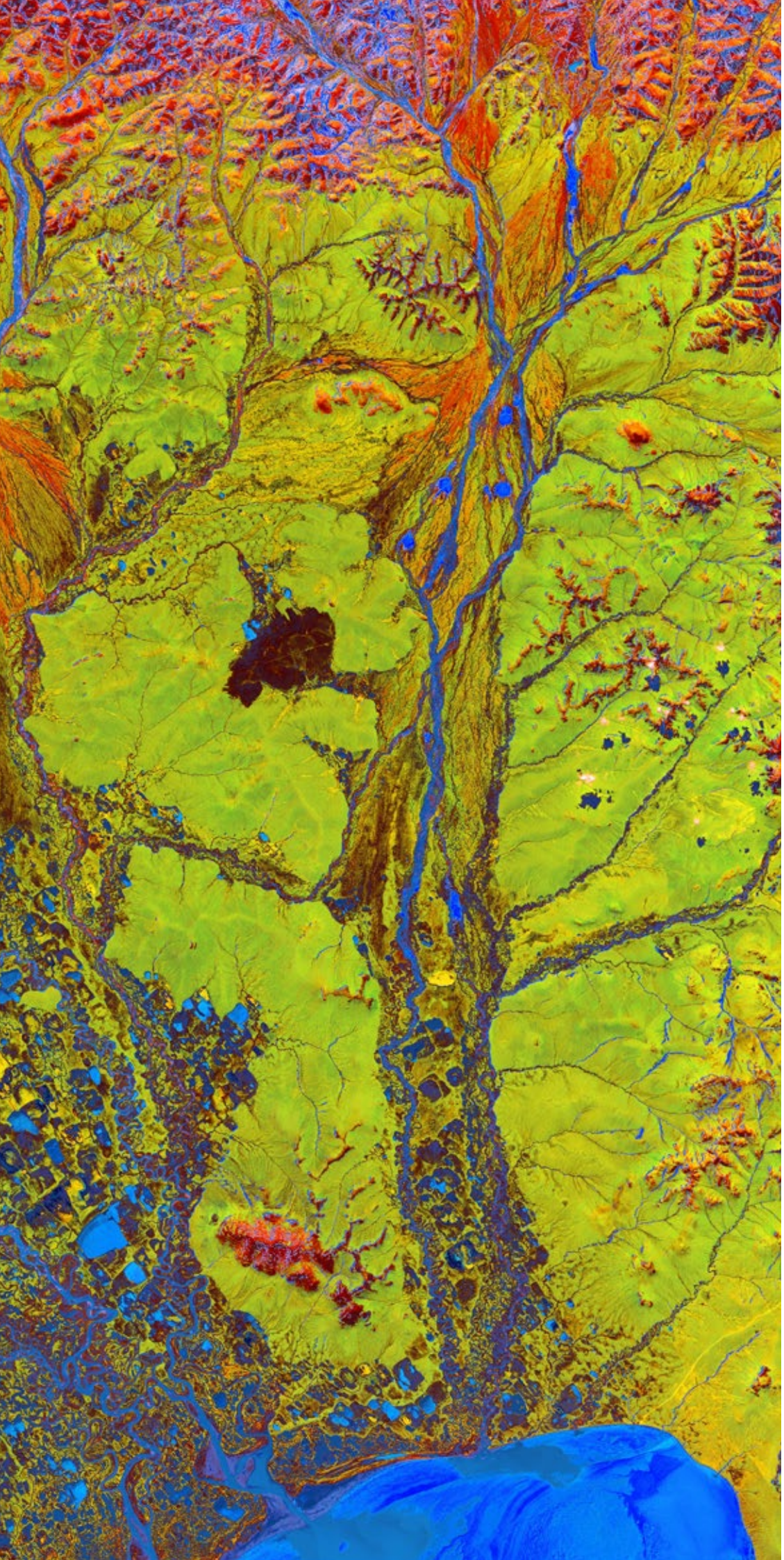
Grasslands are a significant ecosystem type in most parts of Africa. They support the well-being and livelihoods of millions of pastoralists and agropastoralists throughout the region, with an estimated 8 million pastoralists in the Ethiopian portion of the Horn of Africa alone (Boone and others, 2018; GCA, 2021; Kapuka and others, 2021). Grasslands are already subject to several non-climate stresses which include overgrazing, overexploitation, shifts away from traditional modes of rangelands management, bush encroachment, introduction of invasive species and population growth. Higher temperatures and greater frequency and duration of droughts may exacerbate these non-climate stresses. Climate and non-climate stresses may worsen degradation and desertification, lower carrying capacity, decrease plant crude protein content, and lead to possible increase in human

and wildlife competition and conflicts for resources (Boone and others, 2018; GCA, 2021; Kapuka and others, 2021).
Forests are also a significant vegetation type in some parts of Africa, and are important for their biodiversity, natural resources and ecosystem services, their contributions to the health and well-being of the communities that depend upon them, and for the greater economy. Forests are already under pressure from several non-climate stresses, which have contributed to a reduction of forests. Non-climate stresses include encroachment, illegal settlements, conversion of forest land to agricultural and livestock areas, harvesting of fuelwood at a rate faster than regeneration, and weak institutional capacity and policy frameworks to regulate environmental and forest management (Archer and others, 2018).

Wetlands, including mangroves, provide employment as well as water, food and other ecological services. They also serve as important habitats for wildlife, fish and flora, and act as buffers to climate change impacts such as storms. Wetlands throughout the region have experienced significant degradation due to a number of non-climate stresses such as drainage for agricultural purposes, sand and clay mining, settlements, tourist infrastructure, aquaculture, over-harvesting of biomass and pollution (Archer and others, 2018). These impacts are likely to be exacerbated by climate change impacts such as warmer temperatures, greater incidence of heavy rainfall events, and more frequent and prolonged droughts (Trisos and others, 2022; Archer and others, 2018).

Coral reefs and their resources are critical as habitats for biodiversity, sources of food, providers of ecological services and major tourist attractions. They also help protect the shoreline from damage by storms. Coral reefs are already under threat from non-climate stresses, such as sedimentation from urban development and deforestation, overfishing, destructive fishing practices, pollution from herbicides and pesticides, and diseases. Climate change impacts such as warmer sea temperatures, greater intensity of storms and higher carbon dioxide levels, are likely to exacerbate them (Archer and others, 2018; Chandwani and others, 2022). Climate and non-climate stresses have contributed to extensive coral bleaching in various areas. Bleaching can compromise coral health if reefs are not allowed sufficient time to recover (Trisos and others, 2022).





SECTION IV

Cities, Settlements, and Key Infrastructure.

As outlined in previous chapters, the global phenomenon of climate change manifests itself with far-reaching implications for ecosystems, societies and economies (Masson-Delmotte and others, 2021). It poses a significant and multifaceted challenge to urban areas and critical infrastructure, particularly in the context of Africa. The continent is currently witnessing rapid urbanization and development, amplifying the vulnerabilities of cities to the impacts of climate change (UN-Habitat, 2020). The attention directed towards understanding these impacts underscores the critical need for proactive measures in the face of limited risk reducing infrastructure.

One notable challenge confronting African cities is the vulnerability associated with informal settlements. Urbanization in the developing world, marked by urban sprawl and the proliferation of unplanned settlements, compounds the risks for a significant portion of the population (Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). Informal settlements are characterized by high population density, inadequate building materials, limited green spaces, and a lack of access to essential public services and amenities (Yahia and others, 2018; Govender, 2020). This scenario renders inhabitants particularly susceptible to the adverse effects of climate change, such as heightened temperatures, as exemplified in Nairobi (Scott and others, 2017).

While there has been an expansion in the literature focusing on the governance of adaptation since the IPCC's Fifth Adaptation Report (Masson-Delmotte and others, 2021), there is a noticeable gap in studies examining the specific challenges faced by cities and settlements in African countries. This section aims to bridge that gap by critically assessing and synthesizing existing research on the impacts of climate change on African cities and their crucial infrastructure. Concurrently, it will explore the adaptation strategies and resilience-building efforts being implemented in response to these challenges. Through a comprehensive review of academic literature, reports and case studies, this section seeks to contribute to a nuanced understanding of the intricate relationship between climate change and urbanization in the African context.

4.1. Understanding Climate Change Effects on African Urban Areas, Settlements, and Key Infrastructures: Current Impacts, Future Risks, and Vulnerability

Cities stand at the forefront of the global drive for sustainability and resilience amid the challenges posed by climate change, echoing the commitment outlined in SDG 11 and the New Urban Agenda. In the African context, where over half of the population resides in urban areas, a significant portion—approximately 30 percent—dwells in densely populated informal settlements situated on the peripheries of cities. These informal settlements often grapple with the absence of basic services, economic opportunities and avenues for political engagement, accentuating the challenges faced by their inhabitants (Participatory Slum Upgrading Programme Nairobi, 2016). Positioned in high-risk areas and lacking essential amenities, these settlements are exposed to substantial environmental risks, including the looming threats of flooding and landslides (Douglas and others, 2008; Satterthwaite and others, 2016; Ziervogel and others, 2016). The
residents of these urban areas find themselves increasingly vulnerable to environmental hazards, a vulnerability further compounded by the escalating impacts of climate change.

As urbanization, informality and climate-related risks continue to escalate in the African context, local governments confront the formidable task of addressing both adaptation and development needs, particularly for those inhabiting the most precarious environments, such as informal settlements (Seeliger and Turok, 2013; Amin and Cirolia, 2018; Satterthwaite and others, 2020; Ziervogel, 2021).

While our understanding of health in informal settlements largely stems from case studies conducted in specific areas, these studies often lack the comprehensive data needed to represent the entirety of such settlements. Nevertheless, they shed light on the spectrum of risks or the magnitude of specific risks within these communities. For instance, data on the impacts of accidental fires on urban areas in the region, including informal settlements, are notably absent. However, individual studies focused on specific cities, such as Cape Town, strive to address these gaps (Pharoah, 2009).

Barac and others (2011) emphasize that the most dynamic and unregulated urban growth is occurring in informal settlements. While the proportion of the urban population residing in such settlements has decreased over the years, the absolute numbers are still on the rise (UN-Habitat, 2016). Presently, 62 percent of urban residents in Africa live in makeshift shelters or informal settlements (Evans and others, 2016). Based on these trends, Pieterse (2014) asserts that “the shanty city is by and

large the true African city", and suggests that informal practices can complement the urban management functions of the State. As the city appears to evolve from individual (bottom-up) actions driven by micro-strategies of disadvantaged citizens in their daily lives, Pieterse draws this conclusion. The challenge lies in the fact that detailed case studies may not offer the aggregated data essential for shaping city and national policies, while much of the relevant data is overly aggregated to guide localized actions (David and others, 2018).

4.2. Key drivers of climate change impacts on cities, settlement, and Infrastructure in the context of Africa

1. Sea-Level Rise and Coastal Vulnerabilities:

The escalating impact of climate change on sea level rise and coastal storms has become a matter of profound concern, particularly given its extensive ramifications for coastal communities and ecosystems.
This impact presents a pressing challenge for African cities positioned along coastlines. The warming global climate contributes to the melting of glaciers and ice sheets, leading to a projected sea level rise of 0.3–1.3 metres by 2100 (Masson-Delmotte and others, 2021). This surge poses a significant threat to densely populated coastal regions, where major cities and human populations are concentrated. Vulnerabilities
include inundation, storm surges, flooding, erosion and saltwater intrusion (Hobbie and Grimm, 2020).

Rising sea levels are triggering coastal flooding, erosion and the degradation of crucial coastal habitats that serve as natural defences against storm surges. This loss of habitat intensifies the vulnerability of coastal populations. Concurrently, the surge in sea levels aligns with a rapid population increase in Africa's coastal cities. Between 2020 and 2030, the seven largest coastal cities in Africa, including Lagos, Luanda, Dar es Salaam, Alexandria, Abidjan, Cape Town and Casablanca, are projected to grow by 40 percent. Similarly, the overall population of Africa is anticipated to rise by 27 percent. Smaller coastal cities, such as Port Harcourt in Nigeria, are expected to experience even higher growth rates, with a projected expansion of 53 percent in the same period. Globally, Africa's coastal regions are poised to witness the most rapid rates of population growth and urbanization (Africa Center for Strategic Studies, 2022).

For example, coastal cities in the Nile Delta, such as Alexandria, housing 57 percent of Egypt's population and vital agricultural lands, face severe risks of submersion within the next few decades. The rising sea levels will result in millions being displaced, leading to the loss of jobs and property and a decline in tourism. Alexandria alone could incur $50 billion in damages if sea levels rise by 1 metre. Similarly, Lagos, with its growing population and triple flood impact, faces an annual cost of $4 billion due to flooding. The rise in sea levels, coupled with urbanization, could displace a third of Lagos's population (Africa Center for Strategic Studies, 2022).

2. Tropical Cyclone Damages in Southeastern Africa

Table 4 provides an overview of the current global damages under existing climate and baseline conditions, utilizing modeled climatic data (Molua, Mendelsohn and Akamin, 2020). In 2000, assessed damages for Kenya ranged from $1 million to $14 million per year, and projections suggest an increase to between $2 million and $8 million by 2100, even without considering climate change. Madagascar currently faces the most substantial damages, totalling $17 million and potentially escalating to $139 million according to National Centre for Meteorological Research estimates for current climatic conditions. By 2100, these damages are expected to peak at $81 million. Moderate damages are observed for Mauritius, while Mozambique and the United Republic of Tanzania, both with significant primary commodity-based economies, incur maximum damages at $49 million and $52 million, respectively. South Africa demonstrates greater resilience, experiencing lower damages. However, for countries including Mozambique, existing politico-economic vulnerabilities are exacerbated by climatic stress, leading to loss of life and property. For example, in 2002, a storm hit Mozambique's Beira port city, causing significant damage to houses. In 2007, heavy rains from a cyclone led to further flooding and devastation in Mozambique, displacing a large number of people (Mendelsohn and others, 2012). Cyclones and subsequent flooding in southern and central regions of the country resulted in significant casualties and displacements (Molua, Mendelsohn and Akamin, 2020).

Confronting such events in south-eastern Africa necessitates a range of interconnected measures for adaptation. These measures encompass institutional, regulatory, technical, biological, behavioural and economic responses, all of which are essential to enhance the resilience of frontline States in the region.

Climate model	KENYA		MAGAGASCAR		MAURITIUS		MOZAMBIQUE		SOUTH-AFRICA		TANZANIA	
	2OOO	2100	2000	2100	2000	2100	2000	2100	2000	2100	2000	2100
CNRM	1	2	139	81	18	15	19	8			18	7
ECHAM	3	9	67	55	6	4	35	35	1	0	52	36
GFDL	14	15	110	77	5	12	38	38	3	0	20	18
MIROC	8	8	17	54	1	5	38	38	0	0	11	28

Arnt and others (2011) underscore the importance of "no-regret adaptatation measures, such as improved road design and investments in the agricultural sector, in addition to efforts to cultivate a more flexible and resilient society.

Table 4: *Current and future global damages from tropical storms with no climate change.*

Note: Expected damages in millions of $.
CNRM: National Centre for Meteorological Research
ECHAM: European Centre Hamburg Model
GFDL: Geophysical Fluid Dynamics Laboratory
MIROC: Model for Interdisciplinary Research on Climate

Source: Mendelsohn and others (2012).

3. Increased Temperature and Heatwaves

The influence of climate change significantly manifests in African cities, yielding a spectrum of socio-economic and environmental repercussions. With the ongoing global temperature rise, African urban areas are confronted with escalating risks of extreme heat events, amplifying urban heat island effects and posing challenges to health (Satterthwaite and others, 2020). Since 1880, global temperatures have increased by 0.8°C, with projections indicating a continued upward trend. Urban heat islands, where cities exhibit higher temperatures than their surroundings, compound this warming phenomenon. Factors such as limited vegetation, heat-absorbing building materials and waste heat from energy consumption contribute to the exacerbation of urban heat islands. Higher temperatures in cities result in various impacts, including constraints on human and ecological activities, stress on energy systems, aggravated air pollution and intensified heatwaves. Particularly in hot and humid regions, heatwaves have pronounced effects, leading to excess mortality even at lower temperatures when combined with high humidity (Hobbie and Grimm, 2020).

The variations in temperature also impact the rate of evapotranspiration, and influence both the quality and quantity of runoff. Therefore, any alteration in temperature can significantly affect the special and temporal availability of water resources, ultimately impacting the overall water balance (Kusangaya and others, 2014).

4.3. Critical Impacts and Projected Risks for Urban Settlement and Infrastructure

The overall vulnerability of African cities, settlements and key infrastructure to climate change is a pressing concern shaped by a multitude of interconnected factors. Urban areas across the continent confront heightened risks stemming from the intricate interplay of environmental, social and economic vulnerabilities. Climate change effects manifest in diverse ways, encompassing elevated temperatures, modified precipitation patterns and more frequent extreme weather events. These challenges significantly impact pivotal sectors such as water supply, agriculture, energy and transportation. The escalating temperatures contribute to heatwaves and an increased demand for cooling, placing strain on electricity grids. Climate-induced water scarcity affects urban agriculture and overall water supply, placing additional stress on critical infrastructure. Furthermore, extreme weather events, including storms and flooding, pose substantial risks to energy infrastructure, resulting in power supply disruptions. The vulnerability extends to health, education and industry, influencing the overall resilience and developmental trajectory of African cities. Implementing sufficient adaptation and mitigation strategies is imperative to bolster urban resilience and safeguard key infrastructure amid the evolving challenges posed by climate change.

1. Water Scarcity, Flooding and Hydrological Impacts in Urban Areas

Changes in precipitation patterns pose dual challenges of water scarcity and increased flood risk in various African urban areas, particularly informal settlements, leading to property damage and displacement. Additionally changes in temperature and precipitation patterns exert a notable influence on the distribution of disease vectors, leading to the proliferation of vector-borne diseases and posing significant public health risks.

Climate change induces substantial hydrological effects in African cities, impacting water availability, quality and urban infrastructure. Disruptions in the hydrological cycle, stemming from shifts in precipitation patterns, rising temperatures and changing run-off dynamics, particularly affect cities relying on distant water sources or groundwater (Atiem and others, 2022). The variability of hydrological impacts across locations and time is crucial, especially for cities with diverse water sources. Climate change affects water availability differently in various regions, with some experiencing increased rainfall and others facing droughts. Urban areas exacerbate drought risks through heightened water consumption for activities such as vegetation and cooling. Additionally, flooding poses threats to infrastructure along riverbanks, making them vulnerable to inundation and erosion (Hobbie and Grimm, 2020).

2. Transportation Networks

Climate change poses significant threats to transportation systems in African cities, necessitating urgent measures to enhance resilience. Key transportation structures, such as roads and railways, face risks from climate-induced events such as flooding, rising sea levels and storm surges. These events not only cause structural damage but also accelerate deterioration, resulting in substantial financial losses. Coastal cities, exposed to rising sea levels and erosion, such as in the United Republic of Tanzania, face increased risks, with potential daily losses of up to $1.4 million due to transportation disruptions (Masson-Delmotte and others, 2021). The impact is also evident in South Africa, where a study on the effects of climate change on road infrastructure projected annual national-level costs between $116.8 million and $228.7 million by the 2050s, if no adaptation policies are followed (Schweikert and others, 2015). These disruptions not only incur economic losses but also endanger public safety, livelihoods and overall economic productivity by impeding the movement of goods and people (The Conversation, 2021).

3. Energy Supply

Climate change has brought about significant challenges to the energy supply in African cities, affecting multiple facets of energy production, distribution, and consumption. The following impacts illustrate the complexities faced by urban areas:

Hydropower Generation Disruptions: The changing climate, marked by rising temperatures and altered precipitation patterns, poses a substantial threat to hydropower generation—an indispensable source of electricity for many African nations (African Union, Department of Infrastructure and Energy, 2021). Reduced water levels resulting from droughts can diminish hydropower output, leading to energy shortages and potential disruptions in urban areas (Satterthwaite and others, 2020).

Increased Energy Demand and Strained Grids: Elevated temperatures and more frequent heatwaves contribute to a heightened demand for energy, particularly for cooling purposes. This increased demand places stress on electricity grids, potentially causing blackouts as grids struggle to meet the intensified cooling requirements during extreme heat periods (UNEP, 2020).

Infrastructure Vulnerability to Climate Events: Climate-related events, such as storms and flooding, pose significant risks to energy infrastructure. Power plants and transmission lines are susceptible to damage, leading to supply interruptions and extended outages in the aftermath of severe weather events (UN-Habitat, 2020).

These energy supply challenges have far-reaching consequences across various sectors, including health care, education and industry, thereby impacting the overall resilience and developmental trajectory of African cities (Satterthwaite and others, 2020). The intricate interplay between climate change and energy supply underscores the need for comprehensive strategies to enhance the resilience of urban energy systems in the face of evolving climatic conditions.

4. Migration

Prior research has extensively explored the susceptibility of specific populations to climate change projections, with a particular focus on regions where climate-related hazards intersect, notably the African Sahel (Balsari and others, 2020). The Sahel, spanning semi-arid terrain from Ethiopia to Senegal, has witnessed a growing prominence of migration and conflicts attributed to climate change, coupled with associated agricultural and ecological challenges.

The difficulties faced by smallholder rain-fed agriculture and herding activities, arising from unpredictable water availability and the Sahara Desert's expansion in certain areas, are well-documented (Xu and others, 2020). These challenges, along with the competition for available resources, likely contribute to conflicts in countries such as Kenya, Nigeria, the Sudan and Uganda (Fetzek and Mazo, 2014;

Akinyemi and others, 2017). However, it is essential to acknowledge the ongoing and intense debate surrounding the relative contributions of climate change, governance, population pressures and pre-existing sectarian divisions to the outbreaks of organized violence (Levy, Sidel and Patz, 2017).

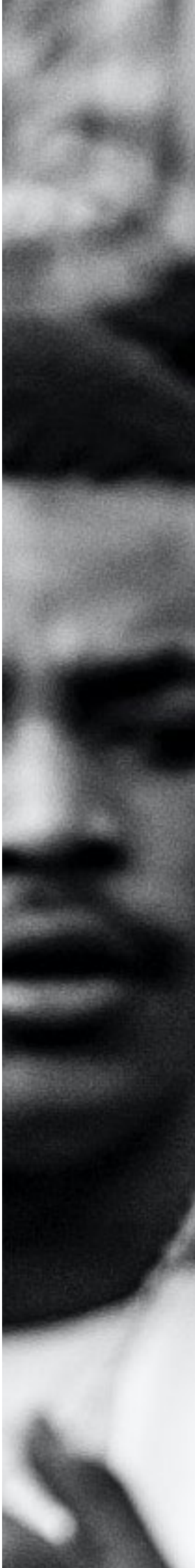
Consequently, individuals facing uncertainties related to weather, food security and, in some instances, violence have opted to abandon their homelands, seeking refuge in urban centers within African nations. This migration often leads to conflicts with existing populations, stemming from disputes over space and essential resources (Henderson and others, 2017; Mbaye, 2019). Another response has been the pursuit of longer and more perilous migration routes across the Sahara and the Mediterranean, with the aspiration of reaching Europe. These migration routes are fraught with conflicts with local populations and Governments along the way, as well as substantial hazards during transportation across deserts and oceans (Watson and others, 2016).

5. Urban Agriculture and Air Pollution

The complex interaction between climate change and air quality in Africa involves multiple factors. Rising temperatures and altered precipitation patterns contribute to increased wildfires, releasing particulate matter and affecting respiratory health. Desertification, influenced by climate change, enhances the transport of windblown soil and dust into urban areas, further compromising air quality. Extreme weather events linked to climate change disperse pollutants, and elevated temperatures contribute to ground-level ozone formation, posing health risks. The cumulative impact disproportionately affects vulnerable populations, emphasizing the need for comprehensive strategies integrating climate change mitigation and improved air quality management. Urban air pollution, originating not only from local sources but also influenced by upwind particulate matter sources, exacerbates the challenge. While health implications are relatively modest compared to broader pollution exposure, varying global mortality rates emphasize the importance of reducing short-lived climate forcers for both limiting global warming and improving air quality.

The challenge of urban agriculture in Africa is complex, shaped by environmental, social and economic factors. Rapid urbanization, population growth and climate change pose significant obstacles to sustainable urban agriculture. City expansion reduces agricultural spaces, escalating land competition and leading to the loss of arable areas. Soil degradation, water scarcity and pollution compromise the quality and quantity of urban agricultural yields. Climate change intensifies these challenges, with unpredictable weather patterns, extreme temperatures and altered precipitation all affecting crop growth. Limited access to essential resources and the prevalence of informal settlements hinder efficient and resilient urban agriculture.

Despite its potential to enhance food security and alleviate poverty, the sector faces a complex battle requiring holistic approaches integrating urban planning, environmental sustainability and social inclusivity. The adverse effects of climate change on food systems compound existing vulnerabilities, impacting various sectors and contributing to rapid urban migration thereby straining urban infrastructure and resources.



SECTION V

Adaptation Strategy

Africa, at the forefront of climate vulnerability, grapples with prolonged droughts, extreme temperatures and increased flood occurrences. Adaptation involves proactive measures aimed at lessening the vulnerability of communities, ecosystems and economies to the impacts of climate change. This encompasses adjusting practices, cultivating resilience and implementing strategies to navigate evolving climatic conditions.

The core of adaptation lies in its capacity to strengthen the continent's resilience, enabling communities not only to survive but to thrive amidst escalating climatic challenges in the context of various global crises. Adaptation extends beyond a mere reaction, unfolding as a journey towards sustainable development. Far from being reactive, adaptation is an integral, proactive strategy intricately woven into Africa's developmental outlook. In the face of high climate change risks spanning economic and productive domains, adaptation remains a pivotal cornerstone of a prosperous Africa. The African continent recognizes this urgency and directs substantial resources towards adaptation efforts.

This section examines ongoing adaptation endeavours, scrutinizes identified gaps, and explores opportunities to elevate the implementation of climate adaptation in crucial sectors such as agriculture, food security, water, health, biodiversity, critical ecosystems, and the intricate web connecting economies and livelihoods.

Box 3: *Decoding Adaptation: Unraveling the Essence of Dynamic Resilience"*

While the primary cause of climate change is global, adaptation efforts mainly focus on local initiatives, employing various interventions. Below a summary of key highlights in adaptation responses, emphasizing a multifaceted approach that includes collaboration, innovation, and inclusive strategies across various levels, from local communities to international partnerships.

National-Level Initiatives:

- **Policy Development:** Continued support for robust CCA policies tailored to their specific vulnerabilities.
- **Institutional Strengthening:** Ongoing efforts aim to enhance institutional capacity for climate adaptation, including the establishment of dedicated agencies and frameworks.

Regional Initiatives:

- **Collaborative Platforms:** Regional organizations such as the Africa Adaptation Initiative foster cooperation and joint adaptation efforts among neighbouring countries.
- **Shared Resources:** Initiatives encouraging the sharing of climate data, expertise and resources at the regional level have proven crucial.

