THE EXACERBATED EFFECTS OF CLIMATE CHANGE-INDUCED LOSS AND DAMAGE & ADAPTATION CAPACITY

A Case Study of Liberia, Mozambique, Nigeria, Sudan, and Uganda

December 2024

LDYC

© Photo of Streets and Pathways flooded after the passage of a hurricane in Gonaives, Haiti by Marco Dormino - UN Photos/UNICEF


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EXECUTIVE SUMMARY

Climate change has become an overwhelming existential challenge. Its adverse impacts are felt across the globe, undermining systems, institutions, and structures, and particularly affecting the most vulnerable populations and regions[1]. It is important to note that 99% of the climate change crisis is anthropogenic, stemming from human activities[2]. This anthropogenic nature of climate change leads to global warming and its associated effects, primarily due to carbon emissions, methane, and deforestation[3].

The report provides a detailed examination of the exacerbated effects of climate change-induced loss and damage, particularly focusing on the vulnerability and adaptation capacity of Sub-Saharan Africa. The findings reveal that this region is experiencing rapid and severe impacts from extreme weather events, which significantly highlight its vulnerability and sensitivity to climate change. These extreme events, such as floods, tropical cyclones, heatwaves, and drought, have resulted in a multitude of adverse outcomes, not only the tragic loss of lives but a worrisome decline of biodiversity, loss of cultural heritage and ancestral lands, increased displacement of communities and peoples, and high levels of damage to public and private infrastructure, homes, and other valuables.

Furthermore, the study offers an in-depth overview of the broader implications of loss and damage within the Global South, spotlighting Sub-Saharan Africa. Despite contributing less than 4% to global carbon emissions, the region is disproportionately affected by climate-related disasters. The research highlights the paradox of this situation, showing that countries least responsible for climate change—due to the significant carbon dioxide emissions released by developed nations—are the ones suffering the most from its consequences. The report delves into the various adaptation capacities of Sub-Saharan African countries in their efforts to mitigate and address the impacts of climate change. It examines the strategies being implemented to bolster resilience, ranging from community-based initiatives to policy-level changes aimed at enhancing both immediate recovery and long-term sustainability. By addressing the interconnected issues of loss, damage, and adaptation, the report aims to highlight the urgent need for international attention and support for this vulnerable region in the face of climate change challenges. While the research report focuses on five Sub-Saharan countries to analyze the effects of climate change within their specific contexts and adaptations, it also expands its scope by examining the influence of climate change in other regions around the world. This broader perspective is achieved through the development of detailed case studies that illustrate the impact of climate change and how different areas are responding to and being affected by climate change, providing valuable insights into a global crisis that transcends geographical boundaries.

This research report is developed to provide valuable insights into the loss and damage caused by climate change in the Global South. It is designed to empower stakeholders, negotiators, and policymakers, including organizations, institutions, agencies, ministries, and departments, to mobilize the necessary resources and implement effective interventions and policies. The report also emphasizes key recommendations to achieve transformative results in addressing climate change-induced loss and damage.

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[1] Intergovernmental Panel on Climate Change. (2023). Climate Change 2023: Synthesis Report. Summary for Policymakers. IPCC. Retrieved from https://www.ipcc.ch/report/ar6/syr/
[2] Intergovernmental Panel on Climate Change. (2022). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Retrieved from https://www.ipcc.ch/report/ar6/wg2/
[3] Intergovernmental Panel on Climate Change. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Retrieved from https://www.ipcc.ch/report/ar6/wg1/

Climate change does not happen in isolation but is systemic, transcending ethnic, racial, economic, and social boundaries of human existence, and addressing it would require inter-generational support in solidarity with those who are particularly vulnerable to loss and damage associated with climate change impacts. This could be reflected in the words of some of the members of the Loss and Damage Youth Coalition, who narrated how climate change impacts their community.