International Cooperation:

- **Global Support:** International agreements, such as the Paris Agreement, underscore the importance of global cooperation. Financial and technical support from developed nations to developing countries is a crucial aspect.
- **Technology Transfer:** Facilitation of the transfer of climate-resilient technologies from developed to developing nations aims to enhance adaptation capacities.

Successful Implementation of Programs and Projects:

- **Innovative Adaptation Projects:** Various successful projects span sustainable agriculture practices to resilient infrastructure development.
- **Community Involvement:** Programmes actively involving local communities in the design and implementation of adaptation measures have demonstrated their effectiveness.

Challenges and Barriers to Adaptation:

- **Resource Constraints:** Limited financial resources and funding gaps present significant challenges.
- **Capacity Building:** Building and sustaining effective adaptation capacity, especially at the community level, remains an ongoing challenge.

Implementation of Successful Adaptation Projects:

- **Agricultural Innovations:** Successful projects in sustainable and climate-resilient agriculture serve as models for other regions.
- **Ecosystem-Based Adaptation:** Initiatives focusing on preserving and restoring ecosystems, such as mangrove restoration for coastal protection, have demonstrated success in enhancing resilience
- **Water Sector:** *Wetland Restoration:* Rehabilitating wetlands to enhance water retention, improve water quality, and mitigate the impacts of extreme weather events.
  Rainwater Harvesting: Implementing systems to capture and store rainwater for agricultural and domestic use, reducing dependence on traditional water sources.
- **Health Sector:** *Disease Surveillance Systems:* Establishing early warning systems for vector-borne diseases, leveraging climate data to predict and prevent outbreaks.
  Community Health Resilience: Strengthening local health systems to address climate-related health challenges, including heatwaves and infectious diseases.
- **Biodiversity Sector:** *Protected Area Management:* Enhancing the resilience of biodiversity through improved management of protected areas, ensuring the survival of vulnerable species or Reforestation Initiatives: Planting native trees to restore ecosystems, combat biodiversity loss, and sequester carbon for climate mitigation.

5.1. Agriculture and food security

1. Overview of current adaptation efforts

CCA encompasses a spectrum of strategies, policies and actions aimed at mitigating or eradicating the adverse effects associated with climate change (AfDB, 2019). In response to the escalating impacts of climate change on agriculture and food security, Africa has implemented various adaptation strategies, as emphasized by Belianska and others (2022).

Crucial components of the global response to climate change, especially under the Paris Agreement, are NDCs and national adaptation plans (NAPs). These instruments provide countries with a platform to articulate their commitments and plans concerning climate change mitigation and adaptation. Given Africa's vulnerability to climate change and the pivotal role of agriculture in many African economies, adaptation in the agriculture and food security sector is a primary focus.

National policies governing agriculture and food security serve as foundational documents that shape the development of the agricultural sector, offering both strategic direction and specific measures to tackle challenges and leverage opportunities. While the focus and specifics of national agricultural policies may vary across countries, a common thread is the acknowledgement of the threat posed by climate change. The integration of climate change into these policies reflects a proactive approach by African nations to safeguard their agriculture and food security, fostering resilience.

A review of African countries' NDCs highlights common approaches to addressing adaptation in agriculture and food security. These include improved agricultural practices, capacity-building, climate information services (CIS) and early warning systems (EWS), risk management and insurance, research and development, policy integration and institutional frameworks, finance and investment, and community and farmer engagement. NAPs, also reviewed for this report, include additional approaches such as risk assessments and agricultural diversification. Furthermore, policies on agriculture and food security incorporate climate change elements such as value addition and agribusiness.

Improved Agricultural Practices: Many countries have embraced enhanced agricultural practices to adapt to climate change, promoting the use of drought-tolerant, disease-resistant and short-maturing crop varieties. Conservation agriculture, employing techniques such as zero tillage, crop rotation and agroforestry, along with improved irrigation management, are pivotal strategies to enhance soil health, water retention and overall resilience. Climate-resilient agriculture extends to urban agriculture, rangeland management, resilient agricultural processing techniques, soil management and water resources management (Kray and others, 2022b). Countries including Ethiopia, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Togo and the United Republic of Tanzania have adopted sustainable land management, conservation agriculture, soil conservation and water resources management to adapt to climate change.

Capacity Building: Countries are strengthening agricultural extension services to provide farmers with the knowledge and skills needed for climate-resilient agricultural practices. The United Republic of Tanzania, for instance, has implemented agricultural training programmes to facilitate the adoption of sustainable and adaptive farming practices. Similar efforts are observed in Kenya, Lesotho, Malawi and Sierra Leone, reflecting a continental focus on enhancing capacity at the grass-roots level.

Climate Information Services and Early Warning Systems: Improved CIS underpin robust EWS, providing timely weather and climate information to help farmers make informed decisions. Angola, Ethiopia, Ghana, Nigeria, Uganda, the United Republic of Tanzania, Zambia and Zimbabwe are among the countries that are actively improving their CIS and EWS.

Risk Assessment, Risk Management, including Insurance schemes: Many countries are developing crop and livestock insurance products to shield farmers from extreme weather events and other climate-induced losses. Kenya, South Africa and the United Republic of Tanzania, among others, offer various insurance products, including multi-peril crop insurance, index-based insurance and indemnity-based products for livestock. Efforts are under way to monitor and assess climate risks in the agricultural sector for better planning and response.

Research and Development: Continued research into climate-resilient agricultural practices, drought-resistant crops, and effective livestock management is a priority for countries like South Africa, Morocco, Namibia, Botswana, Kenya, Mozambique, and Benin. These nations emphasize the importance of developing and disseminating technologies that enhance productivity and resilience in the face of climate change.

Farmer and Stakeholder Engagement: Community-based adaptation, involving local communities in the design and implementation of adaptation strategies, is gaining traction. Chad supports traditional pastoralist systems, while Madagascar focuses on grass-roots initiatives and community grain reserves. Burkina Faso, Cameroon and Mali are other examples of countries actively supporting community-led adaptation.

Other Approaches and Actions: Cross-sectoral policy integration and institutional coordination are essential to ensuring the integration of CCA measures across agricultural, water and land use policies. Decentralization is recognized as a key institutional process, involving the transfer of authority from a central Government to other levels of governance. Agricultural and livelihood diversification, aimed at reducing over-reliance on any single agricultural product, are widely adopted approaches. Livelihood diversification, involving various activities and social assistance capacities, helps households and the agricultural sector withstand unforeseen economic and environmental changes. This approach is evident in the strategies implemented by many African countries (Wale, Nkoana and Mkuna, 2022).

2. Identified Adaptation Gaps

Adapting to climate change in Africa's agriculture and food security sectors confronts a myriad of obstacles, spanning structural, financial, technical, socio-cultural, and political dimensions. Insufficient infrastructure, challenges in land tenure, and fragmented land holdings present significant barriers. Limited funding and constrained access to finance hinder the execution of resilient practices. Inadequate knowledge dissemination, data gaps, and a lack of research and development for climate-resilient technologies impede adaptation efforts. Inconsistent policies, governance issues, and market barriers further complicate climate adaptation. Addressing these challenges demands a comprehensive approach, integrating improved infrastructure, extension services, gender-sensitive policies, and effective governance while nurturing adaptive capacity at all levels.

Technological Barriers: Recent assessments by Suri and Udry (2022) highlight a stagnation in technological progress in African agriculture, contributing to low land and labour productivity over the past two decades. To promote inclusive growth, enhancing productivity through technological advancements becomes imperative. Farmer-tailored digital information platforms, internet-connected sensors (Internet of Things or IoT technology), and high-productivity, disease-resistant seed varieties hold significant potential for boosting productivity and income on farms and post-harvest. However, it is crucial to recognize that not all "modern" technologies are universally suitable. Local factors such as soil types, farming practices, and crop choices can render certain technologies ineffective or inappropriate in specific regions or communities.

Financial Barriers: Many African countries grapple with limited financial resources, restricting their ability to allocate sufficient funds for climate adaptation in agriculture. The implementation of certain adaptation technologies or practices, especially for smallholder farmers, can be financially burdensome. For instance, installing modern irrigation systems, acquiring drought-resistant seed varieties, or investing in post-harvest storage facilities may pose significant financial challenges. Access to affordable credit is crucial for enabling farmers to invest in adaptation measures, but issues like the lack of collateral, formal land titles, or financial histories can hinder access. Moreover, international funding often operates on short-term cycles, which may not align with the sustained investments required for long-term adaptation strategies.

Institutional Barriers: Weak or under-resourced institutions hinder the necessary support, regulation, and oversight required for fostering adaptation. Lack of coordinated action across various governmental and non-governmental entities can lead to siloed efforts and duplicated or counterproductive actions. Insufficiently actionable policies or inadequate enforcement of existing policies in the agriculture sector further compound challenges.

Information Barriers: Insufficient attention is given to the availability and transmission of data on climatic variability, particularly through extension services. Farmers often lack access to reliable and timely information on weather forecasts, climate-resilient agricultural practices, and market prices. This information gap hampers their ability to make informed decisions. Additionally, the lack of localized research tailored to the unique climates, soils, and socio-economic conditions of different regions within Africa exacerbates this information barrier.

Socio-economic Barriers: Uncertain or insecure land tenure can discourage investments in long-term adaptation measures. Women, who play a pivotal role in African agriculture, often face less secure land rights, limiting their ability to implement adaptive strategies. Climate-induced migrations disrupt traditional farming communities, leading to the loss of local knowledge and practices with inherent adaptive capacities.

Market-Related Barriers: Policies often inadequately address the intricate interplay between climate change, trade and agriculture. Market access and trade challenges are primarily approached from a trade negotiation and facilitation standpoint, neglecting the unique intersection of climate and trade. Climate change disrupts supply chains, making it challenging for farmers to access inputs (such as seeds and fertilizers) or sell their produce.

The adaptation components of African Governments' NDCs may lack rigour in terms of clear identification of vulnerabilities, priority sectors, actions undertaken, support required, costing and financial gaps. Addressing these gaps is critical for policy development, resource mobilization and financing of adaptation components in Africa (AfDB, 2019).

3. Opportunities to Enhance Climate Adaptation

Strengthening Policies Related to Adaptation in the Agriculture and Food Security Sector

Monetary and Financial Sector Policies: Effective fiscal policies play a crucial role in reducing food insecurity. The commitment made by African Union nations in 2006 to allocate at least 10 percent of public investment to agriculture development remains pivotal. While social assistance and agricultural input subsidies have been increased, investment in climate-resistant infrastructure has been gradual. Accelerating such investments can enhance access to affordable food for lower-income families, support rapid recovery from severe weather events, and facilitate farmers' access to equipment and technology for climate-resilient and environmentally friendly agriculture.

Regional Trade Integration Policy: A well-structured regional trade integration policy can enhance food availability and affordability. By permitting the sale of excess crops from one country to a neighboring country facing shortages, coupled with robust storage and transport infrastructure, stabilization of prices in both nations can be achieved. This policy approach can encourage longer-term agricultural investment and foster the growth of sub-Saharan African production networks and value chains.

Legal and Regulatory Environment: Well-designed and enforced rules and regulations can contribute to the expansion of climate-resilient agriculture. Regulating water use can reduce reliance on rain-fed agriculture, and regulations controlling farmers' access to water can promote farmer-led irrigation. Simplifying registration requirements for machinery and ensuring trade restrictions are streamlined can enable more affordable and higher-volume agricultural transactions. Additionally, legally recognized property rights can extend selling seasons for perishable goods and enable farmers to use warehouse receipts as collateral for loans.

Climate Information Services and Early Warning Systems

Developing capabilities in prevention, anticipation, absorption, adaptation and transformation is essential for informed decision-making, policies and climate-related actions. Investments in climate risk assessments, impact and vulnerability assessments, multi-hazard early warning systems (MHEWS), and emergency preparedness are crucial. CIS and EWS generate a significant return on investment and can strengthen the resilience of farmers. The WMO's initiative, Early Warnings for All (EW4All) Action Plan, launched in 2023, aims to strengthen EWS across the continent through monitoring, capacity-building, communication and community engagement.

Alternative and Emerging Approaches in Agriculture and Food Security

There are emerging practices aimed at strengthening agricultural resilience in the face of climate change. Here are some examples:

Urban Farming: Urban agriculture presents an opportunity for adaptation in Africa, addressing observed impacts and projected risks of climate change. Besides contributing to increased water retention and reduced erosion, urban farming provides employment opportunities, particularly for women and youth. In cities like Nairobi and Dar-es-Salaam, urban agriculture already plays a significant role, offering benefits such as space efficiency, reduced food mileage, improved water recycling, increased pollination, and reduced air pollution. However, unlocking its potential requires careful planning and policy mechanisms.

Indigenous and Neglected Food Crops: Exploring indigenous and neglected food crops can enhance food security in Africa. Many of these crops, often neglected in favor of more profitable ones, are adaptable to local environmental and climatic conditions, nutritionally dense, and hold substantial potential for creating new markets, jobs, and income. Unlocking the value of indigenous crops involves research and innovation, building local and regional markets through incentives and investments, and fostering an enabling environment by ensuring access to land, farming inputs, and financial incentives.

Increasing finance for Smallholder Farming: Small-scale farming, which constitutes a significant portion of Africa's food supply, can be a vital investment for ensuring food and nutrition security. Supporting rain-fed small-scale agricultural activities proves to be a cost-effective approach for transforming rural areas. Challenges faced by smallholder farmers, including drought, pests, limited market access, and lack of climate information services, can be addressed through strategies such as crop diversification, improved crop varieties, enhanced agricultural extension services, and the use of technology for communication and climate information dissemination.

5.2. Water resources

Water plays a vital role in enhancing resilience and adaptation to climate change. Despite this, more than 90 percent of Africa's surface water resources are distributed across 63 transboundary river basins, spanning multiple borders. This transboundary nature necessitates regional cooperation for effective adaptation, as actions confined to national boundaries face limitations (GCA 2021). International collaborations, especially in the form of regional adaptation initiatives, are essential to address climate-induced hydrological variability, competing water demands, and the unpredictability of water resources.

At the continental level, the African Union and the African Ministers' Council on Water (AMCOW) have prioritized climate change in the Water Resources Priority Action Plan (PAP, 2016-2025). The plan aims to ensure water security, enhance resilience to climate change, manage water-related disasters, and improve environmental integrity through effective wastewater and water quality management. Climate change exacerbates Africa's water crisis, posing a threat to achieving the 2030 Sustainable Development Agenda, the African agenda 2063, and the African water vision 2025. Recognizing the urgency, the Action for Water Adaptation and Resilience (AWARe) initiative, endorsed by the African Union (AU) and AMCOW, seeks to address water's pivotal role in climate change adaptation. AWARe focuses on inclusive cooperation, aiming to decrease global water losses, improve water supply, and propose mutually agreed policies for collaborative water-related adaptation actions. Its co-benefits aim to foster cooperation and interlinkages between water and climate action to achieve Agenda 2030, particularly SDG 6.

1. Current adaptation efforts

Various strategies, ranging from harnessing the power of nature through nature-based solutions to leveraging Indigenous knowledge and embracing integrated water resource management (IWRM), exemplify the rich tapestry of approaches undertaken for water adaptation across the African continent. This diversity described below underscores the multifaceted strategies employed across Africa to adapt to climate change and ensure water security.

Nature-Based Solutions: Nature-Based Solutions are being implemented across the continent to cost-effectively accelerate adaptation, increase water security, and build resilience to a changing climate. Examples include South Africa's initiative in the Berg River Catchment, Zambia's rehabilitation of the Lukanga Swamp, and the restoration of Kigali wetlands in Rwanda. Additionally, coastal mangroves maintenance in Kenya and the Great Blue Wall initiative contribute to climate-resilient water management.

Indigenous Local Knowledge: Indigenous and local knowledge is increasingly employed for climate adaptation in water-related risks. Across southern, western and eastern Africa, communities utilize Indigenous and local knowledge for measures such as irrigation, rainwater harvesting, water conservation and agroforestry. These practices, rooted in collective memories and local insights, have demonstrated success in supplementing climate support services and contributing to water sustainability.

Integrated Water Resource Management: IWRM is identified as a crucial component of climate disaster risk management. At least 42 African nations are in the process of institutionalizing IWRM elements, providing a solid foundation for accelerated progress. South Africa stands out for its commitment to fully implementing IWRM in national and transboundary water management systems by 2030. Blending IWRM with CCA is deemed critical for effective action, and ongoing processes such as NAPs and NDCs are advancing IWRM implementation.

Early Warning Systems: National meteorological and hydrological services (NMHS) in Africa provide essential water EWS, offering services such as rainfall, flood and drought forecasting. These systems, crucial for spatial planning and resilient infrastructure development, have played a significant role in minimizing the impacts of floods, droughts and other water-related climate disasters.

2. Identified Adaptation Gaps

In tackling the adaptation gaps within Africa's water sector, a myriad of challenges surfaces. Financial constraints present a significant hurdle, hampering the response to escalating water-related adaptation needs and posing severe repercussions for vulnerable populations. The realization of nature-based solutions' potential in bolstering water resilience faces obstacles in implementation and funding. Managing transboundary basins is intricate, given geopolitical tensions, sovereignty concerns, and uneven resource distribution, necessitating substantial resources and unwavering commitment. Limited water data obstructs well-informed decision-making, while gaps in reporting on water-related initiatives in national climate plans impede comprehensive planning. Concerns about the efficacy of upfront investments arise due to uncertainty in future rainfall projections, underscoring the imperative for enhanced early warning systems and strategic planning. This sector-specific overview underscores the significance of addressing these gaps to fortify water resilience and promote sustainable resource management in the context of climate change. Below is presented a summary of the critical gaps that need to be addressed.

Financial Gaps

- *Challenge:* The current adaptation finance flows are inadequate to address the growing adaptation needs in the water sector.
- *Implication:* The slow pace of financial support poses catastrophic implications for the most vulnerable populations in Africa.

Nature-Based Adaptation Challenges

- *Challenge:* Implementation and funding challenges are hindering the progress of nature-based adaptation strategies in addressing water-related climate risks.
- *Implication:* The potential of nature-based solutions to contribute to water resilience in Africa is not fully realized.

Transboundary Basin Management Complexity

- *Challenge:* Most of Africa's water resources are within transboundary basins, introducing complexities in effective, equitable, and sustainable management.
- *Implication:* Geopolitical tensions, sovereignty issues, and uneven resource distribution impede collaborative basin management.
- *Resource Need:* Overcoming these challenges requires significant resources, time, and commitment from riparian nations.

Limited Water Data

- *Challenge:* Limited availability of water data in Africa hampers informed decision-making for current and future water resource planning.
- *Implication:* Lack of comprehensive databases inhibits the ability to chart a sustainable development path and enhance climate change resilience.

NDC Reporting Gap
Challenge: Updated Nationally Determined Contributions (NDCs) often do not report the direct impact of climate change on available water resources and corresponding adaptation actions.
Implication: Lack of information hinders a clear understanding of the water-related initiatives outlined in national climate plans.

Rainfall Projection Uncertainty
Challenge: Variability and uncertainty in future rainfall projections for Africa raise concerns about the returns on upfront investments, such as building dams.
Implication: Climate-related uncertainties may affect the effectiveness of investments in water infrastructure.

EWS and Planning
Challenge: Inadequate EWS and planning affect the effectiveness of upfront investments in water infrastructure and preparedness.
Implication: Improved planning and more effective EWS are required to ensure the success of water-related investments.

By addressing these identified gaps, there is an opportunity to enhance the resilience of Africa's water sector to climate change and ensure sustainable water resource management.

3. Opportunities to Enhance Climate Adaptation

Addressing the current risks, vulnerabilities and impacts of climate change requires adapting existing systems through various actions to enhance resilience in the water sector. The success of these actions relies on adequate planning, capacity, financing, enabling policies and effective management. Despite progress, the implementation of adaptation measures in Africa remains uneven, fragmented, incremental and primarily focused on immediate impacts and near-term risks (AfDB, 2023b). This prioritization of short-term risk reduction limits opportunities for transformative adaptation (Pörtner and others, 2022). Ongoing efforts to increase adaptation planning, implementation and public awareness have led to reduced impacts and risks in different regions. However, disparities in estimated adaptation costs and financial resources result in uneven distributions of actions, disproportionately affecting lower-income and environment-dependent livelihoods (Meattle and others, 2022).

Building on the insights provided by AfDB (2023b), strategic CCA is crucial for enhancing resilience in Africa's water sector.

The majority of documented adaptation initiatives target water-related risks (Pörtner and others, 2022). Successful strategies involve implementing EWS and structural measures, such as wetland restoration and land use planning, effectively enhancing natural

water retention and reducing flood risks. Key measures to counteract groundwater depletion include soil moisture conservation and irrigation management. However, anticipated risks and rising temperatures pose challenges to water-related adaptation efforts.

Harris and others (2023), in an Adaptation Without Borders brief, highlight the increasing issue of water insecurity due to transboundary climate-related water risks in Africa. The brief emphasizes the imperative for enhanced coordination among regional economic communities and States in addressing transboundary and cascading climate risks extending beyond water. Coordinated transboundary climate responses in water management offer opportunities for inter-basin transfers, supplementing water-poor basins from more water-abundant ones, as exemplified in southern and northern Africa. These transfers are poised to gain significance in the future and can be leveraged for innovative flood management systems.

The exploration of sea-water desalination aims to augment water availability in coastal areas around Mediterranean regions. Learning from Cape Town's unprecedented 2015–2018 drought, a once-in-400-year event, where the city imposed daily water usage limits per resident to extend its dam reservoirs until the winter rains, countries in the Middle East and North Africa began to significantly invest in desalination technologies to improve their water supply. While desalination is an energy-intensive process, several northern African plants are integrating renewable energy sources to offset increasing emissions. Scaling up the use of renewable energy sources has the potential to mitigate the environmental impact of these interventions.

Groundwater plays a pivotal role in Africa's adaptation to climate change and variability due to its superior resilience compared to surface water resources. Groundwater sources are indispensable for providing dependable water supplies, particularly in rural communities. Investments aimed at increasing and improving access and storage infrastructure in this realm will further fortify water adaptation efforts in Africa. Based on the above, key investments still needed to enhance implementation include:

- Developing decision support systems for effective water management
- Incorporating EWS to enhance knowledge in flood and drought management and hydro-economic modelling
- Managing water allocation, use, environmental/ecosystem requirements and climate change impacts
- Expanding climate-resilient and green water supply and sanitation infrastructure and services in both urban and rural contexts
- Promoting IWRM, encompassing the protection of water sources, watershed restoration, environmental flows determination and protection, and transitioning from single-use to multi-purpose water infrastructure
- Encouraging climate-resilient and green agricultural water management, including the development of irrigation
- Supporting the operation, maintenance and management of

existing water infrastructure to minimize technical and commercial water loss
- Promoting measures that enhance sustainable water resource management
- Strengthening transboundary water resource management and development measures for surface and groundwater resources, emphasizing sub-basin-level planning, governance and equitable utilization
- Implementing cross-cutting measures, such as enhancing information and communications technology (ICT) capabilities and networks, along with corresponding skills, to bolster data and information management, monitoring and advanced analytics that support climate adaptation
- Assisting African countries in developing country profiles for climate risks and vulnerability, as well as project-specific assessments to inform targeted adaptation actions within their National Adaptation Programme of Action (NAPA).

Enabling environment investments in this sector should focus on:

- Building capacity to improve water governance and policy, including natural resources management approaches linked to water resources.
- Strengthening data management systems (generation, collection, and storage) to enhance information and knowledge on water (hydrology, water use), facilitating more effective decision-making in water systems management.
- Enhancing water institutions' capacities to adopt/develop Integrated Land and Water Resource Management (ILWRM) policy and regulatory frameworks, incorporating water efficiency practices, climate resilience safeguards guidelines, and enhancing climate-proof water infrastructure development and regional collaboration on water infrastructure.
- Assisting African countries in developing national WASH master plans that integrate climate resilience and low carbon water infrastructure development through public-private partnerships as financing mechanisms
- Promoting measures that enhance sustainable water resource management.
- Encouraging multi-sectoral coordination and planning WASH services.
- Supporting the adaptive capacity of farmers, including access to finance to diversify income sources.

5.3 Health

There is a growing acknowledgement of the incorporation of health considerations within the national climate change instruments and policies employed by African countries for adaptation planning. This includes the formulation of national health and climate change plans or strategies, which play a crucial role in identifying actions to address the health impacts of climate change and in developing robust plans for specific climate-related events. Such plans may take the form of health NAPs, and extend to broader national planning documents such as NAPAs, NAPs and NDCs. As of 2021, 19 African countries had developed national health and climate change plans or strategies, with two countries still in the process of developing them (WHO, 2021a).

Notable progress has been made in incorporating health considerations into Africa's updated first NDCs. In these documents, the health sector has gained increased priority, with 41 countries either covering or mentioning health aspects related to vulnerability, exposure, impacts and adaptation (WMO, 2022). Despite this heightened consideration, only 12 countries have specific health sector targets or actions, whether time-bound, quantified or qualitative. The inclusion of health considerations in NDCs is crucial for identifying the health impacts of climate change, outlining health adaptation and resilience priorities, and showcasing evidence of the health co-benefits of climate mitigation policies to bolster the case for accelerated climate action.

Furthermore, NAPAs provide an additional avenue for addressing climate change impacts on the health sector in African countries, as exemplified by nations including Ghana, Lesotho and Namibia (Nhamo and Muchuru, 2019). NAPs present an opportunity for countries to set health sector adaptation targets and ambitions. Those African countries that have already developed NAPs, such as Ethiopia, South Sudan, the Sudan and Togo, have clearly defined health priorities and targets.

However, despite the formulation of national health and climate change plans or strategies, several challenges hinder their effective implementation across African countries. These challenges include insufficient finance and budgetary allocations, limited human resource capacity, constraints related to COVID-19, inadequate research and evidence, lack of appropriate technologies, tools and methods, insufficient prioritization or competing priorities, inadequate multisectoral collaboration, and incomplete or inadequate comprehensive plans or strategies (WHO, 2021a). The nature and intensity of these challenges vary across African countries, reflecting the diverse circumstances on the continent. While setbacks such as those associated with COVID-19 are widespread and affect many African countries, financial constraints are particularly prevalent. This underscores the critical need for international support to help African countries overcome the financial barriers they face. The implementation of national and subnational policies and strategies designed to prevent or mitigate climate change-related health impacts in Africa can yield positive outcomes at the local level.

1. Current adaptation efforts

As of the year 2021, 17 African countries successfully conducted climate change and health vulnerability and adaptation assessments, with an additional three countries still in the process of conducting such assessments (WHO, 2021a). These evaluations play a pivotal role in providing insights into the health risks associated with climate change, identifying populations most vulnerable to these risks, evaluating existing policies and programmes, and pinpointing gaps that need addressing. They also aid in prioritizing and implementing effective adaptation interventions. While there is a commendable commitment from some African countries, further efforts are required from others to develop these assessments. The crucial role of international support, facilitated through multilateral funding, is evident in helping African countries establish these assessments and understand their health sector adaptation needs.

Despite the importance of vulnerability and adaptation assessments, implementation faces challenges such as inadequate financing, human resource constraints, and limited research, evidence, technologies and tools, with specific examples of these challenges experienced by various African countries (WHO, 2021a).

Integrated Planning.

Recognizing the need for a collaborative response to climate change, Governments, civil society and communities are increasingly acknowledging the importance of collaboration across all sectors, including health. This collaborative approach involves collective decision-making among diverse stakeholders. Significant progress has been made in developing multisectoral collaboration on policies and programmes related to health and climate change. Coordination mechanisms often include representation from sectors addressing environmental determinants of health, such as safe WASH services, cities and infrastructure development, agriculture, clean air and meteorological services. However, representation from sectors focused on structural and social determinants of health, including education, urban planning, housing, energy and transportation systems, is less common (40–50 percent of coordination mechanisms).

Health Early Warning Systems

A crucial element of climate adaptation in the health sector is climate-informed advisory and management services. Reliable EWS are vital for implementing effective climate adaptation responses across crucial sectors in Africa, including health. While there is a global recognition of the importance of health early warning systems (HEWS), evidence of their use in Africa is limited due to challenges such as a lack of forecasting infrastructure (Trisos and others, 2022). As of 2021, only two countries in Africa had established HEWS, and three countries had a health sector response plan in place (WHO, 2021a). Currently, HEWS primarily focus on heat-related illnesses, and there is a need to extend their scope to other climate risks. Noteworthy progress has

been made in implementing climate-informed health surveillance systems in Africa, particularly for vector-borne, water-borne, airborne or respiratory diseases, as well as heat-related illnesses. Examples include a successful pilot implementation of the Epidemic Prognosis Incorporating Diseases and Environmental Monitoring for Integrated Assessment in the Amhara region of Ethiopia project, aimed at developing a malaria EWS (Neta and others, 2022). Additionally, the Government of Egypt is formulating control initiatives for infectious diseases guided by the EWS, showcasing some of the evidence of projects promoting EWS as an adaptation strategy in the health sector (see Box 4).

Box 4: *EWS Adaptation case study in Ethiopia.*

Climate change impacts: Infectious diseases

Project name: Strengthening Public Health Surveillance and Early Warning System Capacity

Period: 2019–2022

Adaptation measures: Strengthening health surveillance systems with climate and weather data, improving management of groundwater resources, mainstreaming climate resilience measures in national WASH programmes, building the capacity of health surveillance professionals and water managers, and formulating norms and standards to improve access to water and sanitation during extreme weather events.

Partners and funding:
Government of Ethiopia:
Ethiopian Public Health Institute; Environment, Forest and Climate Change Commission; Ministry of Agriculture; Ministry of Health; Ministry of Water, Irrigation and Energy; National Disaster Risk Management Commission; National Meteorology Agency; Water Development Commission

United Kingdom of Great Britain and Northern Ireland, Department for International Development (DFID)/Foreign, Commonwealth & Development Office

WHO

Project summary:
Climate change is adversely impacting health in Ethiopia, primarily through the spread of climate-sensitive diseases like malaria, yellow fever, dengue fever, meningitis, leishmaniasis, and diarrheal diseases. Direct causes like heat stress and weather extremes, and indirect factors such as infectious diseases, water scarcity and health infrastructure impacts, are significant concerns. Ethiopia faces increasing temperatures, variable precipitation, and more frequent extreme weather events like droughts, contributing to high-water stress and limited access to safe drinking water and sanitation for a significant portion of its population. This situation exacerbates the spread of diseases like cholera and acute watery diarrheal disease during dry periods and diseases like leptospirosis during floods.

The WHO, with DFID funding, has launched a project in Ethiopia to strengthen public health surveillance and early warning systems and improve water, sanitation, and hygiene (WASH) services to combat these challenges. The programme focuses on integrating health and climate/weather data for better disease surveillance and making WASH services more climate-resilient.

Source: GCA (2021).

Evidence indicates the effectiveness of implementing adaptation measures in the health sector across Africa. Local, national and international entities have actively embarked on the implementation of health adaptive responses, as underscored by the findings by Trisos and others (2022). Significantly, a multitude of adaptation measures in Africa, contributing to the enhancement of health and well-being, are integrated into various sectors, including food, livelihoods, social protection, WASH and infrastructure (Table 5). Adaptation options across multiple non-health sectors have potential for reducing risk for multiple health outcomes, considering their potential to reduce

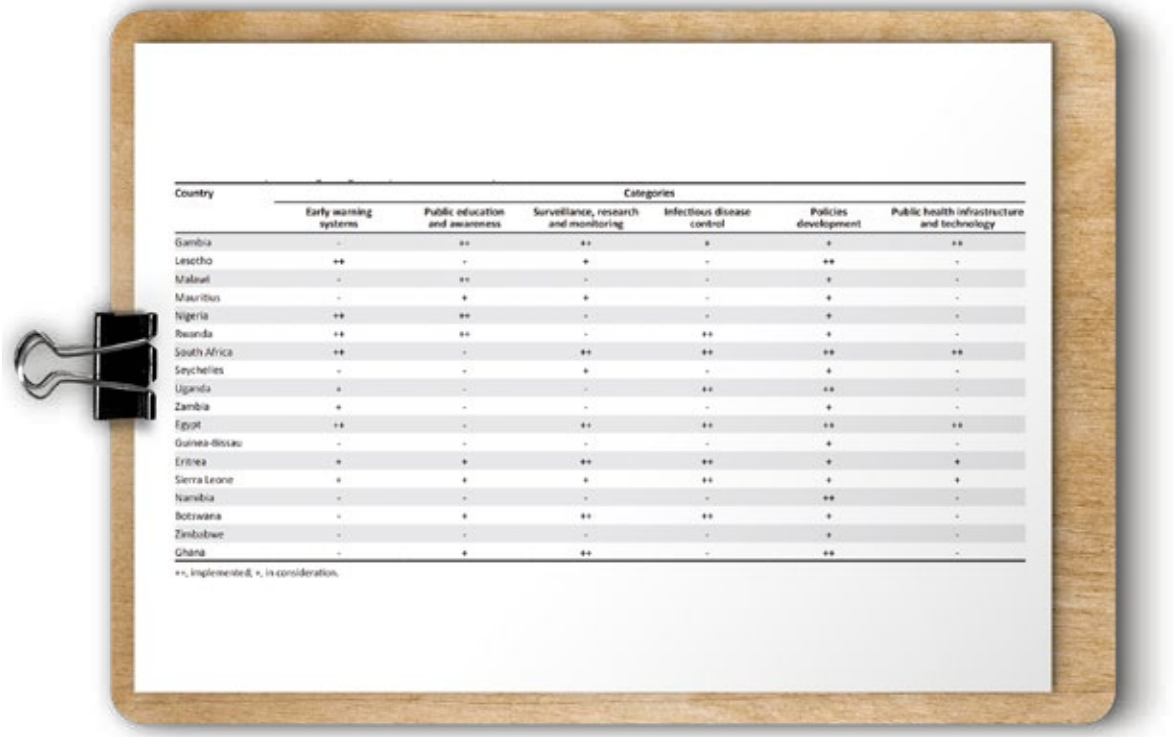
vulnerability. Reduced risk for health may result from targeted actions or as a result of co-benefits. These strategic actions are formulated to specifically address the four primary health impacts arising from climate change, as detailed in Section 3.3. For a detailed overview of these measures, please refer to Table 6.

Table 5 : *Health benefits from non-health sector adaptation.*

Source: Trisos et al., 2022.

Analysis of most recent national communications to the United Nations Framework Convention on Climate Change (UNFCCC) submitted by African countries highlight evidence of health sector adaptation by several countries (see Table 6). A total of 18 out of the 21 countries were either implementing or considering implementing health adaptation measures (Nhamo and Muchuru, 2019). Most of the measures relate to EWS; for example, Nigeria is enhancing its seasonal weather forecasting systems by providing up-to-date and relevant information well in advance, such as dry spells, heavy storms and heat waves. The system can issue health alerts through analysing and integrating weather and health thresholds data (Nigeria, 2014). About nine countries have either implemented or are considering the implementation of early warning systems, while surveillance and monitoring and policy development are the key adaptation priorities for most African countries that were assessed (see Table 6).

Table 6 : *Summary of implementation of adaptation measures by African countries as listed in national communications to the UNFCCC.*



Country	Categories					
	Early warning systems	Public education and awareness	Surveillance, research and monitoring	Infectious disease control	Policies development	Public health infrastructure and technology
Gambia	-	++	++	+	+	++
Lesotho	++	-	+	-	++	-
Malawi	-	++	-	-	+	-
Mauritius	-	+	+	-	+	-
Nigeria	++	++	-	-	+	-
Rwanda	++	++	-	++	+	-
South Africa	++	-	++	++	++	++
Seychelles	-	-	+	-	+	-
Uganda	+	-	-	++	++	-
Zambia	+	-	-	-	+	-
Egypt	++	-	++	++	++	++
Guinea-Bissau	-	-	-	-	+	-
Eritrea	+	+	++	++	+	+
Sierra Leone	+	+	+	++	+	+
Namibia	-	-	-	-	++	-
Botswana	-	+	++	++	+	-
Zimbabwe	-	-	-	-	+	-
Ghana	-	+	++	-	++	-

++, implemented; +, in consideration.

Note: Of the 51 countries, 21 countries are analysed (those submitted in English). The most recent national communications were analysed.

Source: Nhamo and Muchuru (2019).

2. Identified Adaptation Gaps

Despite the presence of international funding mechanisms, only seven African countries received support for climate change and health work through their Ministries of Health in 2021 (WHO, 2021a). Several challenges impede the health sector's ability in African countries and other developing nations to access international funding. These challenges include a lack of information on opportunities, insufficient capacity to prepare proposals, and a disconnect between health actors and climate change processes.

Lack of Health Adaptation Projects from Multilateral Funding:
Among the various adaptation projects supported by the Green Climate Fund (GCF) and other United Nations multilateral funding mechanisms, none specifically focus on the health sector. Globally, less than 0.5 percent of multilateral climate finance has been allocated to health projects (United Kingdom of Great Britain and Northern Ireland, COP26 Presidency, 2021). In Africa, no country has received a project primarily dedicated to health. Health considerations are often integrated into projects related to agriculture, livelihoods, water, cities and other sectors. Addressing this gap requires African countries to submit specific health sector projects, and multilateral organizations should actively promote health funding proposals.

Health Adaptation Barriers and Gaps: While global efforts in adaptation planning, funding and execution are growing, they are not advancing rapidly enough to match the increasing climate impacts. Several factors, as listed below, hinder the execution of health sector strategies to adapt to climate change in Africa.

Lack of Integrated Planning: There is a lack of distinct roles or responsibilities, particularly at the local level. Although most countries have evidence of mainstreaming health in national planning, there is limited evidence of integrated planning in most African countries. Clear definitions of adaptation goals at the national level, and policies outlining responsibilities, are necessary to attract support from the private sector.

Lack of Capacity: Many countries lack the planning and preparedness required to access and utilize adaptation financing. Insufficient technical skills hinder the preparation of proposals to access multilateral climate funds. Climate science training and spatial data management are not integral to health science, leading to a lack of understanding among health authorities. Embedding adaptation projects within sectoral ministries without necessary technical support can result in a business-as-usual approach.

Observational Data: Limited access to climate data and weather infrastructure in Africa poses a significant challenge. The lack of data, not only on weather but also on monitoring and surveillance, hampers health sector adaptation. Less than 40 percent of countries include weather and climate information in their health surveillance systems for climate-sensitive diseases.

Financial Barriers: Few countries have received international funds for climate change and health work. In 2021, only three African countries received such funding. The adaptation finance needs listed in NDCs highlight a significant gap on the continent. The health sector receives minimal climate finance, and a substantial gap exists between funding mobilization and adaptation needs.

Role of Private Sector Funding: Private sector funding, especially from international pharmaceutical companies, can play a crucial role in mobilizing health sector adaptation funds. Creating a conducive environment through attractive investment policies and collaborations is essential.

Inadequate Engagement of Relevant Stakeholders: Involving various stakeholders, including policymakers, Indigenous People, marginalized groups, health care providers and communities, is crucial for effective adaptation. Inclusive efforts are necessary to address patient and community needs, reduce health disparities and enhance government accountability.

Other Challenges: Additional challenges, such as the impact of other pandemics such as COVID-19 diverting health personnel and resources,

and hindering the implementation of protective measures, further complicate health climate action. Countries in need of adaptation also often face resource challenges, further hindering effective implementation of necessary measures.

3. Opportunities to Enhance Climate Adaptation

As countries in Africa increasingly integrate health priorities into their national climate adaptation frameworks, such as NAPs, NDCs and NAPAs, the mobilization of resources for effective means of implementation becomes crucial. The achievement of health sector targets set by countries hinges on the mobilization of resources, particularly given the prevailing levels of poverty in Africa and the substantial financial and technical capacity required for implementing climate adaptation responses outlined in these national planning documents.

Resource Mobilization: Countries are actively implementing a variety of health adaptation measures to bolster the resilience of public health systems against the impacts of climate change. To enhance national and subnational participation in sector adaptation for achieving sector adaptation goals across African countries, the support of various institutions and stakeholders is vital. While African nations allocate funds from their budgets for adaptation implementation, support from international mechanisms plays a crucial role in developing adaptation methods and activities at different levels. This support encompasses not only financial resources but also other key means of implementation, including the following.

Capacity Building in the Health Sector: Efforts to enhance the capacity of the health workforce in understanding the intricate link between climate change and health are under way, with training initiatives conducted in 42 percent of countries. However, there is a need for further endeavours to ensure that capacity-building encompasses a comprehensive set of relevant skills and is seamlessly integrated into the ongoing development of the health workforce. Box 4 presents evidence of diverse capacity-building activities undertaken by stakeholders and institutions in the health sector across the continent to fortify climate adaptation. While strides have been made in capacity-building, particularly in training the health workforce, it is noteworthy that most initiatives associated with international support from multilateral organizations and funding do not exclusively target the health sector. Instead, these initiatives predominantly focus on sectors such as agriculture, water, ecosystems and energy. There is a significant emphasis on addressing challenges related to rainfall variability, drought and flooding (UNEP, 2022). Table 6 provides valuable insights into adaptation implementation initiatives in various sectors, offering a broader perspective on the interconnected nature of climate adaptation efforts across regions and sectors.

Technology Transfer: The transfer of technology, both within different regions of Africa and from developed to developing countries, is a crucial means of implementation. This facilitates the adoption of transformative adaptation strategies and the establishment of climate-resilient health systems.

Box 5: *Climate resilient health system in Africa*

Climate-resilient and environmentally sustainable health care facilities are better able to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stresses. Reducing the health impacts of climate change requires ensuring that health systems and facilities can withstand potential climatic shocks and stresses, manage the health fallout from climate-related events, and continue to deliver health care to those who need it. Table 7 outlines how a climate-resilient health system/sector for Africa can be designed.

Table 7: Five pillars of resilient health systems and associated priority actions.

Resilience in Health Systems	Objectives	Examples of policy actions
Resilient health facilities	Enhanced capacity and resilience of facilities by:	• Understanding climate risks today and in the future • Upgrading structures to withstand climate shocks • Enhancing staff capacity to deal with climate shocks and emergencies • Preparing crisis protocols, business contingency plans, and emergency stocks of essential supplies
Resilient health systems	Integrate individual health facilities into a coordinated network by:	• Using data-driven decision-making process to optimize resources during climate shocks • Improving communication and cooperation between diverse entities of health system • Leveraging facilities outside the health system to delivery emergency services • Deploying mobile clinics to underserved and disaster-hit areas to boost capacity during crisis
Integrated emergency response	Integrate health care into climate shock response systems by:	• Coordinating closely with search and rescue agencies to manage health needs • Establishing inter-agency communication channels and coordination before climate shocks • Clearly defining roles and mandates for crisis response • Enhancing early warning systems and disseminating information to the health system • Integrating health system needs in climate risk finance strategies
Resilient infrastructure	Ensure resilience of critical infrastructure systems on which health facilities depend by:	• Upgrading transport, water, electricity, and telecommunications assets vulnerable to climate shocks, especially those needed for health systems operations • Identifying redundancy in infrastructure assets • Leveraging new technologies for service and supply delivery

Source: Adapted from World Bank (2021), Frontlines.

5.4. Biodiversity and Ecosystems

African nations routinely confront the challenges posed by climate change to biodiversity and ecosystems through comprehensive approaches outlined in their NDCs, NAPs and National Biodiversity Strategies and Action Plans (NBSAPs). These strategic documents play a pivotal role in steering countries' initiatives to not only mitigate and adapt to the impacts of climate change, but also to ensure the preservation of their diverse and invaluable natural environments. Within the framework of these documents, African countries integrate a diverse array of strategies and actions, each carefully designed to address the multifaceted aspects of climate change on their biodiversity and ecosystems. The inclusion of such measures underscores the recognition of the intrinsic link between climate change and the health of natural ecosystems. As a result, NDCs, NAPs and NBSAPs serve as comprehensive roadmaps, guiding nations in their pursuit of sustainable development that harmonizes with the conservation of biodiversity and the resilience of ecosystems in the face of a changing climate.

1. Current adaptation efforts

The analysis of African countries' NDCs, NAPs and NBSAPs reveals a range of shared approaches aimed at adapting biodiversity and ecosystems to the challenges posed by climate change. The key strategies identified are outlined below.

Ecosystem-Based Approaches:

- Many African countries, including Kenya, Madagascar, Namibia, Nigeria, South Africa, Uganda and Zambia, emphasize ecosystem-based approaches in their NDCs, NAPs and NBSAPs.
- These approaches focus on conserving and restoring vital ecosystems, including forests, wetlands and coastal areas, to enhance climate resilience and promote biodiversity conservation.

Reforestation and Ecosystem Restoration:

- Commitments to conserve and restore natural habitats, particularly through reforestation and the restoration of degraded landscapes, are prevalent in African NDCs and NAPs.
- Cameroon, Kenya, Madagascar, Mozambique, Rwanda, South Africa, Uganda, the United Republic of Tanzania and Zambia, among others, have adopted initiatives to restore critical habitats, supporting local livelihoods and biodiversity.

Sustainable Land Management:

- Sustainable land management practices are integrated into the NDCs and NAPs of various African countries, such as Gambia, Ghana, Malawi, Morocco, Senegal and Uganda.
- These practices aim to improve soil health, support biodiversity and address climate change impacts, including erosion and sea level rise.

Protected and Conserved Areas Expansion:

- The expansion and reinforcement of protected areas and conservation initiatives are recurrent themes in NDCs and NAPs across the continent.
- Côte d'Ivoire, Kenya, Madagascar, Mozambique, Nigeria, Rwanda, South Africa, the United Republic of Tanzania and others emphasize the importance of these areas in preserving unique ecosystems in the face of climate-related threats.

Climate-Resilient Agriculture:

- Numerous African countries, such as Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Rwanda, Senegal, Uganda, the United Republic of Tanzania and Zambia, address the impacts of climate change on agriculture and ecosystems.
- Plans promote climate-smart agricultural practices, including the use of drought-resistant crop varieties and sustainable land management techniques to mitigate pressures on land and water resources.

Indigenous and Local Knowledge:

- Recognition of the value of Indigenous and local knowledge in managing ecosystems and biodiversity is evident in various NDCs, NAPs and NBSAPs.
- Countries including Botswana, Cameroon, Côte d'Ivoire, Malawi, Mauritius, Namibia, Niger, Togo and Uganda emphasize the importance of incorporating traditional practices and knowledge into land management and adaptation strategies.

These collective strategies reflect the commitment of African nations to holistic and collaborative approaches, aligning their climate adaptation efforts with the preservation of biodiversity and ecosystems.

2. Identified Adaptation Gaps

Climate adaptation for biodiversity and ecosystems in Africa encounters several formidable challenges, each contributing to a complex landscape that hinders effective implementation. Identifying and addressing these barriers are crucial not only for the preservation of Africa's diverse natural heritage, but also for bolstering the continent's resilience amidst ongoing climatic changes. A comprehensive review of NDCs, NAPs, NBSAPs and existing literature illuminates distinct adaptation gaps related to biodiversity and ecosystems, as outlined below.

Limited Financial Resources:

- **Underfunding priorities:** Scarce public funding allocated to environmental and climate initiatives poses a significant barrier to climate adaptation. Environmental concerns, including projects related to biodiversity and ecosystems, often receive a smaller share of limited resources due to competing priorities such as health care, education and infrastructure development.

- **Uncertain funding:** CCA projects demand consistent, long-term financial commitments. However, the uncertainty and unpredictability of funding for environmental initiatives impede effective planning and execution. Delays or inconsistencies in disbursing funds from donor countries and international organizations further challenge long-term adaptation strategies.

Lack of Technical Capacity:

- **Expertise shortage:** A shortage of qualified experts, scientists and professionals in fields crucial for biodiversity conservation and ecosystem management, including climate science and ecological research, hampers effective planning and execution of climate adaptation projects.
- **Limited technology access:** Insufficient access to technology, such as geographic information systems and remote sensing tools, impedes the monitoring and modelling of ecosystem dynamics. The absence of these crucial tools restricts the ability to make informed decisions about adaptation, exacerbating challenges.

Data and Information Gaps:

- **Incomplete or outdated data:** Inadequate or outdated data on biodiversity, ecosystems and climate change impacts hinders the design of evidence-based adaptation strategies. Comprehensive and up-to-date information is essential for understanding local climate change impacts, identifying vulnerable areas and species, and making informed decisions about conservation and adaptation efforts.

Inadequate Policy and Regulatory Frameworks:

- **Policy ineffectiveness:** Outdated or ineffective policies and regulations related to conservation, land use and climate adaptation, create conflicts and inconsistencies in implementation. Ineffective policy frameworks hinder efforts to protect ecosystems and biodiversity.

Multiple Pressures on Biodiversity and Ecosystems:

- **Habitat destruction and fragmentation:** Pressures such as agriculture expansion, urbanization and infrastructure development driven by population growth and economic development contribute to habitat destruction and fragmentation. These activities pose significant threats to ecosystems and biodiversity, complicating effective adaptation measures.
- **Interconnected pressures:** The interplay of various pressures, including habitat loss, pollution, invasive species introduction and overexploitation, intensifies challenges. Climate change exacerbates these pressures, creating a complex web of interconnected issues that hinder effective adaptation.

These barriers to climate adaptation for biodiversity and ecosystems in Africa are multifaceted, encompassing financial, technical, data-related, policy and other interconnected environmental challenges. Addressing these challenges is imperative for fostering successful climate adaptation initiatives on the continent.

3. Opportunities to Enhance Climate Adaptation

Strengthening the implementation of biodiversity and ecosystem adaptation in Africa requires a comprehensive strategy that encompasses various key elements. This multifaceted approach involves mainstreaming adaptation into different sectors, enhancing ecosystem-based adaptation (EbA) strategies, designing and implementing innovative funding mechanisms, and fostering stronger collaboration. The following points outline critical elements that can enhance the implementation strategies for biodiversity and ecosystem adaptation across the continent.

Mainstreaming Adaptation

Mainstreaming adaptation is a holistic approach that seamlessly integrates climate change considerations into diverse policies, programmes and projects across sectors, enhancing resilience to climate impacts (Global Environment Facility [GEF], 2014; Organisation for Economic Co-operation and Development [OECD], 2018). In the African context, this becomes a potent tool for fostering the resilience of biodiversity and ecosystems. Key aspects include:

- **Alignment with Policies and Regulations:** Ensuring alignment of CCA goals with existing policies and regulations facilitates the development of coherent policies for biodiversity conservation and ecosystem management.
- **Promote Informed Decision-Making:** A robust understanding of current and future climate impacts is imperative. Research and data collection on vulnerabilities and adaptation options for biodiversity and ecosystems are essential for informed decision-making.
- **Strengthen Community Involvement:** Emphasizing the involvement of local communities in decision-making processes is crucial. Engaging communities ensures the development of sustainable and locally relevant solutions.
- **Attracting Funding:** Mainstreaming adaptation can attract funding for biodiversity and ecosystem projects by aligning them with broader climate adaptation goals, enabling the implementation of projects on the ground, enhancing ecosystem resilience.

Enhancing Ecosystem-based Adaptation (EbA)

To maximize the potential of EbA and bolster climate adaptation in Africa, a comprehensive and integrated approach is essential. Key components include:

- **Priority Ecosystem Identification:** Initiating comprehensive assessments to identify priority ecosystems ensures strategic focus on areas that contribute significantly to adaptation.

- **Policy Integration:** Embedding EbA principles into national policies, biodiversity conservation strategies, and sustainable development plans aligns EbA efforts with broader government initiatives.
- **Community Engagement:** Active engagement with local communities is paramount. Incorporating traditional knowledge and empowering communities in decision-making processes enhances effectiveness.
- **Capacity Building:** Implementing capacity-building programs enhances skills and understanding. Public awareness campaigns underscore the importance of ecosystems in climate adaptation.
- **Sustainable Practices:** Promoting sustainable land use practices, including ecosystem-friendly agriculture, and implementing projects focused on ecosystem restoration and conservation are central strategies.
- **Research and Monitoring:** Continuous research and monitoring are necessary to assess the effectiveness of EbA interventions. Adaptations based on evolving knowledge and changing climate conditions ensure ongoing success.
- **Policy Coherence:** Achieving policy coherence requires cross-sectoral collaboration to align policies across various sectors with EbA objectives.

Innovative Funding Mechanisms

Innovative funding mechanisms play a pivotal role in supporting the adaptation of biodiversity and ecosystems in Africa. Strategies include:

- **Green Bonds:** Issuing green bonds tailored for environmentally beneficial projects attracts investments specifically for biodiversity conservation and sustainable agriculture.
- **Payment for Ecosystem Services:** This offers a sustainable funding model where beneficiaries pay for valuable environmental services, aligning incentives with conservation outcomes..
- **Biodiversity Offsetting:** Allowing developers to compensate for environmental impact by investing in conservation or restoration projects.
- **Conservation Impact Bonds (CIBs):** CIBs tie returns to the achievement of predetermined conservation goals, ensuring accountability and measurable outcomes.
- **Debt-for-Nature Swaps:** Exploring innovative debt-for-nature swaps involves structured agreements for debt relief in exchange for commitments to invest in biodiversity and ecosystem conservation projects.

Implementation Collaboration:

Collaborative efforts among Governments, private sectors, NGOs and international organizations are essential for the successful implementation of these innovative funding mechanisms. Tailoring approaches to the specific needs of African countries ensures both innovation and sustainability, contributing to effective biodiversity and ecosystem adaptation.

5.5. African Economies and Livelihoods

1. Current Adaptation Efforts

Exposure to climate hazards can perpetuate a cycle of poverty, with poor individuals in Africa often facing heightened vulnerability to climate-related challenges compared to their non-poor counterparts. Prioritizing interventions, including social protection, for poor households becomes crucial in enhancing their resilience to climate shocks.