"We have lost a lot of trees as a result of the government's development plans. The loss of the green cover or the loss of the green footprint has affected the air around us and our mental health. It has made it easier for the cars but harder for the residents, which has reduced the quality of life. We tried to cope by planting trees in our homes and visiting nearby parks. We need the government to take loss and damage into consideration while planning and make sure that it is not influencing slow on-set events like urban heat island effect and air pollution" – **Lamis Elkhatieb, Cairo, Egypt**

"Recent flooding caused by rising waters of Lake Tanganyika has caused significant losses and damage in the towns of Uvira and Baraka, located in South Kivu province, Democratic Republic of Congo. The flooding has affected more than 1,200 families, leaving them homeless and facing extreme hardship. This phenomenon, directly linked to climate change, reveals the extent of the risks faced by vulnerable communities living on the shores of the lake. Water levels in Lake Tanganyika have risen significantly in recent months, submerging several neighborhoods in Uvira and Baraka. The rising waters have swept away homes, property, crops, and essential infra-structure. Residents have seen their homes and possessions washed away, leaving thousands homeless and unable to continue their economic activities. The material losses are enormous: personal belongings such as clothing, furniture, work tools, and food supplies have been destroyed. The disaster has also destroyed vital infrastructure, including schools, hospitals, and roads, exacerbating difficulties in accessing health services, education, and other necessities. In addition, displaced populations are living in unsanitary and precarious conditions, increasing their vulnerability to health risks. As a member of the Loss and Damage Youth Coalition and climate negotiator at the Francophonie, I would like to stress that this situation highlights the urgency of taking measures to address the impacts of climate disasters in the Great Lakes region. The consequences of the rising waters of Lake Tanganyika are not only a matter of humanitarian emergency but also a warning of the need to adopt prevention and adaptation policies in the face of climate change. It is crucial to put in place compensation mechanisms for the losses and damage suffered by these communities and to strengthen local capacities to deal with such crises.

Relocation and humanitarian assistance initiatives are underway, but they remain insufficient given the scale of the disaster. It is therefore imperative to intensify the mobilization of the international community to provide sustainable support and strengthen climate change adaptation efforts in the region. This tragedy must also catalyze concrete actions to limit future climate risks and protect vulnerable populations, particularly young people, who are most affected by these events." **– Jean-Paul BYA'NDAOMBE LONGYE, Kalehe, DRC.**

"Food insecurity has caused many people to become malnourished. Evolving weather patterns pose a serious threat to the food system in Nigeria. Increased flooding has made it difficult for farmers to obtain optimum crop yields and suitable production levels. Variable rainfall patterns and rising temperatures have interrupted agricultural activity and reduced crop output, contributing to food shortages. This condition has caused recurring disputes between farmers

and herders, as herders look for animal feed within the farmers' fields, raising tensions due to the herder's mobility. All these challenges resulting from climate change mostly impact rural communities that rely largely on natural resources for their economic life. This necessitates the implementation of a bottom-up strategy for enhancing climate resilience in local communities, as well as the encouragement and support of Indigenous solutions and local knowledge in tackling situational climate vulnerabilities, with a focus on locally-led adaptation" **– Timothy Ogenyi, Abuja, Nigeria.**

"Loss and damage resulting from climate change have devastating effects, especially in regions like Kenya and East Africa, where communities face increasingly severe events such as floods, droughts, and storms. These climate-induced disasters lead to irreversible losses in livelihoods, infrastructure, and economic stability while exacerbating food insecurity and health crises. Vulnerable groups, such as women, children, and indigenous populations, are disproportionately affected due to limited resources and adaptive capacities. Despite these challenges, communities have shown resilience through various coping mechanisms, including grassroots adaptation initiatives like local early warning systems and sustainable farming practices. Economic diversification, such as promoting agroforestry and eco-tourism, has helped reduce dependency on climate-sensitive sectors, while mental health support networks are emerging to address trauma. Active policy advocacy also remains crucial as local leaders push for financial support and fair compensation on global platforms. To address loss and damage effectively, it is crucial to strengthen international financial mechanisms, ensuring swift and adequate support for impacted communities. Funding should also cover non-economic losses, such as cultural heritage. Investing in community-based solutions, empowering local organizations, and integrating indigenous knowledge into adaptation strategies are essential. Mental health programs should be prioritized and embedded in broader disaster response frameworks. Continued policy advocacy at global forums, such as COP, is necessary to push for fair financial commitments from high-emission countries. Additionally, comprehensive research and data collection should be prioritized to inform evidence-based policies and sustainable solutions, building long-term community resilience and stability" **– Claudius Mbuya, Kisumu, Kenya.**