Social protection programmes, deeply rooted in eastern and southern Africa, play a pivotal role in shielding impoverished and vulnerable populations from poverty and food insecurity (Trisos and others, 2022). These programmes encompass diverse instruments such as public works initiatives, cash transfers, in-kind assistance, social insurance and microinsurance schemes. They provide essential support during crises, effectively reducing social inequality.

Countries such as Ethiopia, Kenya and Uganda showcase the effectiveness of national social protection programmes in building resilience against climate-related shocks. Even when not explicitly designed for climate risks, these programmes prove beneficial. Recognizing the need for enhanced resilience, there is a growing call to integrate climate risk management seamlessly into the design of social protection programmes. This integration holds the potential to contribute significantly to the long-term resilience of communities grappling with climate change challenges.

Public works programmes, for instance, present an opportunity to boost climate resilience by focusing on initiatives related to soil, water, ecosystem conservation and carbon sequestration. South Africa's Working for Water programme is a notable example, diligently restoring river catchments to mitigate wildfire risks and augment water supplies. By innovatively intertwining social protection with climate risk management, we can pave the way for more sustainable and resilient societies in the face of a changing climate.

Unconditional cash transfers have proven valuable in Kenya, Uganda and Zambia, empowering vulnerable groups to withstand the adverse effects of climate-related shocks and proactively prepare for such challenges. These transfers play a pivotal role in strengthening community resilience.

The FAO's proposed comprehensive approach, known as Cash+, combines cash transfers with the provision of productive assets, essential inputs or technical training. This strategy aims to address the specific needs of vulnerable households during emergencies while enhancing their potential for sustainable livelihoods, income generation and food security.

In northern Africa, novel economic models targeting impoverished households, youth and women have been introduced. These models facilitate access to credit and offer support in implementing policies that strike a balance between cash and food crops, social safety nets and broader social protection measures.

While climate insurance innovations, especially in weather and drought index-based schemes, have made progress, substantial constraints persist, hindering their widespread adoption in African communities. Affordability, limited awareness and distribution challenges contribute to their underutilization. Issues including basis risk, a lack of transparency and negative perceptions surrounding insurance impede their uptake. Data gaps further affect insurers' ability to accurately price risks.

Local adaptation strategies also play a pivotal role in addressing the challenges posed by climate change on the livelihoods of rural and impoverished communities. In semi-arid western Africa, Ethiopia, northern Kenya and Senegal, communities implement various local adaptation options, including water conservation, growing drought-resistant crops, optimizing crop-livestock integration and considering migration. External support from government organizations and NGOs, including technology adoption and insurance, complements these efforts. For instance, in Zimbabwe, the Muzarabani community has revived and developed new livelihood strategies, including local informal safety nets, traditional farming practices and floodproofing structures, to manage risks effectively.

2. Identified Adaptation gaps

African nations encounter numerous obstacles in effectively addressing the economic impacts and livelihood disruptions caused by climate change through adaptation measures, with challenges stemming from both financial and institutional realms.

A key hurdle lies in the inadequate mobilization of adaptation finance for the region. While climate funds such as the Adaptation Fund and the GCF have introduced direct-access modalities to enhance local ownership of adaptation actions, many African countries struggle to gain accreditation for this direct access. Complex and protracted accreditation processes coupled with stringent institutional and fiduciary standards impede their ability to secure access. Notably, as of December 2019, over 80 percent of developing countries lacked national direct access entities. Additionally, the insufficient capacity to formulate fundable adaptation projects in Africa is apparent, reflected in the low approval rates for proposals submitted to the GCF from the region.

Even upon achieving accreditation, institutional and financial hurdles persist during the programming and implementation of adaptation activities. Low disbursement ratios underscore a lack of capacity to execute approved projects, underscoring the imperative for enhanced institutional development. Furthermore, multilateral climate funds

frequently fall short of providing full-cost adaptation funding, establishing systemic barriers. The disproportionate allocation of funds towards readiness activities, at the expense of concrete project implementation and pipeline development, obstructs transformative and sustained adaptation efforts in Africa.
The formulation of NAPs to address medium- and long-term adaptation needs encounters challenges in accessing funding through the GCF. Despite the commitment to fund NAPs, only a few African countries had completed theirs as of October 2020. Transforming adaptation planning documents into projects that are both fundable and implementable constitutes a substantial barrier to fortifying adaptation endeavours in the region. Effectively addressing these barriers is paramount to enhancing the outlook for climate-related investments and supporting institutional strengthening and targeted project preparation, thereby reinforcing Africa's resilience to climate change.

3. Opportunities for scaling up

The economic foundations of many African nations rely heavily on key sectors such as agriculture, tourism, and coastal and water resources, all of which are highly susceptible to climate variations. Integrating adaptation practices into these sectors and identifying viable investment projects contribute significantly to fortifying the resilience of African States. In response to the escalating climate risks faced by countries, climate insurance innovations have become a critical component.

Evidence suggests that diversifying livelihood activities is a prevalent strategy among rural smallholder households in the agricultural sector, helping them navigate economic instability and challenges posed by climate change. While these activities may be seasonal and unpredictable, they offer crucial income alongside traditional farming. Smallholders often maintain small farms as cost-effective safety nets in addition to other income sources, making substantial contributions to local livelihoods and food security.

Climate-related losses are prompting shifts in livelihood strategies across various social groups, although these shifts are not uniform, with some groups adapting more easily than others. These changes have far-reaching implications for livelihood security at transboundary scales. By enhancing the effectiveness of adaptation measures, incentives for vulnerable individuals to engage in high-risk activities are diminished. Recognizing the pivotal role of political authorities in maintaining effective social protection programmes across different scales in African countries is crucial for enhancing risk reduction and local assurance initiatives. Social protection not only reduces reliance on illicit sources of income, but also facilitates adaptation efforts.

Investing in adaptation measures is a pivotal strategy aimed at mitigating the need for significant loss and damage payments associated with the impacts of climate change. Adaptation involves proactive actions and strategies designed to help communities,

nations and regions better withstand, cope with and recover from the adverse effects of a changing climate. Implementing robust adaptation measures enables countries to alleviate the severity of these impacts, thereby limiting the associated financial and social costs. Consequently, access to adequate financial resources emerges as a critical factor for effective CCA in African countries.

Climate Information Services (CIS): Risks, Impacts and Vulnerabilities in Africa


SPACEX

6.1. Climate information Services infrastructure in Africa

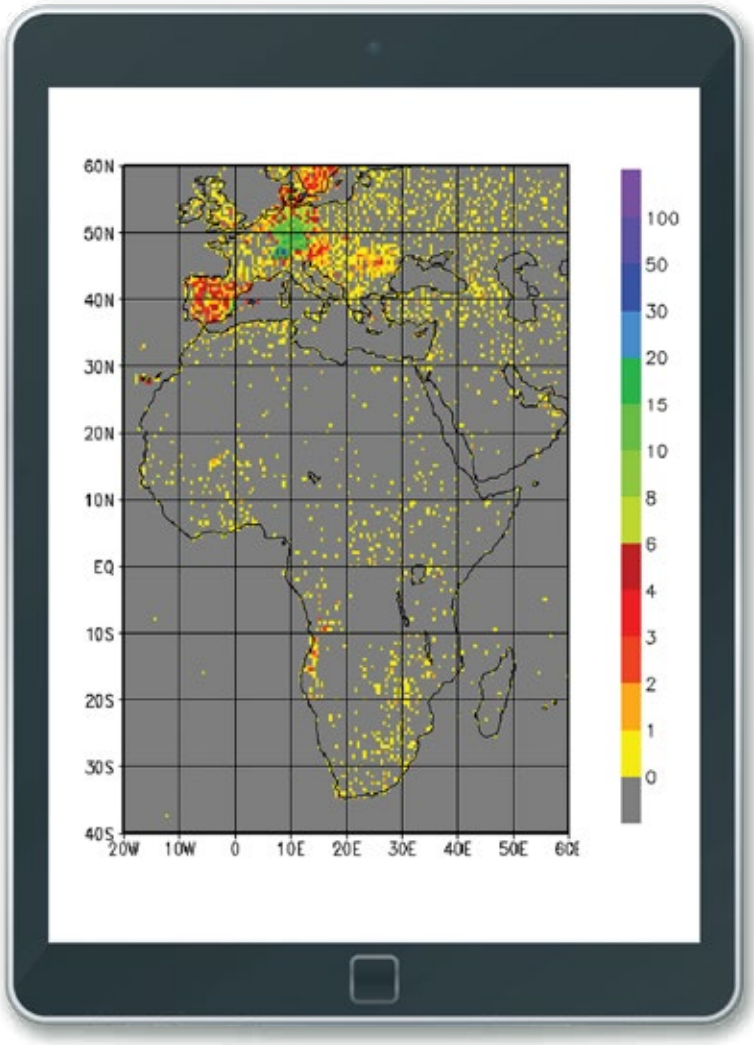


Figure 11: *Number of observation stations per 0.5° grid box for August 2020 using the Global Precipitation Climatology Project (GPCC) full data gridded monthly rainfall product.*

Source: Map generated using GPCC Visualizer, https://kunden.dwd.de/GPCC/Visualizer

Dinku (2019) highlights the pervasive issue of climate data-collection sparsity in Africa, particularly in regions facing conflicts, remote geographies and low investment in observation infrastructures. While national observation networks serve as the primary sources of climate information in many African countries, they suffer from extensive infrastructure deficiencies. These observation networks are characterized by sporadic coverage and, as Dinku notes, observation stations are declining in both number and quality. Furthermore, the existing stations are often unevenly distributed, with a concentration around urban areas, leaving rural areas – considered more vulnerable – with limited coverage, as depicted in Figure 11.

The WMO State of the Climate in Africa 2022 report emphasized that more than 60 percent of its members in the African region provide basic climate services, such as climate monitoring, data analysis, and predictions. However, it is noteworthy that less than 30 percent of the members have stated they offer climate projections, and less than 40 percent have indicated providing customized solutions, as illustrated in Figure 12. This disparity poses a significant challenge to future risk reduction efforts.

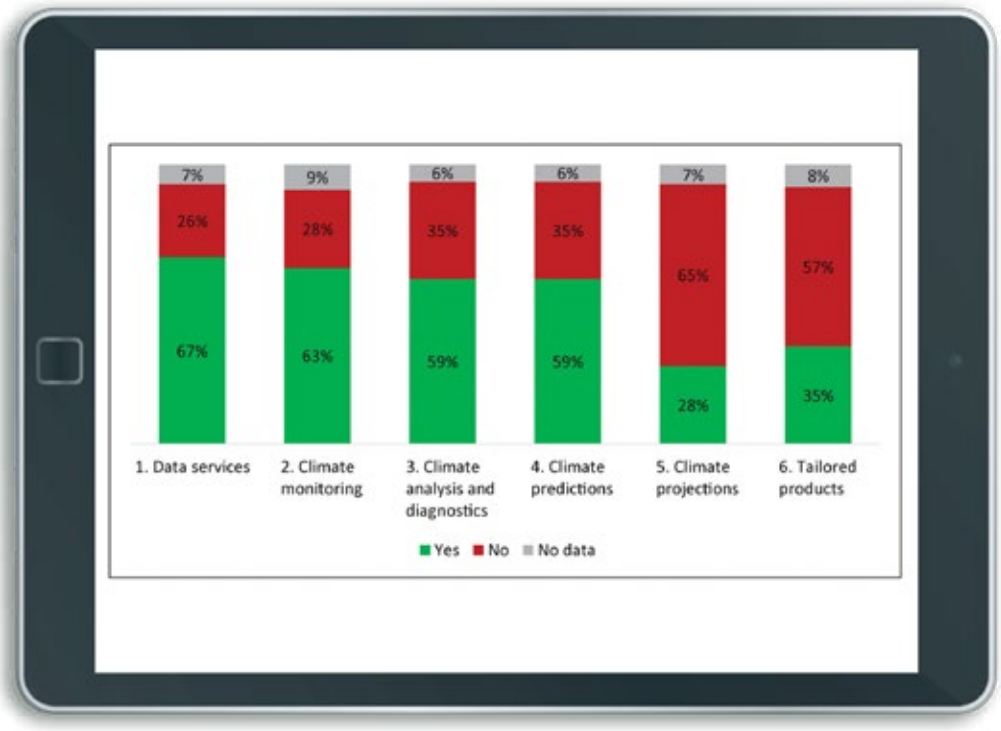


Figure 12: *Percentage of meteorological services providing climate services for the disaster risk reduction sector.*

Source: WMO (2022a).

6.2. Climate information system application

1. Climate Information Services in Africa

Climate change risks in Africa are on the rise, with observed and projected warming surpassing the global average (Masson-Delmotte and others, 2021). Anticipated increases in the intensity and frequency of climate-related disasters pose significant challenges to achieving the goals outlined in the UNFCCC and the Paris Agreement, and the SDGs, particularly for African countries (GCF, 2022). The impacts of these changes vary across the continent's regions, resulting in substantial losses and damages that affect water resources, food and energy security, key developmental sectors, health and biodiversity, and jeopardize lives and livelihoods (Pörtner and others, 2022). This situation exacerbates underlying vulnerabilities in Africa.

Given the disparities in climate change risks and impacts across the continent, there is a pressing need for comprehensive climate risk management. Such management requires holistic CIS (Omukuti and others, 2023) – which are becoming more prominent on the global agenda for climate adaptation and mitigation – to inform decision-making on climate risks, foster climate-smart decisions and support adaptation and resilience-building. This approach should strike a balance between short- and long-term CIS, providing decision support at the local, national and regional levels.

The WMO defines "climate information services" or "climate services" as decision support tools derived from climate information that enhance ex-ante decision-making. The IPCC's definition, although slightly distinct, is related and refers to the generation, tailoring and provision of climate information for decision-making at all levels of society. Meanwhile, the United Nations Economic Commission for Africa (UNECA) frames CIS as the packaging and dissemination of climate information to specific users, playing a vital role in supporting Africa's response to climate change.

CIS encompass the acquisition, generation, processing and supply of climate information and data to diverse users. This crucial resource for adaptation in Africa can play a vital role in reducing the impact of climate change. Climate information should be appropriate, timely and easy to comprehend, aid decision-making and inform early action and readiness. Despite being recognized as a climate change response enabler on the continent, the use of CIS in Africa has been relatively weak and needs to be integrated into adaptation, climate resilience, disaster risk management, EWS and various other climate response systems.

Omukuti and others (2023) categorize the types of climate information used in Africa based on timescales of collection and use. Short timescales (including hourly, daily, weekly, monthly, or three-monthly), are referred to as sub-seasonal-to-seasonal, while longer timescales (yearly, five years, 10 years, or longer) are termed medium-to-long-term. Information generated from these services informs decision-making at various levels in response to climate change. Short-term responses, requiring minimal processing of forecast information, easy interpretation of data, and the capacity to respond, are widely used to inform diverse adaptive responses in Africa (Okukuti and others, 2023).

Table 8: *CIS and early warning needs across sensitive sectors in Africa*

Sectoral Guide	**Cross-Sectoral enabler**
CIS and EWS	· Strengthening of hydrological and meteorological (hydromet) monitoring, development of CIS/climate advisories and impact-based MHEWS, and application of climate information and early warning systems (CIEWS) for investment and financial decisions to manage climate risks
Agriculture and food security	· Climate advisories for agricultural production and projections for longer term planning.
Cities, buildings, and urban systems	· Urban disaster risk reduction and management informed by CIEWS (integrated urban CIEWS services) · Climate information for climate-resilient infrastructure design
Ecosystems and ecosystem services	· Use of CIEWS for forestry, land use/land cover change, fisheries, marine, and related natural systems.
Water Security	· Use of CIEWS for integrated water resources management and investment planning. · Climate information for the design of water systems infrastructure.
Health	· Avoidance of direct impact of climate-related disasters via preparedness and EWS · Reduced adverse health impacts from malnutrition, exposure to pollutants, heatwaves, lack of access to water, and gaps in environmental and public health
Economies and livelihood	· Reduced losses to critical infrastructure, economic damages and livelihoods risks through CIEWS

Source: Adapted from GCF (2022).

Box 6: *Use of Early Warning Systems in Africa*

Climate information is a crucial trigger for EWS, which are considered cost-effective measures for adapting to climate change and reducing the risk of climate-related disasters, ultimately safeguarding lives, livelihoods and ecosystems. Although traditional local and community-based EWS are widely utilized in Africa (Apraku, Morton and Gyampoh, 2021), growing recognition of the significance of CIS in providing comprehensive decision support is prompting increased resource allocation and investment in CIS. This is often complemented by local climate knowledge to bridge gaps (Omukuti and others, 2023).

This trend is also fostering the development of impact-based MHEWS, which offer comprehensive short- to medium-term climate information. MHEWS support well-informed, science-based decision-making for adaptive responses, ensuring prompt and suitable capabilities (GCF, 2022). The United Nations Office for Disaster Risk Reduction (UNDRR) defines MHEWS as an integrated system that addresses various hazards of similar or different types, considering contexts where hazardous events may occur alone, simultaneously, cascading, or cumulatively over time, while accounting for potential interrelated effects. Several African countries have expanded their early warning system assets and coverage. For example, in 2022, the African Centre of Meteorological Applications for Development inaugurated a new Continental Multi-Hazard Advisory Centre that connects to situation rooms in Nairobi and Addis Ababa.

According to the 2022 analysis by UNDRR and the WMO, countries with comprehensive EWS experience only one eighth of climate disaster mortality compared with countries with limited or no coverage (UNDRR and WMO, 2022). The report further reveals that, by mid-2022, only about 40 percent of African countries (21 countries) had reported having MHEWS, and most lacked effective communication and dissemination systems for MHEWS.

Figure 13: *Status of MHEWS coverage in Africa*

2. Effectiveness of Climate Information Services and Early Warning Systems in Informing Adaptation Actions in Africa

The utilization and integration of CIS and EWS to inform decisions and actions related to CCA in Africa have faced several challenges, as highlighted by Amha and others (2022). Despite these challenges, various CIS and EWS are making strides in different regions of Africa, showcasing promising results.

One such initiative is Developing Risk Awareness through Joint Action (DARAJA), a regional early warning initiative. DARAJA focuses on enhancing the uptake and utilization of weather and climate information for informal settlements in Nairobi, Kenya, and Dar es Salaam, the United Republic of Tanzania. The pilot programmes in these cities have yielded significant impact results, with a notable 20:1 benefit-cost ratio in enhanced productivity and the prevention of climate-related damage and loss.

Supporting observation networks and monitoring in least developed countries (LDCs) and Small Island Developing States (SIDS) in Africa and the Pacific, the Global Basic Observing Network and the Global Ocean Observing Systems (GOOS) are backed by the Systematic Observations Financing Facility (SOFF) (GCF, 2022). Proposed expansion to Guinea-Bissau, Sao Tome and Principe, the Sudan, Uganda and Zambia, among other countries, indicates progress in addressing observation gaps.

EWS are not new to Africa, with Indigenous and local knowledge being historically used. Rainmakers, believed to predict or induce rainfall, and rural farmers relying on Indigenous and local knowledge-based systems demonstrate the rich heritage of weather forecasting in Africa. Recognition of the significance of CIS is growing across Africa, driven by initiatives such as the WMO Global Framework for Climate Services (GFCS). The Mozambique National Institute of Meteorology (INAM) employs satellite imagery, radar, and observation networks to provide early warning data, which is disseminates through community radios and trained community brigades. In Burkina Faso, the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) helps reduce health risks posed by airborne dust.

Studies link farmers' use of CIS to improved household food security, citing increased spending on food (Namibia), enhanced dietary diversity (Rwanda and Uganda) and improved crop productivity (Rwanda, Kenya and western Africa). In Senegal, smallholder farming sees a 10–15 percent increase in crop value with the support of weather and climate information. Similar benefits are observed in the United Republic of Tanzania, where CIS significantly contribute to sustainable agriculture. In Ghana's northern region, timely access to climate information, combined with effective extension services, enhances farmers' decision-making on crop and land management. In the Central-North region of Namibia, rain-fed subsistence farming leverages climate forecasting services to manage climate-related risks effectively.

6.3 Climate Information Services and Early Warning Systems: Risks, Impacts and Vulnerabilities in Africa

Despite being highly beneficial, climate information systems and related services, including EWS, encounter significant risks in Africa, due to the impacts of climate change. These risks not only jeopardize the progress made in mitigating climate-related risks and disasters in Africa but also have the potential to exacerbate underlying vulnerabilities and threats on the continent. Moreover, they present a formidable challenge to the ability of these systems to furnish timely and valuable decision support information.

Weather and climate patterns are becoming more variable and intense, leading to uncertainty in predictions. This in turn impedes the capacity of CIS to provide accurate climate information that can trigger anticipatory actions. Especially in sub-Saharan Africa, constant shifts in the timing and quantity of rainfall pose challenges in delivering precise climate information. Global warming and rising air temperatures intensify hydrological processes, heightening the risk of, and exposure to, extreme events (Chen and others, 2023). Elevated temperatures and increased emissions introduce uncertainties and inaccuracies in climate forecast data related to rainfall, heat stress warnings and energy demand predictions (Bouramdane, 2022).

In addition to the challenges posed by climate change impacts, technical obstacles further hinder efforts to scale up the utilization of modelling, climate information systems and EWS in Africa. Despite notable progress in climate modelling, the persistent lack, or low-quality, of climate data in various African regions significantly impedes the ability to estimate long-term trends and validate climate models, both of which are essential for accurate projections. This limitation becomes particularly pronounced in regional-scale assessments where the inherent erratic behaviour of local climate specifics complicates analysis (Bouramdane, 2022).

Analysing and monitoring risks to CIS and EWS is complex, requiring an understanding of the trends and an assessment of the impacts of climate drivers associated with rising sea levels and coastal erosion in Africa. These phenomena not only pose substantial threats to meteorological infrastructures, but also compromise the integrity of CIS and early warning processes. Additionally, capacity gaps in meteorological and climate science, coupled with limitations in infrastructure and funding, may impede the timely delivery of critical climate information (Antwi-Agyei, Dougill and Abaidoo, 2021). The cumulative impact of these technical challenges exacerbates the vulnerabilities of African communities to climate change, putting their socio-ecological systems at risk and impeding their capacity to make proactive climate adaptation decisions and take necessary actions (Nkiaka and others, 2019).

6.4. Current adaptation actions and investments

Despite the challenges, CIS continue to demonstrate their effectiveness in contributing to CCA and responses in Africa (Ayim and others, 2022), with many successful adaptation endeavours in Africa attributed to the receipt of relevant, adequate and timely climate change, early warning or forecast information (Okello, Kirui and Gitonga, 2020). CIS play a pivotal role in developing appropriate national disaster preparedness plans, informing citizen responses and helping countries seek relevant support.

Various tools, resources and data sources are currently being explored by individuals, communities, scientists and Governments in Africa to aid their climate change response decisions. Despite existing challenges in obtaining climate information and the anticipated limitations, utilizing CIS tailored to the needs of vulnerable sectors has the potential to support future planning and contribute to adaptation actions (Carr and others, 2018; Ziervogel and others, 2010).

CIS are thus regarded as a practical means to drive climate adaptation and continue to build and strengthen resilience development goals across all sectors in Africa. Weather and Climate Information Services for Africa (WISER) is one of several initiatives on the continent aimed at encouraging African Governments and vulnerable groups to make use of these services (Cullman and others, 2019).

Basic systems and capacities to provide CIS are on the rise in Africa, encompassing observation networks, data collection and data management. Many of these basic systems are considered less sophisticated than average global CIS systems (Cullman and others, 2019). Furthermore, while functional capacities to support basic systems are sufficient, there are gaps in capacities for advanced CIS monitoring and evaluating socio-economic outcomes and benefits for Africa.

The high-end application of CIS on the continent is advancing, enabling countries to use real-time data to inform their adaptation actions. However, Africa is the region with the highest percentage of non-functional monitoring stations (Dinku, 2019). Support from international organizations continues to facilitate the uptake of CIS in Africa through investments and capacity-building in the use of improved CIS monitoring systems, data collection, analysis and technology transfers.

Growing awareness and manifestations of the contributions of CIS to adaptation actions are evident in several regions in Africa (Nkiaka and others, 2019). The potential benefits of these services are currently

underexplored and constrained due to various factors, such as the pathway of dissemination and infrastructure (Hewitt and Stone, 2020).

National meteorological services and national hydrological services provided by NMHS are somewhat established across Africa (WMO, 2022a). Although constrained by human capital, financial and technological limitations, they can provide basic meteorological and hydrological data collection, analysis and dissemination (Omukuti and others, 2023).

In addition to national monitoring services, the regional climate centres (RCCs) in Africa have also been contributing to the to the implementation of actions based on the observed meteorological and hydrological conditions,including implementation of specific climate adaptation measures, issuance of warnings or advisories in response to certain weather patterns, and any other actions taken at the national or regional level to address the impact of weather and hydrological events. These centres were instituted to bridge the gap between coarse global climate data and local climate situations. RCCs have therefore been instrumental in consolidating climate infrastructures, networks and capacities housed in NMHS for regional benefit. RCCs can generate products, expertise, infrastructure, resources and skills development that support national NMHS (UNECA, 2018). Some functional African RCCs include the Inter-Governmental Authority on Development Climate Prediction and Applications Centre (ICPAC), the Climate Application and Prediction Centre for Central Africa (CAPC-CA), the African Centre of Meteorological Applications for Development (ACMAD), the Agriculture, Hydrology, and Meteorology (AGRHYMET) Regional Centre and the Southern Africa Development Community – Climate Services Centre (SADCCSC).

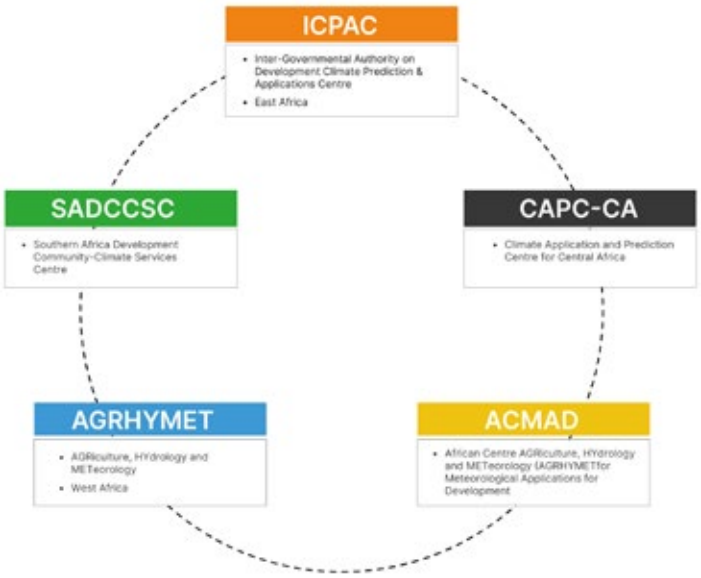


Figure 14: *Regional Climate Centres in Africa, driving Africa's access to climate and weather information services*

Regional processes and practices involve establishing regional centre data repositories, where WMO Member States share and exchange climate resources generated by NMHS and process data to generate tools and products. National systems facilitate and maintain linkages with the private sector and educational and research institutions for data and product exchange (African Climate Policy Centre [ACPC], 2021).

African countries can regularly share their raw data with the RCCs for processing and to back up national hydroclimate data in case of national storage system failures (ACPC, 2021). RCCs also coordinate the regional climate outlook forums, comprising stakeholders such as policymakers, climate scientists and community members who produce climate information to support vulnerable, climate-sensitive sectors.

At the continental scale, WMO operates a data management facility referred to as the WMO Information System (WIS), which collects and disseminates weather and climate data through the WMO Global Telecommunication System (ACPC, 2021). This system collates climate data from all African NMHS within a continental data hub in Casablanca, Morocco, for global redistribution and exchange.

Other major players in the CIS spectrum in Africa are depicted in Figure 15. The Climate for Development in Africa (ClimDev-Africa) programme was initiated by the African Union Commission, UNECA and the AfDB to increase funding and investment in CIS (African Union, 2022). Global Monitoring for Environment and Security and Africa (GMES and Africa) is another initiative established with the intent of meeting the growing Earth observation needs of African countries by expanding CIS infrastructures and capacities in Africa (African Union, 2022). ACMAD supports efforts to strengthen the capacity of countries in Africa to forecast severe weather. According to UNECA, all NMHS act as national centres; only eight countries (Algeria, the Democratic Republic of the Congo, Egypt, Kenya, Morocco, the Niger, Senegal and South Africa) host data-collection or production centres.

The WMO, in conjunction with the African Union and other relevant stakeholders, has also developed the Integrated African Strategy on Meteorology, which seeks to position weather and climate services as an essential component in national and regional development frameworks and sustainable development in Africa (African Union, 2022). This strategy is expected to increase cooperation among African States and build capacities.

The African Ministerial Conference on Meteorology (AMCOMET), initiated in 2010, aims to promote cooperation, security, socio-economic development and poverty eradication on a pan-African level through sound governance of the science of meteorology and its related applications. Climate Research for Development in Africa (CR4D) aims to create an enabling environment for effective decision maker–scientist collaborations to co-explore, co-design, co-produce and co-communicate climate information and services to inform decisions and actions that will positively influence people whose livelihoods are threatened by hydroclimatic risks and hazards.

Figure 15: *Major players in the CIS arena in Africa*

SOFF is currently providing grant funding for the collection of weather and climate data to support climate adaptation decisions in different regions of the continent. By September 2023, 24 African countries (Figure 16) had applied for SOFF funds to enhance their capability to provide CIS in support of resilience-building.

Figure 16: *SOFF operations coverage in 2023.*

The recently launched Early Warnings for All (EW4All) Action Plan is fully aligned with Africa's Agenda 2063 and other global imperatives. It is designed to strengthen EWS across Africa through observation monitoring, capacity-building, communication and community engagement, to enhance disaster preparedness, increase public awareness and promote regional cooperation. EWS provide more than a tenfold return on investment; by giving 24 hours' notice of an impending hazardous event, they can cut the ensuing damage by 30 percent (WMO, 2023). In Africa, 13 countries that are particularly at risk (Chad, Comoros, Djibouti, Ethiopia, Liberia, Madagascar, Mauritius, Mozambique, the Niger, Somalia, South Sudan, the Sudan and Uganda) will be added to the initial sets of countries to be supported (International Telecommunication Union, no date).

The Sendai Framework for Disaster Risk Reduction 2015–2030 is a global initiative providing continent-wide support, with the aim of substantially reducing climate disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. The review by van Niekerk, Coetzee and Nemakonde (2020) of the progress made through the Sendai Framework reveals that African States are making slow progress, and decisive action is required to reach its 2030 targets in Africa.

For more information, see https://un-soff.org/operations/.

6.5. Addressing Climate Information Services-related gaps and barriers

As Africa contends with the ongoing impacts of climate change, the role of CIS in facilitating the continent's adaptation efforts has gained prominence (Singh and others, 2018). The timely availability of comprehensive meteorological and climate information is deemed crucial for making the necessary adjustments to mitigate impacts. However, numerous barriers hinder the widespread adoption of CIS across the continent, thereby impeding effective adaptation to climate change.

The following factors can impede the adoption of CIS:

Data, infrastructure and network considerations:

- **Capacity limitations and data issues:** Capacity limitations and issues related to the availability, usability or suitability of data contribute significantly to the underutilization of CIS (Griggs and others, 2021).
- **Infrastructure challenges:** Deficiencies in climate information infrastructure, infrastructure collapse, lack of maintenance and technical challenges inhibit Africa's effective adaptation responses (Cullman and others, 2019).
- **Sparse infrastructure:** The sparse infrastructure for CIS limits the ability of national systems to generate and disseminate climate information for informed adaptation responses (Dinku and others, 2018; Talebzadehhosseini and Garibay, 2022).
- **Observation network limitations: Ozor,** Acheampong and Nyambane (2021) highlight the sparse and uneven distribution of climate observation networks across Africa, revealing weaknesses in forecasting capabilities in various African countries.

Functional climate data and adaptation:

- **Scarcity of functional climate data:** The scarcity of functional climate data and information necessary for adaptation decisions and actions puts vulnerable communities at risk (Talebzadehhosseini and Garibay, 2022).
- **Communication challenges:** Challenges in successfully disseminating climate information through effective communication channels are recognized as significant barriers to scaling up CIS in Africa (Carr and others, 2018; Singh and others, 2018).
- **Lack of resources:** Insufficient communication and information dissemination resources and capacity are major impediments to the provision of climate services.

Financial barriers:

- **Insufficient allocation of resources:** The lack of financial allocation and support for the sustainability of CIS infrastructure is a key barrier to the uptake of these services in Africa (Cullman and others, 2019).
- **Global disparities in financial commitments:** Noticeable increases in investments in CIS in Africa are insufficient to match the average global trend in financial commitments to meet the continent's adaptation needs.

Indigenous and local knowledge:

- **Underutilization of Indigenous and local knowledge:** Indigenous and local knowledge is underutilized in national adaptation policies in Africa, despite its widespread use by communities to anticipate and respond to climate change (Leal Filho and others, 2022b).

MHEWS:

- **Lagging establishment:** Africa lags behind in establishing MHEWS, leaving six out of 10 people without coverage (GCF, 2022).
- **Challenges in monitoring and evaluation:** The continent faces challenges in monitoring and evaluating the outcomes and benefits of these systems.

Specialized capacity challenges:

- **Inadequate expertise:** Inadequate specialized capacity hinders Africa's ability to interpret climate information into actionable decision tools, provide demand-driven climate information and train communities on suitable adaptation actions.

For more information, see https://unece.org/sendai-framework.

6.6. Opportunities for scaling up

In the face of escalating climate extremes, the role of CIS and EWS is pivotal, with them acting as crucial safeguards against the devastating consequences of climate-related events. African Governments and beneficiaries of CIS are increasingly acknowledging the invaluable contribution of timely climate information in shaping decisions for climate adaptation and resilience development.

Despite this growing recognition, sub-Saharan Africa has the lowest investment in weather and CIS (Georgeson, Maslin and Poessinouw, 2017; African Union, 2022). There is a clear need for Africa to harness existing opportunities, given the substantial benefits that could accrue from enhancing its adaptation and mitigation efforts.

CIS are predominantly delivered by national meteorological and hydrological institutions in Africa and are primarily funded by national Governments (ACPC, 2021). However, sustaining and efficiently managing these institutions pose challenges for many African Governments. Regional CIS, anchoring the national monitoring systems, face inefficiencies in resource allocation, hindering their ability to capture, analyse and disseminate timely climate information to end-users (African Union, 2022).

Investment in weather and CIS in Africa lags behind global standards. Nevertheless, the high benefit-to-cost ratio of EWS, indicated by a remarkable 16:1 ratio in an analysis around Malawi and Lake Victoria, presents a compelling case for increased funding as a bridge towards accelerated implementation of CCA (WMO, 2021).

Recent investments, such as the AfDB's €36 million to modernize observation networks through the RCCs and the substantial ClimDev-Africa portfolio ranging from $800 million to $1 billion over 2022–2027 (African Union, UNECA and AfDB, 2023), indicate positive strides. Other supporting systems such as the Climate Risk and Early Warning Systems (CREWS) initiative and SOFF require increases in investment, coordination and international cooperation to improve Africa's climate preparedness, reduce vulnerabilities and foster resilience.

While financial resources for hydrometeorological infrastructure from national Governments, international support organizations and the private sector remain limited, opportunities for recovering the cost of CIS infrastructure are emerging. Many national CIS offer their services without charge, but as interest in them grows, imposing tariffs on these services could offset some data-collection costs (ACPC, 2021).

Addressing gaps in specialized human and technical capacity in infrastructure maintenance and climate data processes, exchange, transfer, storage, coding and timely uploading into the Global Telecommunication System becomes imperative. This upgrade is crucial for reducing data gaps and facilitating effective information-sharing (ACPC, 2021).

With 30 of the global 46 recognized LDCs situated in Africa, efforts to improve LDCs' and SIDS' uptake and access to MHEWS will significantly enhance their adaptation decisions, preparedness and actions.

Affording climate information greater priority in political and socio-economic development discussions is crucial for appropriate responses in Africa. Exploring and scaling up ICT service providers and mobile networks for wider and timely dissemination of CIEWS to decision makers and vulnerable sectors will enhance access to CIS, foster adaptive responses and reduce climate risks in various parts of the continent (Mapiye and others, 2023; Sansa-Otim and others, 2022).

Through the collaborative efforts of organizations operating in the climate information sphere, significant strides have been made in enhancing the usefulness of climate information. Positive feedback from such collaborations, as exemplified in the agricultural sector by Ofoegbu and New (2021), shows the potential for synergy and shared success.

Acknowledgement of the potential contribution of Indigenous and local knowledge to enhancing climate adaptation in Africa is on the rise (Zvobgo and others, 2022). The rich reservoirs of local climate knowledge, largely untapped and underexplored, may be able to fill the knowledge void created by sparse and coarse climate data, particularly in depicting local impacts (Zvobgo and others, 2022).

6.7. Cross-cutting Areas of Importance of Climate Information Services in Africa

The importance of climate data and information systems to the comprehensive understanding and interpretation of climate impacts cannot be overstated. This understanding is pivotal for developing appropriate interventions, providing decision support and effectively managing climate variability and change (Dinku and others, 2018). The availability of pertinent and accessible climate data is indispensable for fostering resilience against the impacts of climate change within vulnerable sectors in Africa, as illustrated by Figure 17. Consequently, ongoing initiatives aim to enhance CIS on the continent, with the overarching goal of empowering African nations to increase their resilience and attain sustainable development objectives within a dynamically changing climate.

Figure 17: *Cross-cutting areas of importance of CIS in Africa.*

SECTION VII

Finance and Investment for Adaptation in Africa

Recent assessments of climate finance needs and utilization in developing countries have found a significant gap between the challenges posed by climate change and the financial support available. Africa, grappling with substantial challenges, is the continent with the highest needs and the most pronounced gap in climate finance.

The report by Meattle and others (2022), Landscape of Climate Finance in Africa, emphasizes Africa's urgent financial requirements, at an estimated $2.8 trillion for 2020–2030. This demand is intricately tied to fulfilling the continent's NDC targets under the Paris Agreement, with an identified annual commitment of around $277 billion for 2020–2030 to effectively address climate change. Despite commendable efforts, shortfalls persist in meeting investment needs across critical sectors. While investments show an upward trend by 2021, a substantial gap remains, necessitating increased mobilization of climate finance.

The Adaptation Gap Report 2023 underscores the underfinanced and underprepared state of climate adaptation, with the adaptation finance gap now standing at $194–366 billion per year. This gap is 10–18 times greater than current finance flows, underlining the urgency for increased funding and accelerated progress in adaptation initiatives. Africa, despite contributing minimally to global greenhouse gases, bears severe consequences from climate change. However, climate finance inflows fall short, with estimates indicating a need for $2.5 trillion annually between 2020 and 2030. Current annual inflows to the continent amount to only $30 billion, primarily in the form of concessional loans.

Challenges to securing financing include governance and regulatory issues, technical infrastructure risks and financial obstacles. The complicated funding approval process impedes the ability to access climate funds, prompting African countries to scrutinize climate finance flows for equity. In Ghana, bilateral channels dominate climate financing, but barriers include inadequate project development capacity. South Africa relies on private finance for clean energy, exemplified by the $8.5 billion Just Energy Transition Partnership. Zambia directs climate finance to sectors such as energy, agriculture, forestry and water, emphasizing the potential of the private sector, including pension funds. However, challenges in project development and institutional capacity persist in both Zambia and Ghana.

To meet the demand for substantial financial resources to bolster the continent's climate adaptation projects, African Governments and institutions strategically tap into diverse funding sources, including global mechanisms such as the GCF, the GEF and the Adaptation Fund. These international avenues are complemented by domestic budgets, international aid and collaborative ventures with private entities. Commitments from the African Union, bilateral agreements and innovative financing tools such as debt-for-nature swaps exemplify the multifaceted approach employed by African nations.

However, the journey to secure financing for adaptation projects is not without its obstacles. Challenges range from a lack of detailed financial data and limited access to global funds for health sectors, to insufficient capacity for proposal formulation and minimal engagement of health entities in climate change processes. The private sector's involvement in water projects faces prolonged cost recovery and delayed repayment timelines. EbA initiatives encounter hurdles such as limited knowledge, policy misalignment, resource constraints and cultural considerations.

In response to these challenges, Africa is witnessing the emergence of innovative financing mechanisms. Results-based financing, exemplified by initiatives such as Social Success Notes, facilitates interest-free loans for climate projects, repaid through accrued savings. Climate risk insurance, as seen in the InsuResilience Global Partnership, aims to protect vulnerable populations from climate risks. Debt-for-nature swaps, witnessed in Seychelles and Zambia for example, not only alleviate debt burdens but also support environmental conservation.

International organizations and donors play a crucial role in supporting Africa's climate adaptation endeavours. Initiatives such as the Comprehensive Africa Agriculture Development Programme (CAADP), championed by the African Union, advocate for strategic investments in agriculture. Global entities such as the GCA provide crucial insights and support. The African Risk Capacity Group offers integrated solutions, and collaborative efforts on an international scale address trade barriers and facilitate policy harmonization. Key players in this support system include international climate funds and organizations such as the GCF and the GEF.

In summary, Africa navigates its climate adaptation landscape by leveraging a range of funding sources, addressing challenges through innovative mechanisms and fostering collaboration with international entities. This comprehensive approach shows the continent's commitment to strengthening climate resilience across various sectors in the face of ongoing and future climate challenges. The next subsection offers a concise overview of the finance and investment status across key sectors assessed in this report, including agriculture and food security, water resources, health, biodiversity and ecosystems. Additionally, the report provides an overview of the status of climate investment and financial needs to address climate change impacts on the overall economy, as well as the climate information systems and services across the continent.

7.1. Finance and Investment for Agricultural Adaptation and Food Security in Africa

Climate finance for agriculture and food security in Africa is being mobilized, with numerous countries actively utilizing both domestic and international financial resources to strengthen climate adaptation initiatives within the agricultural sector. Substantial investments are being directed towards critical agricultural infrastructure, including irrigation systems, storage facilities and rural roads, aiming to enhance the resilience of the agricultural industry. The development of such infrastructure serves as a crucial enabler for productivity and long-term economic growth across the continent, contributing significantly to recent economic upturns.

In Nigeria, commitments have been made to construct climate-resilient infrastructure supporting agriculture and food storage. Ghana has implemented financial mechanisms to support farmers during climate-induced agricultural shocks, while Tanzania is actively developing climate-resilient infrastructure, including roads and storage facilities, to strengthen agricultural activities.

Given Africa's diverse ecosystems and reliance on predominantly rain-fed agricultural practices, the continent remains highly vulnerable to the adverse impacts of changing weather patterns, prolonged droughts and extreme weather events. Adequate financial support is essential to provide African nations with the necessary resources and resilience to navigate the changing climate and ensure food production security and the well-being of millions of people whose livelihoods depend on agriculture.

Without effective adaptation measures and sufficient financial backing, the potential for long-term food security and economic stability in Africa is at risk. Therefore, the allocation of adaptation finance is not only a matter of urgency but also represents a fundamental investment in the continent's resilience, self-sufficiency and sustainable development within a changing climate landscape.

Studies, such as those by Kray and others (2022b) emphasize that, on average, investing in climate adaptation costs less than a tenth of the expenses associated with doing nothing. For example, Table 9 provides a breakdown of adaptation-related costs compared with the cost of inaction in key priority areas concerning agriculture and food security in Africa.

Table 9: *Comparison of costs associated with adaptation versus inaction in agriculture and food security in Africa.*

Public Sector Investment for agriculture and food security		
Adaptation Option	Adaptation Cost (Billion USD)	Cost of inaction (Billion USD)
Water management	6.1	90.7
Research and Extension	3.9	71.2
Land restoration	3.4	26.8
Infrastructure	2.1	12.6
Climate information Services	0.1	0.5

The GCA (2021) emphasizes that the cost of inaction, encompassing expenses for recurrent disaster relief and recovery post-floods and droughts, is estimated at approximately $210 billion annually, constituting around 12 percent of GDP. Generally, evidence suggests that the benefits of adaptation outweigh the costs, although outcomes vary depending on the type of adaptation and location.

CAADP is a visionary framework led by the African Union, advocating for a strategic approach to investments in agriculture and rural development across the continent. Recognizing agriculture's pivotal role in economic growth, food security and poverty alleviation and the critical role of financial resources in propelling agricultural transformation, CAADP commits African countries to allocating at least 10 percent of their national budgets to agriculture and rural development.

Beyond financial commitment, CAADP promotes a holistic approach to agricultural development, encompassing research and technology, infrastructure, market access and capacity-building. It emphasizes inclusivity, encouraging diverse stakeholders – including smallholder farmers, women, youth and marginalized groups – to actively engage in the formulation and implementation of agricultural investment plans. CAADP also acknowledges the essential role of the private sector in agricultural development by fostering partnerships and investments in agribusiness and value chains.

In the context of climate change, CAADP advocates for climate-resilient agricultural practices and adaptation measures, emphasizing the importance of building resilience. It calls for African countries to take ownership of their agricultural development agendas, formulate national agricultural investment plans and establish robust mechanisms for monitoring progress and ensuring government accountability. Through fostering regional cooperation and integration, CAADP aims to address trade barriers and facilitate policy harmonization.
However, adaptation finance information, particularly disaggregated

by sector, remains challenging to obtain, both regarding adaptation financing needs and adaptation finance flows (Richmond and others, 2021; GCA, 2022; Guzmán and others, 2022). Figure 18 provides an overview of adaptation funding needs by subregion and sector. The graph illustrates that most reported adaptation finance needs are not disaggregated by sector. A review by the CPI estimates that adaptation finance needs related to the agriculture, forestry and other land use (AFOLU) sector (as reported in African countries' NDCs) amount to $48.6 billion per year, equivalent to 8 percent of total reported adaptation finance needs. The water sector, which is closely linked to adaptation and food security, is reported to require $29 billion per year, constituting 6 percent of total reported adaptation finance needs (Guzmán and others, 2022).

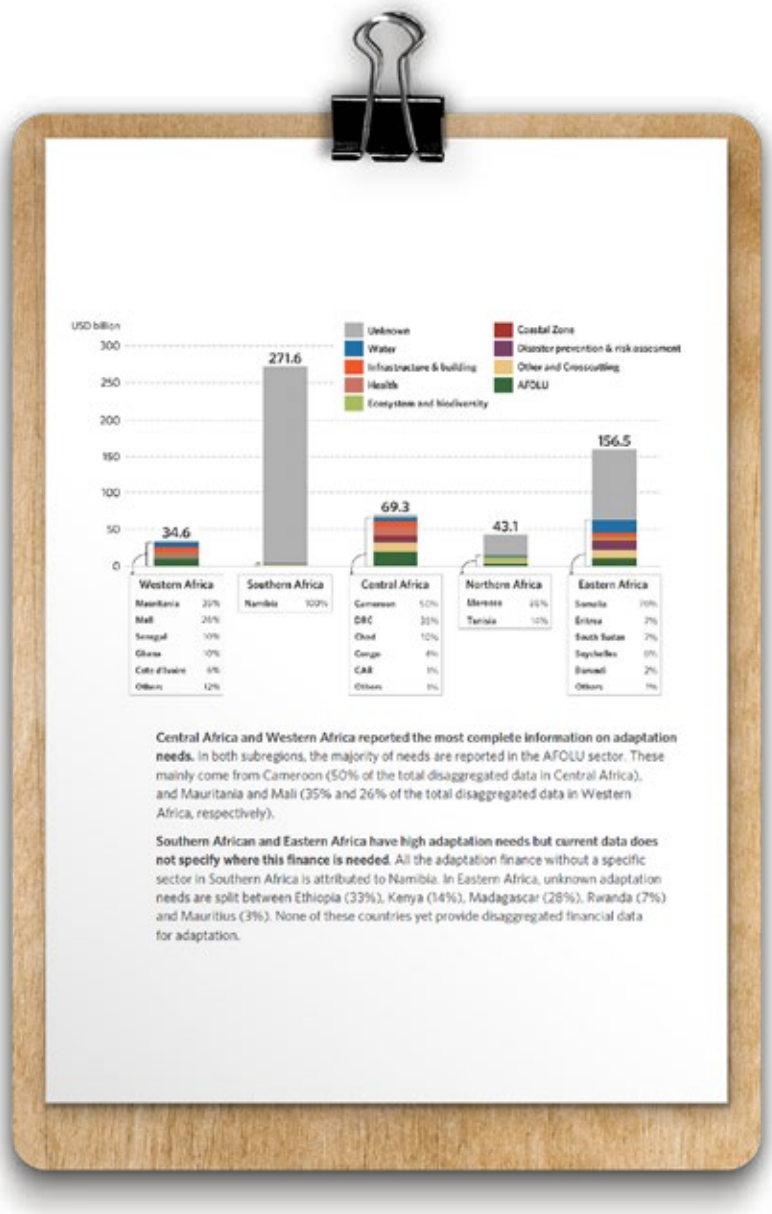


Figure 18: *Climate finance adaptation needs by subregion and sector, USD billion.*

Source: Adapted from Guzmán and others (2022)

Central Africa and Western Africa reported the most complete information on adaptation needs. In both subregions, the majority of needs are reported in the AFOLU sector. These mainly come from Cameroon (50 percent of the total disaggregated data in Central Africa), and Mauritania and Mali (35 percent and 26 percent of the total disaggregated data in Western Africa, respectively).
Southern African and Eastern Africa have high adaptation needs, but current data do not specify where this finance is needed. All the adaptation finance without a specific sector in Southern Africa is attributed to Namibia. In Eastern Africa, unknown adaptation needs are split between Ethiopia (33 percent), Kenya (14 percent), Madagascar (28 percent), Rwanda (7 percent) and Mauritius (3 percent). None of these countries yet provide disaggregated financial data for adaptation.

According to the GCA (2022), there is a critical and pressing deficit in climate adaptation funding for Africa. A substantial portion (41 percent) of the committed adaptation funding, totalling $4.7 billion in 2019 and 2020, was allocated to cross-sectoral activities. The second-largest allocation was directed to the AFOLU sector, representing $2.8 billion or 25 percent of the total (GCA, 2022). The IPCC provides comparable figures, estimating that agricultural adaptation finance constitutes 30 percent of the overall adaptation finance, as depicted in Figure 19.

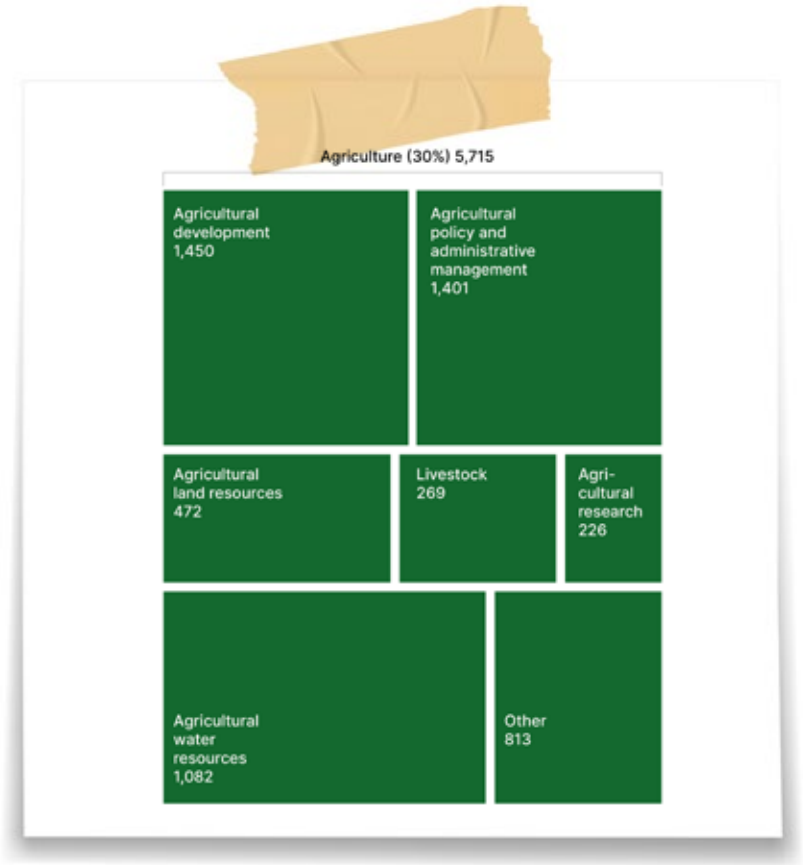


Figure 19: *Sectoral distribution of adaptation finance commitments to Africa, 2014–2018*

Source: Trisos and others (2022).

Strategic investments in agriculture and food security take a number of forms, including national policies, infrastructure development, research, financial mechanisms and community engagement. In Kenya, the Climate Smart Agriculture Project, funded by the World Bank to the tune of approximately $250 million, aims to enhance agricultural resilience among smallholder farmers. Ethiopia's Productive Safety Net Programme, backed by over $1 billion from various donors, provides food and cash transfers to food-insecure households while implementing projects to strengthen community resilience. Nigeria issued a $29 million green bond, a portion of which was allocated to climate-resilient agriculture. Zambia is directing around $65 million towards climate-resilient livelihoods, particularly irrigation and conservation agriculture. Meanwhile, Senegal's Naatal Mbay project, funded at $40 million, promotes climate-resilient agriculture practices in cereal value chains. These diverse investments across Africa signify a dedicated effort to address climate-induced threats to food security and establish sustainable agricultural systems.

Box 7: *Examples of investments in CCA in the agriculture and food security sector*

Burkina Faso: The Climate Resilience Support Project (Projet d'Appui à la Résilience Climatique, PARC in French) promotes climate-resilient agriculture through improved practices and diversified income sources. It is supported by a $25 million grant from the Least Developed Countries Fund managed by the GEF (according to data from the early 2020s).

Ghana: The Ghana Commercial Agriculture Project (GCAP) facilitates smallholder farmers' access to finance for investments in climate-resilient agricultural practices. Following an investment of about $145 million from the World Bank and the United States Agency for International Development in this project, additional partners and phases may influence the final investment amount.

Madagascar: The Integrated Growth Poles (Pôles Intégrés de Croissance, PIC in French) project focuses on regions highly vulnerable to climate change, investing in rice and fish farming using modern techniques that are resilient to unpredictable weather patterns. With an estimated budget of approximately $190 million, the World Bank contributed around $52.5 million (figures from the 2010s).

Mali: The National Rural Infrastructure Programme (Programme National d'Infrastructures Rurales, PNIR in French) strives to enhance rural infrastructure, including irrigation, to ensure food security amid shifting climate patterns. Originally backed by the World Bank with an initial commitment of around $50 million in the early 2000s, subsequent phases and support from additional partners may have increased its overall budget.

Mozambique: The Sustainable Land and Water Management Project focuses on rehabilitating and conserving natural resources to improve resilience against soil erosion and erratic rainfall. With an initial estimated total budget of $47.6 million, contributions from the World Bank, the GEF and the Government of Mozambique play a key role.

Namibia: The Climate-Resilient Agriculture in three of the Vulnerable Extreme northern crop-growing regions (CRAVE) project aims to boost the adaptive capacity of farming systems and increase food security. By the early 2020s, the project has received about $9.3 million in funding from the GCF.

7.2. Financing and Investment for Adapting Water Resources in Africa

In Africa, the challenges of prolonged cost recovery and delayed repayment timelines have hindered private sector investment in water projects (Guzmán and others, 2022). However, innovative financing solutions are now emerging, overcoming these constraints by introducing results-based financing. Some noteworthy examples include:

- **Social success notes by UBS Optimus Foundation and Impact Water:** This initiative blends funds from donor organizations, Governments, and private debt and equity in Uganda to provide interest-free loans to over 600 schools, enabling them to access clean drinking water. The schools, in turn, repay the loans using the savings they make from reducing their fuel use for water purification (Morgan and others, 2021).
- **Climate risk insurance:** This approach is gaining traction in Africa, particularly in mitigating water-related risks. InsuResilience, for instance, aims to promote effective climate risk insurance to enhance the resilience of developing countries and safeguard the lives and livelihoods of poor and vulnerable people. These interventions complement CCA, particularly in the water sector, with a significant impact expected in sub-Saharan Africa (Infrastructure Consortium for Africa, African Ministers' Council on Water, and Global Water Partnership, no date).
- **African Union's African Risk Capacity:** African Risk Capacity is an integrated solution designed to address the impact of natural disasters on vulnerable populations by shifting the burden of weather risk away from Governments. This enables them to build resilience and plan, prepare and respond to extreme weather events. Since its establishment in 2014, African Risk Capacity has provided drought insurance to countries including Kenya, Mauritania, the Niger and Senegal (Infrastructure Consortium for Africa, African Ministers' Council on Water, and Global Water Partnership, no date).
- **African Cities Water Adaptation Fund:** This emerging catalytic financing instrument adopts an integrated approach towards financing innovative urban water-resilience solutions. The goal is to leverage at least $5 billion in funding and financing to implement strategic and innovative projects in 100 African cities by 2032.
- **Development Bank of Southern Africa's Infrastructure Investment Fund:** With a substantial value of $5 billion, this fund contributes to addressing infrastructure challenges, including those related to water projects.

Table 10: *Some of the water adaptation investments in Africa*

Investor	Amount	Types of Projects
NDCs	US$1.7 billion	water and wastewater sector
Green Climate Fund	US$500 billion	Capacity gaps in early warning to African countries, LDCs and SIDS
African Cities Water Adaptation Fund (ACWA Fund)	$5 billion	Implement strategic and innovative projects in 100 African cities by 2032
Egypt's Green Sovereign Bond	US$400 million	14 water and wastewater projects including desalination and sludge treatment facilities
Domestic Public Finance for Adaptation in Kenya	US$128 million	Water and wastewater management
Adaptation Fund	USD 10,620,000	Integrated water resources management and early warning system for climate change resilience in the Lake Chad Basin (Cameroon, Central African Republic, Chad, Niger, Nigeria)
	US$7.92 million	To improve existing flood and drought management strategies Volta Basin, West Africa
	US$9,5 million	Enhancing community adaptation to climate change through climate-resilient flood early warning, catchment management and water, sanitation and hygiene (WASH) technologies in Mpologoma Catchment, Uganda
	US$7.6 million	Enhancing resilience of communities to climate change through catchment-based integrated management of water and related resources in Uganda
	US$5,4 million	Integrated water and soil resources management in Djibouti
	US$5 million	Strengthening Local Communities' Adaptive Capacity and Resilience to Climate Change through Sustainable Groundwater Utilisation in Zimbabwe
	US$11,9 million	Transboundary Water Management South-western African communities in Angola and Namibia.
	US$5 million	Adapting to Climate Change in Lake Victoria Basin (Burundi, Kenya, Rwanda, Tanzania, Uganda)
	US$5 million	Pilot rural desalination plants using renewable power and membrane technology in Namibia
	US$8,3 million	Increased resilience to climate change through the management of water resources and diversification of livelihoods in northern Ghana
	US$7,5 million	Building Resilience in the greater uMngeni Catchment, South Africa
	US$6,5 million	Water management Seychelles
Multilateral Climate Funds	$ 3.2 billion / year	15 percent of all multilateral climate funds are directed to water-related projects in Africa
OECD Common Reporting Standard	US$1.5 billion	Water related projects
BRICS, gulf states, and philanthropy	US$0.5 billion	Water related projects
African Governments budgets	US$6 billion per year	Water expenditure infrastructure unknown staffing and maintenance
One Planet Summit	€20 million over 5 years	Incubating 100 water adaptation project over a five-year period.

7.3. Financing and Investment for Adapting the Health sector in Africa

The most climate-vulnerable countries, both globally and on the continent, face the dual challenge of high disease burdens and insufficient resources to effectively prepare for and mitigate the extensive impacts of climate change. Establishing funding mechanisms is imperative in order to provide these nations with the means of accessing financing for climate project implementation, thereby reducing the adverse effects of climate change on their populations. African countries can leverage various finance mechanisms from public, private and alternative sources to enhance or strengthen their health sector's adaptation to climate change impacts. These mechanisms include the GEF, the GCF, the Special Climate Change Fund, the Least Developed Countries Fund and the Adaptation Fund. Additionally, regional development banks, such as the AfDB, play a pivotal role in extending financial support to African countries for health sector adaptation. Box 8 contains specific examples illustrating how the AfDB mobilizes resources to bolster countries in this regard.

Box 8: *Role of the AfDB in supporting health sector adaptation in the region.*

Fund name: Climate Change Health Risk Assessment (CCHRA) fund

Countries target: Five African countries

Description: Studies will be undertaken in five countries to support the undertaking of climate change health risk assessments, in order to provide evidence to guide the development of national adaptation and mitigation strategies.

Impact: By the end of the project, study countries will have enhanced capacity to undertake and manage climate change-related health risks. In addition, mechanisms will have been established to support climate change-resilient health policy formulation, lessons learned will have been collected and knowledge management components will have been established and shared, as an important element of this project's sustainability and replicability strategies. The achievement of these outcomes will ensure a significant improvement in adaptive capacity for Africa. In the long term, project actions will enhance adaptive capacity by building systems and processes for better integration of climate change risks into the health sector and by improving human health in general.

Size of investment: Mobilizing $434,500 in grant resources

Fund name: The African Integrated Surveillance System on Environment and Health (AISSEH) Project

Countries target: 20 African countries

Description: The project focuses on technical and institutional capacity-building for the monitoring and management of environmental factors most relevant to health, health outcomes most influenced by the environment and policy action deemed to reduce and prevent the risks. This will be achieved through training a critical mass of national staff in various areas of environmental health, equipping/ renovating national centres, laboratories and stations in 20 countries, procuring data collection and management devices (hardware and software), rolling out the use of new technologies, remote sensing and geographical information systems and fostering in-country and intercountry cooperation and technical networking. The project intends to build an integrated system that will facilitate links between diverse sources of information in relevant scientific areas of health and environment.

Impact: The project will ensure that policy analysis data on various health and environment aspects are integrated and will create tools for assessment and reporting in 20 African countries. The project intends to facilitate linkages between diverse sources of information in relevant scientific areas of health and the environment. It will help decision makers to formulate succinct, policy-relevant messages suitable for various user groups – including the general public, environmental and health managers, decision makers and scientists.

Size of investment: The AfDB is considering a contribution of $39 million.

Source: AfDB (2012).

Despite the existence of international funding mechanisms, only seven African countries had their Ministries of Health receive international funds for climate change and health initiatives in 2021 (WHO, 2021). The health sector in African countries and other developing nations faces several challenges in accessing these global funds, including a lack of information about available opportunities, insufficient capacity to formulate country proposals, and limited engagement by health entities in climate change processes.

The active involvement of the private sector in funding holds significant potential for mobilizing essential funds for health sector adaptation. The participation of private entities, such as international pharmaceutical companies like Pfizer and Johnson & Johnson in Africa, has the potential to substantially increase climate funding in the region. However, creating an environment conducive to attracting private funding requires the implementation of favorable investment policies and effective collaborations.

7.4. Financing and Investment for Adapting Biodiversity and Ecosystems in Africa

Climate finance plays a pivotal role in addressing the challenges posed by climate change. By providing the necessary resources for implementing adaptive strategies that promote ecosystem resilience, it safeguards the unique flora and fauna of Africa. As Guzmán and others (2022) note, it is difficult to obtain detailed financial data on investments in the adaptation of biodiversity and ecosystems in Africa. According to the available information (see Figure 20), the AFOLU sector, which contains elements of biodiversity, totals $48.6 billion and accounts for 8 percent of the identified adaptation finance needs. Ecosystems and biodiversity constitute 2 percent of the overall adaptation finance needs, amounting to $8.9 billion, while coastal zones account for another 2 percent, with their adaptation finance needs totalling $7.9 billion. A regional breakdown of adaptation finance needs by subregion (see Appendix 8) indicates that ecosystems and biodiversity, along with coastal zones, are explicitly mentioned in western Africa, eastern Africa and northern Africa, while AFOLU is explicitly referenced across all regions (Guzmán and others, 2022).

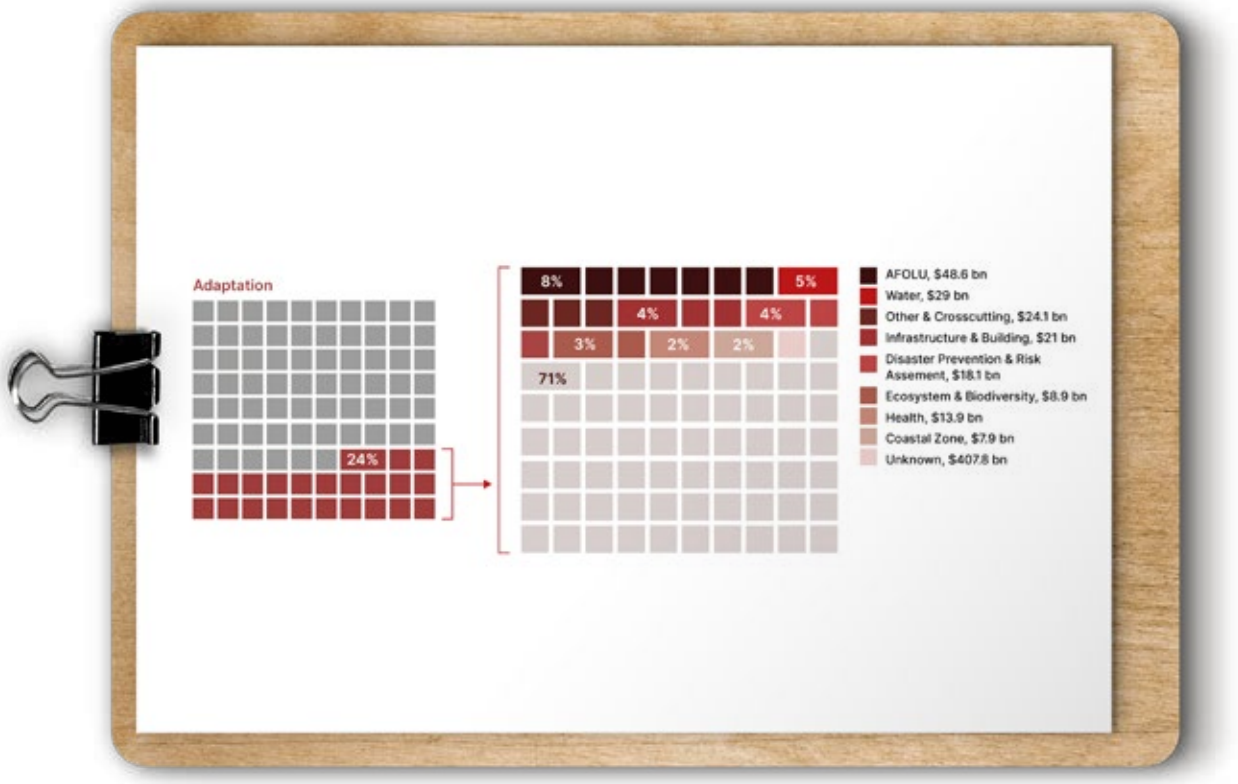


Figure 20: *African adaptation finance needs by sector.*
Source: Adapted from Guzmán and others (2022).

Most adaptation finance directed towards biodiversity and ecosystems is commonly categorized under the AFOLU sector or as part of cross-sectoral allocations. Meattle and others (2022) report that, according to adaptation finance commitments, the AFOLU sector – which includes components of biodiversity – received $2.8 billion in adaptation finance. However, it is unclear what proportion of this funding was specifically allocated for the conservation, restoration and sustainable use of ecosystems. When considering climate adaptation finance explicitly earmarked for biodiversity and ecosystems, the estimated amount is significantly lower, hovering around $200 million per annum (Meattle and others, 2022; Trisos and others, 2022).

Adaptation finance directed towards the AFOLU sector is predominantly influenced by international public financial entities, with grants being the predominant financial instrument, followed by low-cost project debt and market-rate project debt (Meattle and others, 2022). However, specific information regarding the types of financial instruments for adaptation finance directly allocated to biodiversity and ecosystems is currently unavailable.

A notable financial mechanism gaining prominence is the innovative concept of debt-for-nature swaps. These offer a dual benefit by allowing countries to alleviate their debt burden while simultaneously promoting environmental conservation and sustainability (African Natural Resources Management and Investment Centre [ANRMIC], 2022; Hebbale and Urpelainen, 2023). In a typical debt-for-nature swap, a creditor nation or international organization agrees to reduce or write

off a portion of a debtor country's debt. In return, the debtor country commits to utilizing the freed-up funds to support environmental conservation, biodiversity protection and sustainable development initiatives (ANRMIC, 2022; Hebbale and Urpelainen, 2023).

Debt-for-nature swaps can take the form of either multilateral or bilateral agreements. Multilateral initiatives often involve collaboration between multiple creditors, international financial institutions and conservation organizations (ANRMIC, 2022; Hebbale and Urpelainen, 2023). Bilateral agreements are negotiated directly between a debtor country and a specific creditor. Conservation organizations, including NGOs and international environmental groups, play a leading role in facilitating and implementing debt-for-nature swaps. They collaborate with Governments and creditors to structure agreements, define conservation goals and ensure that projects are implemented effectively.

While debt-for-nature swaps seem to be a promising approach, they are not without their challenges. Critics raise concerns about the adequacy of the debt relief provided and highlight variations in the effectiveness of conservation projects. Additionally, ensuring the equitable benefit of local communities and projects' long-term sustainability requires ongoing consideration.

Several noteworthy examples of debt-for-nature swaps include the Madagascar Protected Areas and Biodiversity Conservation Project in the early 2000s, where funds from debt reduction supported conservation projects within the country (ANRMIC, 2022). In 2015, Seychelles entered a debt restructuring agreement with The Nature Conservancy and the Paris Club of creditors, committing to strengthening marine conservation and establishing new protected areas in exchange for having part of its national debt written off (Hebbale and Urpelainen, 2023). In the late 1990s, Zambia signed agreements with the United States and other creditors, reducing its debt burden in exchange for commitments to allocate funds to environmental conservation projects. Finally, since signing the 30 by 30 initiative and the Bonn Challenge announced at COP26 in 2021, the Democratic Republic of the Congo has explored debt-for-nature swaps as part of its initiatives to address deforestation and promote sustainable land use (ANRMIC, 2022).

7.5. Financing Ecosystem-Based Adaptation

EbA is a strategic response to climate change, harnessing the functions and services of ecosystems to fortify the resilience of communities and the environment against the impacts of a changing climate. By recognizing ecosystems as vital providers of services such as water purification, flood regulation, food resources and wildlife habitat, EbA aims to enhance climate resilience, ensuring ecosystems can withstand and recover from climate-related stressors (Secretariat of the Convention on Biodiversity [CBD], 2009; Rizvi, Baig and Verdone, 2015).

This approach emphasizes adaptive governance, community engagement and the inherent cost-effectiveness of nature-based solutions. EbA encompasses diverse actions, including forest conservation, wetland protection, agroforestry and urban green infrastructure. Prioritizing biodiversity preservation, sustainable development and the maintenance of ecosystem services, EbA reduces vulnerability to climate change. It offers a holistic and sustainable strategy, often integrated with other adaptation efforts, which highlights the interconnectedness of ecosystems, human communities and climate change impacts (Secretariat of the CBD, 2009; Rizvi, Baig and Verdone, 2015).

In Africa, which is extremely vulnerable to climate change, EbA is gaining recognition as a powerful strategy (Archer and others, 2018; Trisos and others, 2022;). Central to EbA is community engagement, emphasizing the involvement of local communities and Indigenous Peoples in planning, implementing and managing projects. This ensures context-specific and culturally sensitive approaches that are enriched by traditional knowledge and priorities. Adaptive governance structures facilitate flexible decision-making, allowing adjustments to be made in response to new information and evolving climate conditions. The cost-effectiveness of EbA is evident, offering sustainable solutions with lower upfront investments compared with traditional infrastructure-based approaches (Secretariat of the CBD, 2009; Rizvi, Baig and Verdone, 2015).

EbA has substantial benefits in Africa in terms of bolstering the resilience of ecosystems and communities to climate change. It ensures the availability of crucial ecosystem services, offering protection and resources amid changing climatic conditions. Cost-effective and sustainable, EbA supports biodiversity conservation, enhances local livelihoods and mitigates climate-related disasters by regulating water flow and providing natural barriers. Multifaceted barriers to successful EbA implementation, including limited knowledge, policy alignment, resource constraints and cultural considerations, must nevertheless be addressed (Secretariat of the CBD, 2009; Rizvi, Baig and Verdone, 2015; Trisos and others, 2022).

Recognizing the significance of EbA, African countries are actively investing in initiatives that span protected area management, sustainable agriculture and land use. These endeavours involve the preservation and restoration of critical ecosystems such as wetlands, mangroves and forests. Box 9 contains illustrative examples of EbA projects.

Box 9: *Examples of EbA projects, taken from NDCs, NAPs and NBSAPs.*

These examples illustrate the diverse approaches that African countries are taking to implement EbA projects, leveraging their natural ecosystems to adapt to climate change while also providing socio-economic benefits to local communities. Each project is tailored to the specific environmental and societal challenges within its region.

Watershed management in Ethiopia: Ethiopia has implemented watershed management projects to restore degraded highland ecosystems. By conserving forests, grasslands and wetlands, these projects mitigate the impacts of heavy rainfall and reduce erosion, benefiting downstream communities.

Rangeland management in Kenya: In arid and semi-arid regions of Kenya, rangeland management projects are being implemented to restore and sustainably manage grasslands. These efforts help pastoralist communities adapt to changing rainfall patterns and reduce land degradation.

Community-based forest management in Madagascar: Madagascar's community-based forest management projects empower local communities to sustainably manage and conserve forests. By safeguarding these ecosystems, the projects enhance resilience to changing climate patterns and support livelihoods.

Coastal erosion management in Morocco: Morocco is addressing coastal erosion through dune stabilization projects. By planting native vegetation, these projects help protect coastlines from erosion and storm surges, thus safeguarding coastal communities and infrastructure.

Reforestation in Nigeria: Nigeria has launched reforestation programmes to restore its degraded forests. These efforts not only sequester carbon but also improve soil health, regulate water flow and enhance the overall resilience of ecosystems to climate change.

Lake and wetland restoration in Rwanda: Wetland and lake restoration projects in Rwanda focus on preserving critical water resources. These ecosystems provide freshwater supply and are important for agriculture and livelihoods. Their conservation helps communities adapt to variable rainfall and water scarcity.

Mangrove restoration in Senegal: Senegal has embarked on mangrove restoration initiatives in the Casamance Delta. Mangroves act as natural buffers against storm surges and sea level rise. By restoring and conserving these ecosystems, the project helps protect coastal communities and their livelihoods from the impacts of climate change.

Urban green spaces in Senegal: Projects in urban areas such as Dakar create and preserve green spaces. These spaces help mitigate the urban heat island effect and provide recreational areas, enhancing the quality of life in cities and contributing to climate resilience.

Biodiversity conservation in South Africa: South Africa's protected area network plays a vital role in biodiversity conservation. By expanding and improving the management of these areas, South Africa enhances ecosystem resilience and protects species that are threatened by climate change.

Current initiatives prioritize enhancing the capacity of local communities and organizations by equipping them with the necessary knowledge and skills to effectively address the impacts of climate change. Simultaneously, there is a concerted effort to develop climate-resilient infrastructure projects, including robust roads and coastal defences, aimed at safeguarding ecosystems.

African nations are proactively engaging with international climate funds and organizations, such as the GCF and the GEF, to secure vital financial support for their adaptation initiatives. This multifaceted approach involves scientific research, continuous monitoring, policy development and legislation, all of which play pivotal roles in seamlessly integrating biodiversity conservation and climate adaptation into national development plans. By recognizing the intricate linkages between these critical issues and harnessing both domestic and international resources, African countries are actively working to strengthen their resilience and preserve their invaluable natural heritage amid the challenges posed by climate change.

7.6. Navigating the Intersection of Financing and Investment for Climate Information Systems in Africa

The issue of financing and investment for climate information systems in Africa converges at the crossroads of policy integration, usability and application. In the intricate landscape of CIS in rural Africa, challenges persist, echoing a comprehensive gap analysis conducted by the International Research Institute for Climate and Society and the Global Climate Observing System in 2005. This analysis delved deep into the complexities and revealed four pivotal gaps that continue to shape the narrative of climate information access and usability across the continent.

The first challenge identified lies in integrating climate considerations into policy decisions. Bridging this gap means not only acknowledging the importance of climate data in policymaking, but also seamlessly incorporating it into the decision-making processes at various governance levels.

Moving beyond policy, the second gap is the struggle in integrating climate information into practical applications at scale. While acknowledging the relevance of climate data is a critical first step, realizing its practical benefits on a larger scale remains a significant challenge that needs to be addressed for effective adaptation strategies. This challenge also emerges in the form of gaps in providing comprehensive climate services. These services encompass the entire

spectrum of activities, from collecting and analysing data to packaging and distributing it for practical use. Unless these gaps are addressed, the potential of climate information to drive meaningful change will remain under-realized.

Lastly, access to reliable and up-to-date climate data is key to the success of any climate information system. Unless the gap concerning availability and quality of climate data is closed, efforts to enhance climate services are bound to face setbacks.

Despite these challenges, European Union-funded initiatives such as the Intra-ACP Climate Services and Related Application Programme (ClimSA), Co-production of climate services for East Africa (CONFER) and Global Challenges Research Fund – African Science for Weather Information and Forecasting Techniques (GCRF-African SWIFT) strive to be beacons of change. These initiatives focus on key priority sectors – agriculture and food security, disaster risk reduction, energy, health and water. They aim to not only address the identified gaps but also to empower African nations with robust CIS.

However, the investment needed reveals the magnitude of the task at hand. According to a report by the Brookings Institution, the financial gap for building reliable climate information systems and related services in Africa stands at an astounding $453 billion. This staggering figure attests to the urgency and the substantial resources required to fortify Africa's resilience against the challenges posed by climate change. Closing this investment gap is not just a financial imperative; it is a crucial step towards safeguarding the hard-earned economic gains and advancing social development witnessed across the continent over the past decade.

If the rythm of the drum beat changes, the dance step must ADAPT.

African Proverb.

SECTION VIII

Future Outlook

This State of Adaptation in Africa Report 2023 acknowledges the significant progress made in adapting to the ever-changing climate across critical sectors, while also recognizing the enormous challenges that lie ahead. It emphasizes the ongoing need for innovation to empower the continent in effectively addressing these pressing issues. This section presents emerging trends, adaptation strategies and requirements to support such innovation and embrace resilience across the key sectors analysed in this report.

8.1. Emerging Trends in Adaptation Strategies

Looking to the future, this report ventures beyond the known landscape, delving into the uncharted territories of emerging trends. This section serves to guide African countries through the currents of change that shape climate adaptation. The following pages aim to illuminate the path ahead, where new challenges and opportunities await in the ever-shifting terrain of climate resilience. It will examine emerging trends with the potential for innovation and adaptation, and the blueprint for a resilient future. The following critical elements require immediate attention to bolster resilience across the key sectors assessed in the State of Adaptation in Africa Report 2023.

Agriculture and Food Security: Agriculture is central to the continent's development, and the increasing impacts of climate change pose significant economic threats at the macro level. To strengthen resilience, several crucial interventions are needed. Expanding unwavering support for agricultural research and development is paramount and involves carrying out in-depth studies on climate-resilient crops, emphasizing the preservation of traditional African crops, establishing local seed banks and analysing the suitability of crops to future climate risks. Additionally, there is a need to scale up sustainable farming practices while integrating cutting-edge technologies. Collaborations involving Governments, the private sector and research institutions play a catalytic role, contributing invaluable agricultural knowledge. Moving beyond research, the practical application of technological breakthroughs is essential. The latest advancements can address specific challenges faced by farmers, from using drought-resistant seeds to adopting precision farming techniques. Ensuring accessibility for smallholder farmers is crucial, requiring economically viable solutions. NGO- and private sector-led programmes tailored to diverse conditions play a pivotal role in improving the resilience of agriculture and food security.

Water Resources: Africa is navigating the intricate challenges posed by climate change impacts on water resources and witnessing pivotal trends in its adaptation efforts. All water-related adaptation initiatives will require a primary focus on understanding, among other risks, the specific water-related risks and recognizing the urgent need to anticipate challenges stemming from rising temperatures. The implementation of successful strategies is central to the ongoing battle against climate change. This involves deploying EWS and structural measures, such as wetland restoration and land use planning, with the aim of enhancing natural water retention and mitigating flood risks. Awareness of transboundary and cascading climate risks is growing, especially in terms of understanding the growing water insecurity in Africa, emphasizing the importance of coordinated responses and calling for enhanced collaboration among regional economic communities and their Member States to address these complex

challenges. A forward-looking approach will involve coordinated responses that open avenues for inter-basin transfers, envisioning the supplementation of water-poor basins from those that are more water-abundant. In its pursuit of innovative solutions, Africa will explore sea-water desalination to improve water availability in coastal areas. Significant investments from countries in the Middle East and northern Africa are under way, some of which integrate renewable energy sources, showing a commitment to mitigating environmental impact.

Recognizing the superior resilience of groundwater compared with surface-water resources, groundwater is taking centre stage in Africa's adaptation strategies. A comprehensive approach necessitates strategic investments, encompassing the development of decision support systems for effective water management, the expansion of climate-resilient water supply infrastructure, the promotion of IWRM and the support of sustainable agricultural water practices. Lastly, creating an enabling environment involves building capacity for improved water governance, enhancing data management systems and empowering water institutions to adopt integrated land and water resource management policies. This holistic approach ensures a water-resilient future for Africa, underscoring the continent's commitment to sustainable water management in the face of evolving climate challenges.

Health and public health: An emerging area of concern centres around the intricate relationship between climate change and health within the African context. As the impacts of climate change continue to unfold, it becomes increasingly evident that they are not limited to environmental changes alone; they significantly intertwine with and affect the health of the continent's population. This nexus between climate change and health represents a complex and evolving field of study that requires a comprehensive understanding and tailored strategies to address the unique challenges faced by African communities.

Climate change heavily influences health outcomes both directly and indirectly. Direct impacts include the rise in temperature-related illnesses, the spread of vector-borne diseases and an increased frequency of extreme weather events, all of which pose immediate threats to human health. Meanwhile, the indirect consequences involve shifts in disease patterns, disruptions to food and water security, and the exacerbation of existing health disparities, increasing the vulnerability of certain populations. With such diverse ecosystems, Africa faces a spectrum of health challenges stemming from climate change. Prolonged droughts, changing precipitation patterns and the resultant impact on agricultural productivity can lead to food shortages and malnutrition. The increased prevalence of water-borne diseases due to altered rainfall patterns and flooding further compounds health risks. Additionally, the expansion of disease vectors, such as mosquitoes carrying malaria and dengue, adds another layer of complexity to the health challenges posed by a changing climate.

In this context, it is imperative to explore and implement adaptive strategies that integrate climate-resilient health care systems, early warning mechanisms for climate-related health risks and community-based interventions. Understanding the socio-economic and environmental determinants of health is crucial for developing targeted and effective measures. Furthermore, the recognition of Indigenous knowledge and practices plays a pivotal role in fostering resilience within local communities. Collaborative efforts between the health sector, environmental agencies and communities can help build a robust framework for climate-resilient health systems in Africa. As this field continues to unfold, research, policy and community engagement will be essential components in addressing the dynamic interplay between climate change and health on the continent.

Biodiversity and Ecosystem: The intricate connections between climate change, biodiversity and ecosystem preservation form a complex web in which each element influences and is influenced by the others. Recognizing this interdependence is crucial for developing comprehensive strategies that extend beyond isolated efforts and address the multifaceted challenges posed by climate change.

Preserving biodiversity is a linchpin in the broader endeavour to maintain the health and resilience of ecosystems. Biodiversity, representing the variety of life on Earth, plays a fundamental role in stabilizing ecosystems. It enhances their adaptability to changing environmental conditions and supports their ability to provide essential services to both nature and humanity. In the face of climate change, preserving biodiversity is a proactive strategy to fortify ecosystems against the impacts of temperature shifts, altered precipitation patterns and the increased frequency of extreme weather events. Acting as a natural buffer, biodiversity enables ecosystems to better absorb climate shocks, recover from disturbances and sustain their functionality over time. Furthermore, the preservation of biodiversity is intricately linked to the mitigation of climate change; healthy ecosystems, rich in biodiversity, act as carbon sinks, sequestering and storing substantial amounts of carbon dioxide and thus significantly contributing to mitigating the greenhouse gas emissions responsible for climate change. Therefore, efforts to safeguard biodiversity are not only about protecting individual species, but also about promoting the long-term stability of the entire planet's climate.

Embracing innovative solutions to enhance biodiversity monitoring, habitat restoration and conservation practices can amplify positive impacts on ecosystems. Additionally, incorporating sustainable land use practices, embracing agro-ecological approaches and promoting green infrastructure contribute to the dual goals of biodiversity preservation and climate change mitigation. Recognizing that the preservation of biodiversity is not a stand-alone goal but an integral part of ecosystem health emphasizes the need for cross-sectoral collaboration. Integrating biodiversity considerations into sectors such as agriculture, forestry and urban planning is essential for fostering resilience in the face of climate change.

Addressing the linkages between climate change, biodiversity and ecosystem preservation requires a holistic and synergistic approach. It involves not only recognizing the intrinsic value of biodiversity but also understanding its pivotal role in shaping the resilience of ecosystems and mitigating the impacts of climate change. Scaling up technologies and adopting integrated, cross-sectoral strategies are key elements in building a sustainable and harmonious relationship between human activities and the natural world.

1. Other interlinkages

The intricate interconnections and the pivotal role of sustainable energy, transportation and infrastructure, along with the central significance of ICT, will become clear as we explore the developments outlined in the following subsection.

Energy and Transportation Infrastructure Investments with a Focus on Rural Areas: Investments in energy and transportation infrastructure in rural areas emerge as crucial components for maintaining robust supply chains. The vitality of rural prosperity relies on well-functioning supply chains connecting agricultural production to markets. Prioritizing investments in energy and transportation infrastructure becomes imperative to sustain these chains, prevent post-harvest losses, and ensure a continuous supply of goods to meet market demands. The impact extends beyond agriculture, influencing broader economic development while supporting climate change resilience.

Expanding Access to ICT Services: In the digital age, increasing access to ICT services is vital for fostering improved communication and helping farmers make informed decisions. ICT tools, including mobile applications and online platforms, are at the centre of decision-making, providing insights into weather forecasts, market trends and best agricultural practices. ICT also supports the resilience of all the other sectors reviewed in this report.

African nations are embarking on a holistic journey of resilience-building that addresses challenges in agriculture, water resources, health, biodiversity, energy and access to technology. Each sector plays a vital role, contributing to the collective resilience of African nations and ecosystems in the ever-evolving landscape of climate adaptation. It is a story of adaptation, innovation and the indomitable spirit of African communities navigating change.

Box 10: *Examples of agricultural innovation in Africa*

- **Astra Aeriel Solutions, a firm established in Kenya, uses remote sensing to support agricultural spraying, crop inspection and irrigation management. The organization has digitalized data on farm ownership and gender, farm distribution, and crop and livestock value chains after mapping roughly 2,500 farms. This information can be used to project possible flooding vulnerabilities, tailor remedies and shorten scouting times.**
- **In 2020, catastrophic locust swarms would not have been contained by Kenyan farmers without the use of machine learning and satellite links. According to the Food and Agriculture Organization of the United Nations (FAO), these measures prevented losses of $1.5 billion and 34 million livelihoods in eastern Africa. In conjunction with the United Nations and FAO, technology companies such as Plant Village used satellite links and ground crews trained in machine learning to take photographs. This increased the accuracy of information on maturity and project swarm motions by up to 90 percent. Shamba Shape Up and Mercy Corps provided weekly advice to around 14 million farmers. Mobile spectrophotometry is another tool used by Plant Village to give farmers information on the health of their cassava crops.**

Box 11: *Examples of other emerging water adaptation solutions from Africa*

To address rising sea level challenges, Egypt is implementing its National Climate Change Action Plan by integrating climate change concerns into national policies, such as through the adoption of Law 4/94 requiring an environmental impact assessment for coastal infrastructure developmental projects, which prescribes relevant setback distances and structural requirements.

In the Sudan, the expansion of climate-change-induced drought is of major concern. Expanding the use of traditional rainwater harvesting, building shelterbelts and windbreaks to improve resilience of rangelands, improving water conservation techniques, monitoring the number of grazing animals, cutting down trees and setting up revolving credit funds have been found to provide relief.

Stampriet Aquifer is a very large transboundary (Botswana, Namibia and South Africa) aquifer system, receiving insignificant recharge in a dry region without permanent surface water. A range of adaptation initiatives that include Indigenous Peoples and women are being implemented, the adoption of an interdisciplinary approach in the integrated management of the transboundary resource. Expertise and perspectives are being pooled, leading to more relevant and efficient management (United Nations, 2023).

8.2. The Way Forward

Addressing the multifaceted impacts of climate change on African economies and livelihoods calls for comprehensive strategies for both mitigation and adaptation. Africa, being particularly vulnerable to adverse effects such as severe droughts, extreme temperatures and frequent floods, experiences consequences that extend beyond agriculture, affecting sectors such as infrastructure, tourism and small and medium-sized enterprises (SMEs). These impacts disproportionately affect vulnerable populations, exacerbating existing inequalities.

To effectively tackle these challenges, adaptation efforts must take centre stage. The following recommendations are crucial for enhancing resilience and safeguarding African economies and livelihoods:

1 - Incorporate Climate Resilience in Macroeconomic Planning:

- Integrate climate resilience into economic sectors, investing in climate-resistant infrastructure and adaptive measures that enhance community and national resilience.
- Mainstreaming adaptation can yield high economic benefit-to-cost ratios.

2 - Leverage Social Protection:

- Strengthen social protection through cash transfer programs and public works to enhance individual and household resilience to climate-related shocks.
- Integrate climate risk management into social protection schemes for long-term resilience.

3 - Support for the Informal Sector:

- Provide tailored support for the often-overlooked informal sector, assisting small to medium-sized enterprises in vulnerable areas to prepare for and recover from climate shocks.

4 - Embrace Regional Cooperation:

- Given the transboundary nature of climate impacts, prioritize regional cooperation to address issues related to food security, renewable energy, and livestock trade while mitigating climate-induced losses.

5 - Enhance Data and Awareness:

- Improve data collection and modeling to increase awareness of climate risks, benefiting both insurers and clients.
- CIS play a vital role in addressing this challenge.

6 - Strengthen Climate Insurance:

- Promote climate insurance, particularly weather and drought index-based schemes, as a means to support vulnerable communities.
- Address affordability constraints, trust issues, distribution challenges, and basis risk.

7 - Invest in Adaptation:

- Redirect investments towards adaptation to reduce loss and damages.
- Support African governments in mobilizing funding for adaptation, which can be more cost-effective than responding to climate-induced crises.

8 - Diversify Adaptation Financing:

- Explore innovative financing mechanisms to attract private sector investments, including insurance, bonds with guarantee schemes, and carbon market initiatives.

9 - Address Funding Gaps:

- Realize efforts to increase climate finance for adaptation, including achieving the $100 billion per year goal, leveraging international sources such as the Green Climate Fund, and mobilizing domestic public and private resources.

In light of escalating climate threats, proactive, multisectoral and regionally coordinated measures are imperative. By investing in adaptation, diversifying financing and ensuring equitable support, the continent can build resilience, safeguard livelihoods and protect the economies of its nations against the growing challenges posed by climate change. Urgent and concerted efforts are needed to secure a sustainable and climate-resilient future for Africa.

8.3. Call to Action

In the face of the escalating climate crisis, the State of Adaptation in Africa Report 2023 lays bare the imperative for immediate and concerted efforts at the national, regional and international levels. The urgency of adaptation calls for a unified continental voice, compelling African Governments to prioritize the implementation of adaptation measures both in international communications and national policies. Recognizing the importance of transitioning from planning to implementation, countries across the continent are urged to signal this urgency to the international community through clear communications, especially to forums such as the UNFCCC. The rallying voice is clear: international financial institutions must accord equal priority to planning and implementing adaptation measures, acknowledging the critical role of adaptation in safeguarding nations against climate-induced challenges.

Successful implementation, as witnessed in some regions, hinges on robust coordination structures that ensure the efficient allocation of both domestic and international finance to priority areas. A developmental approach, championed by African stakeholders, necessitates balancing the implementation of adaptation with its planning process. To achieve this equilibrium, a multifaceted approach is outlined as follows:

- **Send clear Signals to the International Community:** National Governments must send unequivocal messages on the urgency of transitioning to implementation through international communications, such as those sent to the UNFCCC.

- **Restructure International Climate Finance Mechanisms:** Align mechanisms to enable equal allocation priority between planning and implementing adaptation measures.

- **Integrate Technology Needs and Capacities:** Embed these into national development plans and budgets, recognizing them as critical tools for improving climate resilience and community adaptation.

- **Increase Finance for Implementing Adaptation:** To bridge the financial gap, there is a crucial need to scale up the mobilization of international climate finance to complement domestic efforts. The continent's capacity to respond to climate risks is limited. Industrialized countries must commit to honouring their longstanding promise to provide and mobilize $100 billion annually from 2020 to 2025, and to double financing for adaptation. Accurate estimates of adaptation finance needs, based on UNFCCC technical guidance, are indispensable. Grant-based adaptation finance is crucial, requiring a commitment from development finance institutions to scale up the proportion allocated to African countries.

- **Invest in Digital Technologies for Adaptation:** Harnessing digital technologies for adaptation, particularly for SMEs facing barriers to accessing finance, becomes paramount. Climate finance should support the deployment of these technologies, empowering SMEs to adapt to climate change challenges. Examples of interventions funded by adaptation finance include credit enhancement mechanisms, blended financing, and designing SME-targeted lending instruments based on cash flows.

- **Strengthening Regional Integration and Collaboration:** Regional cooperation is key to advancing technology for sectoral adaptation across Africa, especially in digital transformation and the management of transboundary resources. The African Continental Free Trade Area (AfCFTA) agreement acts as a catalyst, offering opportunities for trade and income growth. The full implementation of the African Continental Free Trade Area requires strategic infrastructure development and digital technology investment to enhance connectivity, particularly for SMEs seeking access to regional markets. Countries are encouraged to align their national strategies with the Africa Agenda 2063 framework, thus leveraging regional integration for sustainable development and CCA. Financial and technical resources must be allocated towards implementing regional coordination policies in order to enhance resilience and foster economic growth across the continent.

8.4. Recommendations for Future Actions

The following are additional recommendations that respond proactively to climate change.

Establish a loss and Damage Mechanism: For over a decade, Africa has emphasized the importance of establishing a loss and damage fund in global climate negotiations (Matola and Ekeruche, 2022). On the international stage, milestone initiatives such as the Warsaw International Mechanism for Loss and Damage have been playing a pivotal role in raising awareness of the need for a more robust institution capable of filling the financing gap between global financial and risk management institutions and making resources available to the most vulnerable communities. The redirection of resources and support to these communities through international governance arrangements holds significant potential to mitigate risks, enhance local resilience and, in the broader context, promote sustainable development in the face of climate-induced challenges. The culmination of this advocacy resulted in approval at COP27 in Egypt. Here, the term “loss and damages” encompasses the far-reaching effects of climate change that go beyond the reach of mitigation or adaptation measures. COP28 began with a landmark agreement on a loss and damage fund, aiming to assist developing countries in addressing the impacts of climate change. Adopted by consensus by all parties, including India, an amount of approximately $700 million was pledged by several countries for loss and damage as a one-time contribution. (UNFCCC, 2023).

Utilize community engagement and participation: This plays a critical role in the adaptation process, given the paramount importance of local knowledge and community involvement. The significance of community engagement extends beyond mere participation; it embodies a collaborative and inclusive approach that taps into the wealth of Indigenous knowledge and fosters a sense of ownership and resilience within local populations. One key aspect of community engagement is acknowledging the unique insights that local communities possess regarding their environment, climate patterns and traditional coping mechanisms.

Actively involving communities in the adaptation planning and decision-making processes provides an opportunity to integrate this Indigenous knowledge into formal strategies. This collaborative approach ensures that adaptation initiatives are contextually relevant, effective and reflective of the specific challenges faced by each community.

Strengthen knowledge sharing including through case Studies of Community-Led Adaptation Initiatives: This requires a multifaceted effort that involves delving into success stories and exploring the intricacies of these initiatives. Such case studies serve as a valuable canvas, illustrating the effectiveness of local knowledge and community engagement in the profound act of building resilience to climate change. Embarking on an exploration of success stories involves conducting in-depth analyses of specific community-led adaptation projects that have yielded positive outcomes. These case studies provide a nuanced understanding of the challenges faced, strategies employed and the impact achieved by communities actively engaged in adaptation efforts.

Firstly, these case studies shed light on the contextual relevance of local knowledge. They showcase how communities, drawing upon their traditional wisdom and intimate understanding of local ecosystems, have implemented measures that align with their specific needs and challenges. This contextual relevance is crucial in ensuring that adaptation strategies are not only effective but also sustainable in the long run. Moreover, case studies offer insights into the process of community engagement throughout the adaptation journey. They highlight how communities have been active participants in decision-making, from the identification of vulnerabilities to the planning and execution of adaptation measures. This involvement fosters a sense of ownership and empowerment, making communities more resilient to climate-induced challenges. Finally, they provide a platform for sharing best practices and lessons learned. They showcase innovative approaches that have succeeded in enhancing adaptive capacity, whether through ecosystem-based solutions, sustainable agricultural practices or community-based EWS. These success stories may inspire other communities and policymakers grappling with similar challenges.

Forge Partnerships with NGOs and Civil Society Organizations: This approach is considered an important strategy within the narrative of action, where fruitful collaboration takes centre stage and the emphasis is on bringing together diverse perspectives, resources and expertise. NGOs and civil society organizations often operate at the grass-roots level, which gives them an intimate understanding of local communities and their unique challenges. Partnering with these entities facilitates inclusivity, ensuring that adaptation initiatives are contextually relevant and sensitive to the needs of the communities involved.

One key aspect of these partnerships is the exchange of knowledge and skills. NGOs and civil society organizations, with their on-the-ground experience, bring valuable insights into the intricacies of community dynamics, cultural nuances and the specific vulnerabilities faced by different groups. Collaborating with them enriches the overall understanding of adaptation challenges and strengthens the development of targeted, effective solutions. Moreover, these partnerships amplify the collective impact of climate adaptation initiatives. NGOs and civil society organizations often have networks, both local and international, that can be leveraged to mobilize resources, garner support and advocate for policy changes.

The collaborative effort harnesses the strengths of each partner, creating a synergy that makes adaptation projects more effective and sustainable. Community engagement is further bolstered through these partnerships, as they provide platforms for inclusive decision-making. Local voices are uplifted and communities become active participants in shaping the adaptation strategies that directly affect them. This participatory approach therefore fosters a sense of ownership and empowerment, ensuring that the initiatives resonate with the community's priorities and aspirations.

CONCLUSION AND FINAL REMARKS

This State of Adaptation in Africa Report 2023 highlights Africa's progress in CCA, examining diverse strategies across crucial sectors while acknowledging ongoing challenges. Key documents, including NDCs and NAPs, help integrate climate change threats into policies that safeguard the economy, biodiversity, ecosystems and food security. Adopting sustainable practices, capacity-building, CIS and risk management are common approaches to adapting to climate change.

The report emphasizes the need for resilience in critical sectors, advocating for support for agricultural research and development, sustainable farming practices and cutting-edge technologies. Collaboration between Governments, the private sector and research institutions is vital. Water resource challenges due to climate change require adaptation efforts, with a focus on EWS, structural measures and regional coordination. The report calls for increased investment in renewable energy sources and highlights groundwater resilience.

Disproportionate impacts on vulnerable populations emphasize the urgency of prioritizing adaptation efforts.
Incorporating climate resilience into macroeconomic planning, leveraging social protection, supporting the informal sector, embracing regional cooperation, improving data and awareness, strengthening climate insurance, investing in adaptation, diversifying financing and addressing funding gaps are all critical. These measures aim to build resilience, safeguard livelihoods and protect African nations' economies against the growing challenges of climate change. Proactive, multisectoral and regionally coordinated measures are crucial for securing a sustainable and climate-resilient future for Africa.

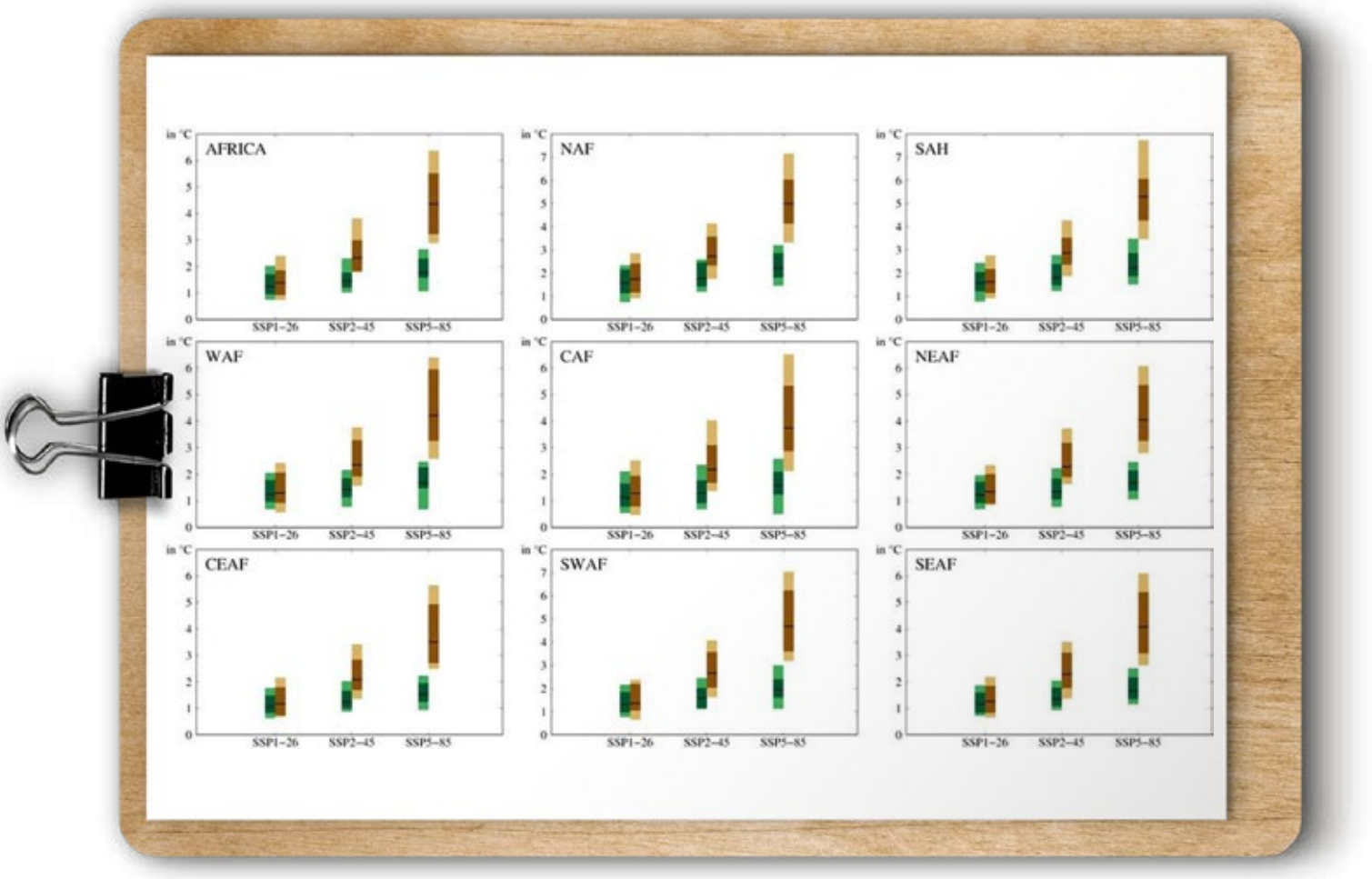
Identifying and addressing adaptation gaps is key to preserving Africa's ecosystems. Social protection programmes, integrated with climate risk management, enhance resilience against climate-related shocks. However, financial constraints and the lack of institutionalization pose challenges. Climate finance in developing countries faces significant underfunding, especially in Africa, which requires approximately $2.8 trillion from 2020 to 2030 to meet its NDC targets under the Paris Agreement. Despite concerted efforts, shortfalls persist in meeting investment needs across critical sectors, with the adaptation finance gap ranging from $194 billion to $366 billion per year; 10–18 times greater than current finance flows.

Key recommendations include integrating climate resilience into macroeconomic planning, leveraging social protection, supporting the informal sector, embracing regional cooperation, improving data and awareness, strengthening climate insurance, investing in adaptation, diversifying financing and addressing funding gaps.
Identifying and addressing adaptation gaps is crucial for preserving ecosystems. Social protection programmes, integrated with climate risk management, enhance resilience, yet financial constraints and a lack of institutionalization pose challenges. Climate finance in Africa faces significant underfunding, requiring strategic tapping into diverse funding sources, including global mechanisms, domestic budgets, international aid and private collaborations. The report stresses the

interconnected nature of adaptation strategies, and recommends integrating them into macroeconomic planning, leveraging social protection, enhancing data and awareness, fortifying climate insurance, diversifying financing and addressing funding gaps. Urgent, multisectoral and regionally coordinated efforts are imperative for fortifying resilience in Africa amid a changing climate.

The State of Adaptation in Africa Report 2023 emphasizes urgent and coordinated efforts at the national, regional and international levels. It calls for a unified continental voice, prioritizing implementation of adaptation measures in international communications and national policies. The report advocates clear signals to the international community, restructuring climate finance mechanisms and integrating technology needs into national development plans. It calls for increased finance for implementing adaptation, digital technologies for SMEs and regional cooperation for sectoral adaptation. Aligning national strategies with the Africa Agenda 2063 framework is encouraged. Its suggested recommendations include a loss and damage mechanism to fill financing gaps, community engagement and participation, strengthened knowledge-sharing through case studies, and partnerships with NGOs and civil society to support CCA efforts.

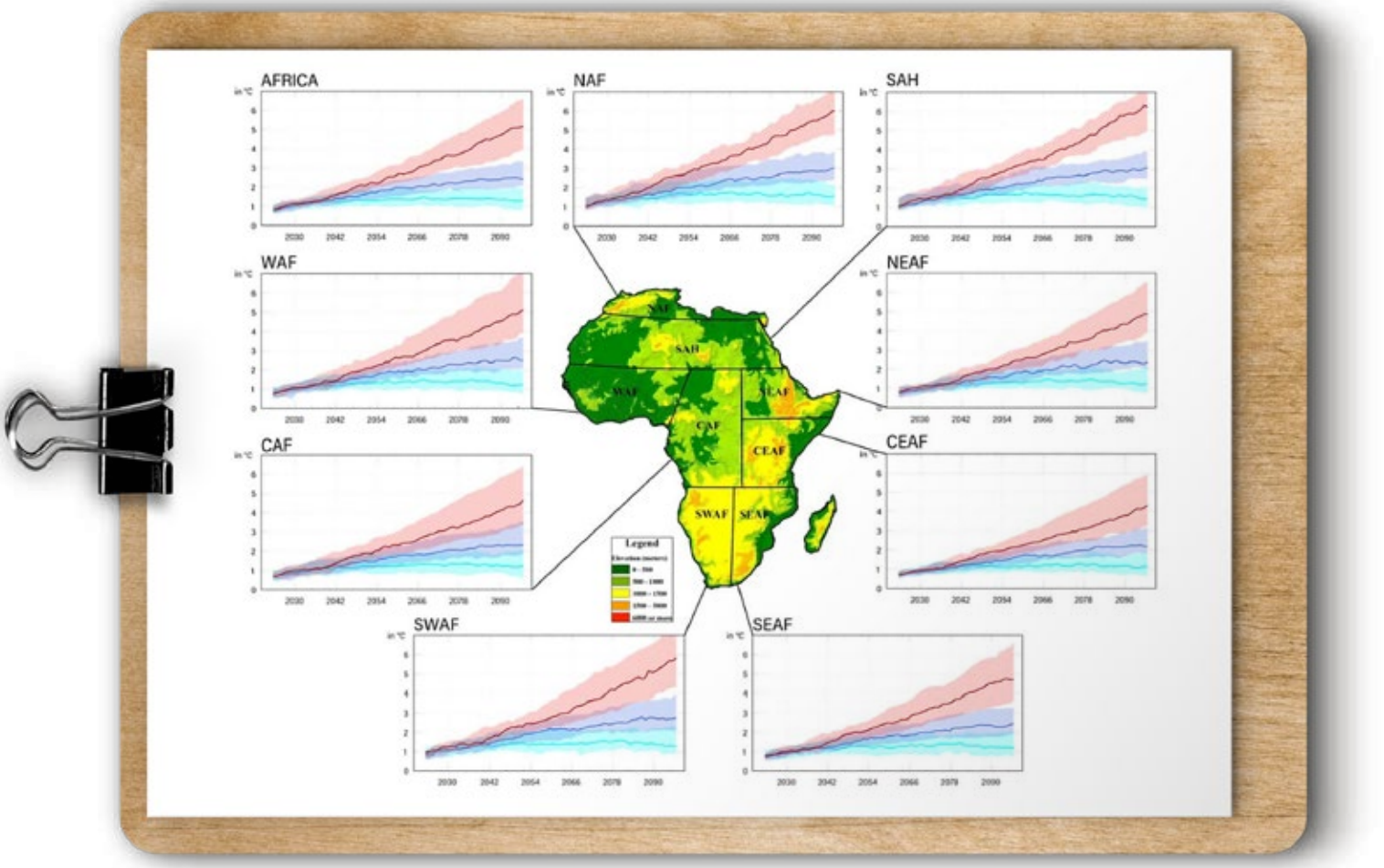
APPENDICES



Appendix 1: Projected changes in annual temperature (°C) spatially averaged over the eight regions and the whole of Africa.

Note: Green and brown bars represent the results for the near term (2030–2059) and long term (2070–2099), respectively, for the three scenarios (SSP1–2.6, SSP2–4.5, SSP5–8.5). The length of the bars shows full ranges (results from all the models) and the darker colour shows likely ranges (66 percent of all projected changes are within this range).

Source: Almazroui and others (2020).



Appendix 2: Area-averaged changes in temperature (°C) for the eight regions and for the whole of Africa during the 21st Century.

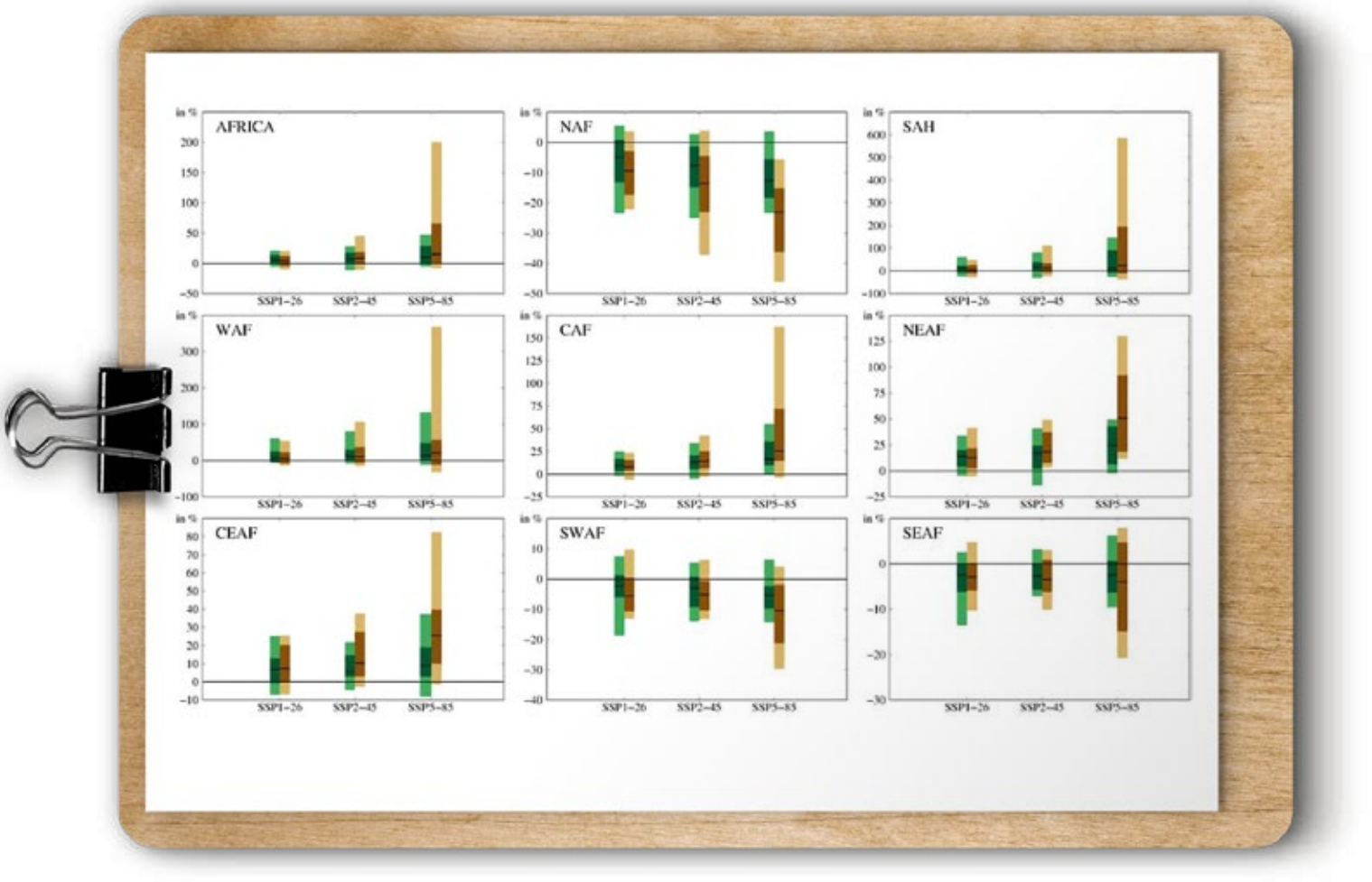
Note: Green, blue and red curves represent the median values for SSP1–2.6, SSP2–4.5 and SSP5–8.5, respectively, and the shaded areas around each of the curves represent the likely range (66 percent of the projected changes). The curves are obtained by taking the difference of each future year with respect to the average from the historical period (1981–2010), and then taking the seven-year running average afterwards.

Source: Almazroui and others (2020).

Appendix 3: Multi-model mean changes in mean daily precipitation characteristics for December–January–February for the period 2071–2100, with 1981–2010 as the reference period, under SSP5–RCP8.5

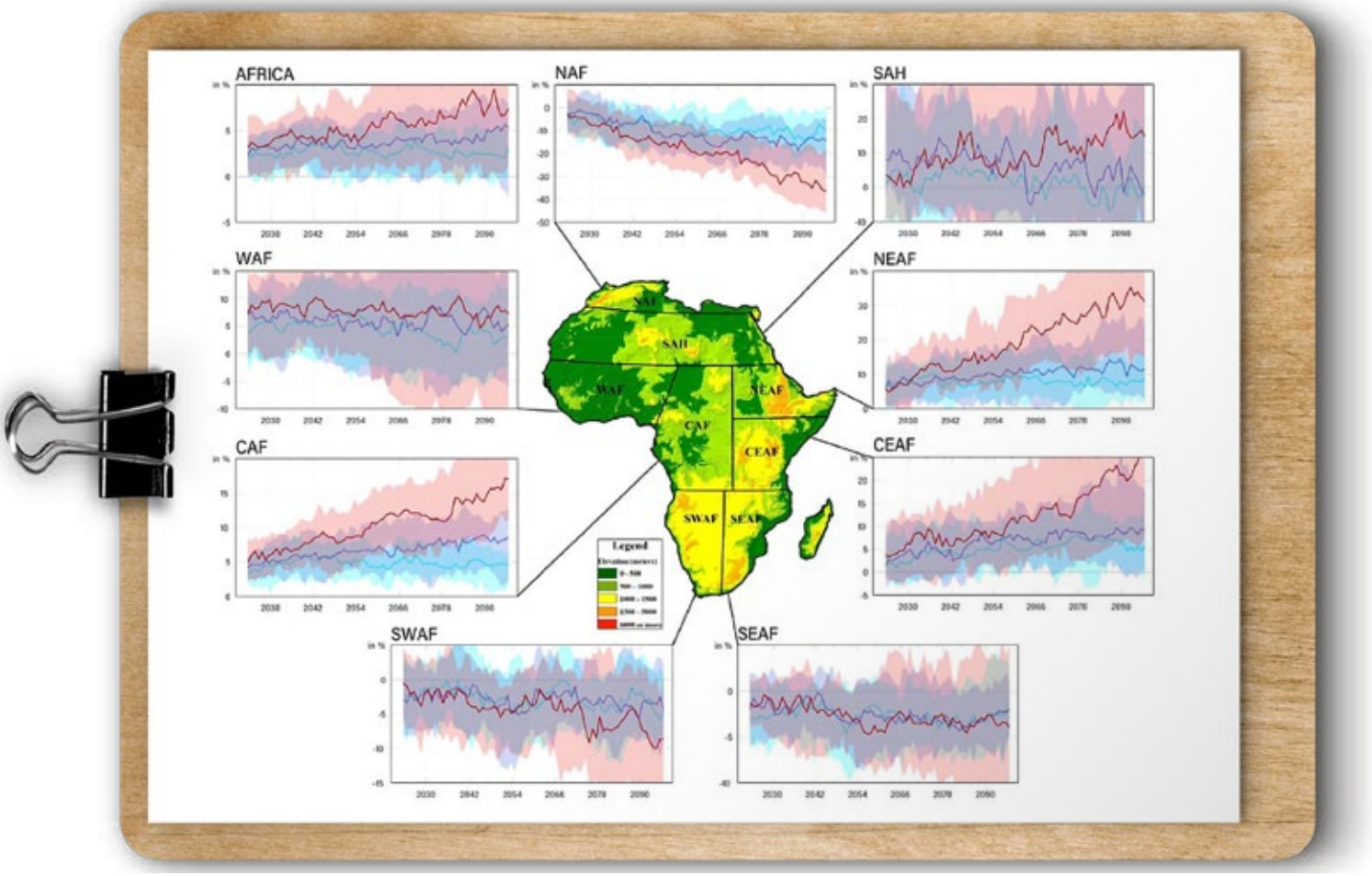
Note: Areas with no hatching (i.e. in full colour) are those where the signal is robust. The regions where the change is non-significant or uncertain are highlighted by hatching, together with the areas where there is little agreement on the change's significance (positive or negative change) and/or magnitude. The number of models used for each ensemble is shown near the ensemble name.

Source: Dosio and others (2021).



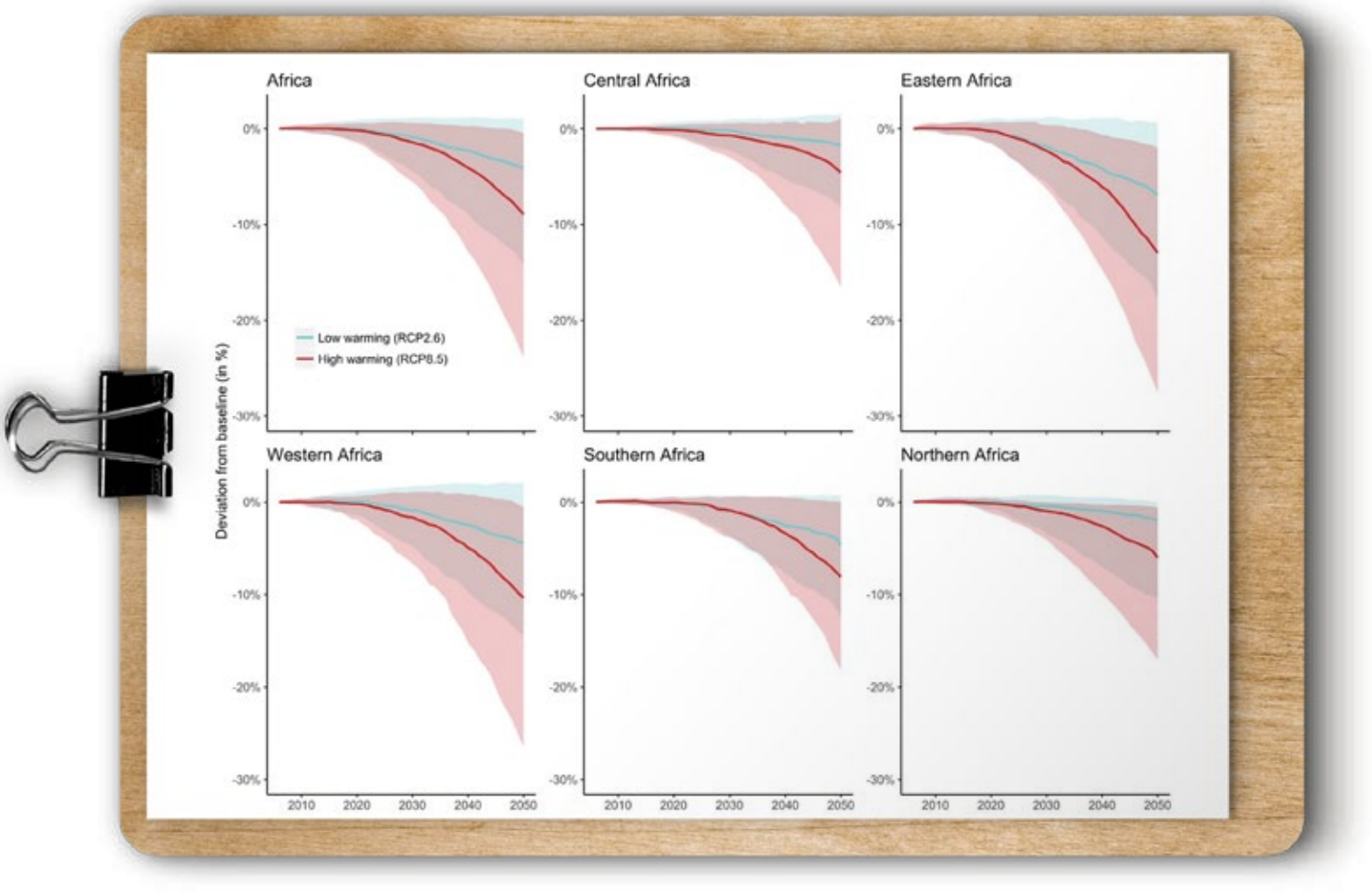
Appendix 4: Projected changes in annual precipitation (%) spatially averaged over the eight regions and the whole of Africa.

Source: Almazroui and others (2020).



Appendix 5: Area-averaged precipitation change (%) for the eight regions and for the whole of Africa during the 21st Century.

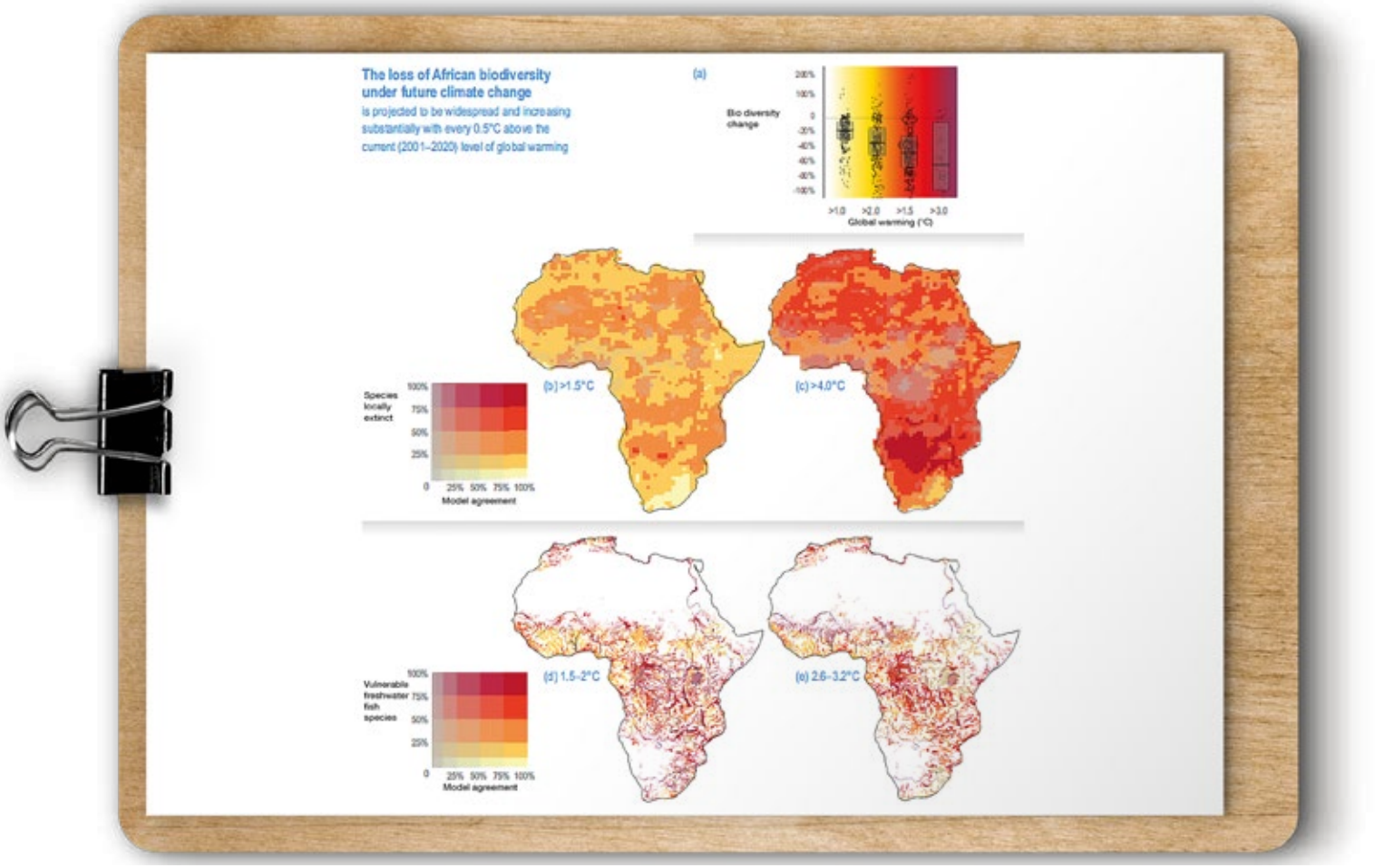
Source: Almazroui and others (2020).



Appendix 6: GDP per capita growth risk measured as a deviation from a GDP per capita baseline (here SSP2) in African countries and regions for the period 2005–2050.

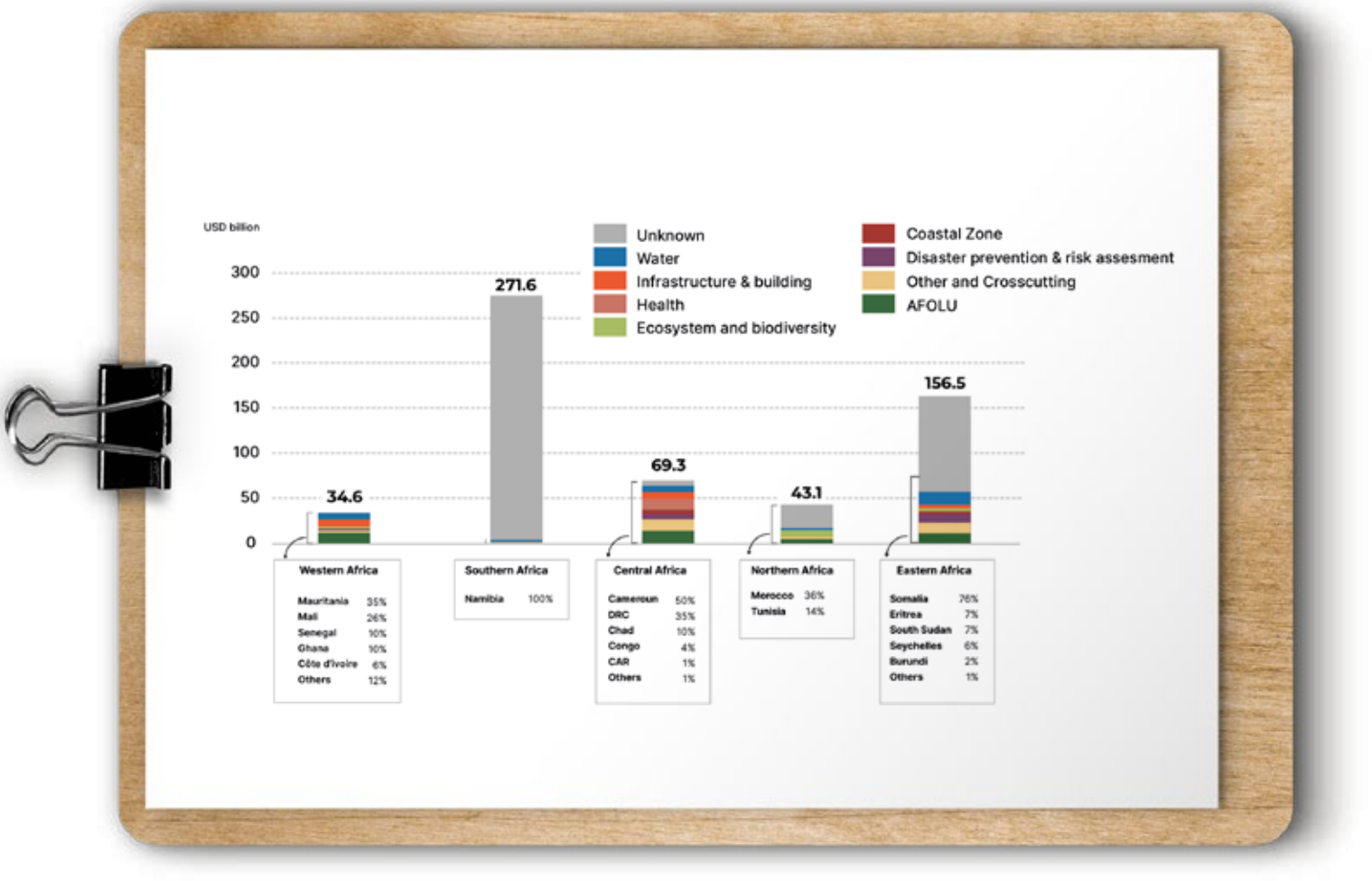
Note: GDP per capita baseline is SSP2. A low warming scenario (RCP2.6) is shown in blue and a high warming scenario (RCP8.5) is in red.

Source: Baarsch and others (2020).



Appendix 7: Loss of African biodiversity under future climate change.
Note: (a) Projected biodiversity loss, quantified as percentage change in species abundance, range size or area of suitable habitat; (b–c) The mean projected local extinction of vertebrates, plants and insects within 100 km grid cells; (d–e) The mean projected increase in species of freshwater fish vulnerable to local extinction within 10 km grid cells.

Source: Trisos and others (2022).



Appendix 8: African adaptation finance needs by subregion and sector.

Source: Adapted from Guzmán and others (2022).

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Section IV: Cities, Settlements and Key Infrastructure

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Section VI: Climate Information Services: Risks, Impacts and Vulnerabilities in Africa

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ACRONYMS AND ABBREVIATIONS

AAI	Africa Adaptation Initiative
ACDI	African Climate and Development Initiative
ACMAD	African Centre of Meteorological Applications for Development
ACPC	African Climate Policy Centre
AfDB	African Development Bank
AFOLU	Agriculture, forestry and other land use
AMCOW	African Ministers' Council on Water
ANRMIC	African Natural Resources Management and Investment Centre
ARIN	African Research and Impact Network
ATIM	African traditional and indigenous medicines
AWARe	Action for Water Adaptation and Resilience
CAADP	Comprehensive Africa Agriculture Development Programme
CAF	Central Africa
CBD	Convention on Biological Diversity
CCA	Climate change adaptation
CDKN	Climate and Development Knowledge Network Programme
CEAF	Central-eastern Africa
CIEWS	Climate information and early warning systems
CIS	Climate information services
ClimDev-Africa	Climate for Development in Africa
CMIP	Coupled Model Intercomparison Projects
CPI	Climate Policy Initiative
EbA	Ecosystem-based adaptation
EWS	Early warning systems
FAO	Food and Agriculture Organization of the United Nations
GCA	Global Center on Adaptation
GCF	Green Climate Fund
GDP	Gross domestic product
HEWS	Health early warning systems
ICT	Information and communications technology
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated water resource management
LDCs	Least developed countries
MHEWS	Multi-hazard early warning systems
NAF	Northern Africa
NAP	National adaptation plan
NAPA	National Adaptation Programme of Action
NBSAPs	National Biodiversity Strategies and Action Plans
NDC	Nationally determined contribution
NEAF	North-eastern Africa
NGO	Non-governmental organization
NMHS	National meteorological and hydrological services
OECD	Organisation for Economic Cooperation and Development
RCC	Regional climate centre
RCP	Representative Concentration Pathway
SAH	Sahara
SDG	Sustainable Development Goals
SEAF	South-eastern Africa
SIDS	Small Island Developing States
SME	Small and medium-sized enterprise
SOFF	Systematic Observations Financing Facility

SSA	Sustainable Solutions for Africa
SSP	Shared Socioeconomic Pathway
SWAF	South-western Africa
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlements Programme
WAF	Western Africa
WASH	Water, sanitation and hygiene
WHO	World Health Organization
WMO	World Meteorological Organization

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