"Tanzania was ranked 34th most susceptible and 54th least prepared to adapt to climate change in the Notre Dame Global Adaptation Initiative Index 2015. Based on the climate change trajectory, Tanzania's losses may accumulate about 20 percent of its GDP if mitigation and adaptation efforts are not implemented. Economic losses are reported in crop production, biodiversity, building, and infrastructure, among other sectors. Economic losses due to climate change manifest in different sectors, such as crop production, livestock death, and demolition of infrastructure. The estimates indicate that the net economic costs of climate change can reach 1-2 percent of the GDP by 2030. With the agriculture industry accounting for over 20% of Tanzania's GDP and annual production losses exceeding US $200 million due to weather-related factors, the impact of climate change is anticipated to be severe. The drought events that are highly remembered in northern Tanzania pastoral communities occurred in 1974, 1984, 1994, 2000, 2004, 2009, 2012, 2016, and 2018. The recent drought event that led to the death of 92,047 livestock (cows, goats, sheep, and donkeys), occurred in 2022 based on the reports of Citizen Paper. Climate change L&D has not been on the research agenda; the international research community and funding organizations should equally consider climate change-related loss and damage paramount in informing climate action. Robust L&D policies are needed to support communities where adaptation efforts encounter hard limits. These policies should also include insurance, compensation, and any other assistance needed to smooth the post-disaster period and speed recovery. Finally, as a new topic in climate change research, L&D lacks well-developed evaluation tools, particularly a strategy for assessing non-economic losses, therefore a framework for assessing these losses, which are typically overlooked, is important" **– Upendo Ernest Lyimo, Tanzania.**

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ACRONYMS AND ABBREVIATIONS

CRED	Centre for Research on the Epidemiology of Disasters
COP	Conference of Parties
DRC	Democratic Republic of the Congo
ENSO	El Nino-Southern Oscillation
FAO	Food and Agriculture Organization
IFRC	International Federation of Red Cross and Red Crescent Societies
IRB	Indus River Basin
IPCC	Intergovernmental Panel on Climate Change
L&D	Loss and Damage
LDCs	Least Developed Countries
NBS	Nature-Based Solutions
NGOs	Non-Government Organizations
RCP	Representative Concentration Pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SSA	Sub-Saharan Africa
SIDS	Small Island Developing States
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
UNDP	United Nations Development Programme
UNISDR	United Nations Office for Disaster Risk Reduction
USD	United States Dollar
WHO	World Health Organization

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DEFINITION OF TERMS

Adaptation	Actions taken by communities and nations to adjust to actual or expected effects of climate change in order to minimize impact, avert harm, and take advantage of beneficial opportunities.
Adaptive Capacity	The ability of an individual, family, community, or other social group to adjust to changes in the environment guaranteeing survival and sustainability.
Climate Change	Refers to long-term shifts or alterations in the earth's climate, particularly changes in temperature, precipitation patterns, and extreme weather events, largely caused by human activities.
Climate Change-induced Disaster	The effects of changes in the earth's climate, resulting from extreme weather and slow onset events such as rising temperatures, more extreme weather events, sea level rise, and shifting ecosystems, can harm the environment, human health, livelihoods, and economies. These impacts include droughts, floods, heatwaves, and tropical cyclones.
Coping Mechanism	The ability of people, communities, states, and countries using scarce available skills, resources, and common-sense knowledge to live with and manage adverse effects of climate change disasters.
Loss and Damage	Refers to the negative impacts of climate change that go beyond what can be mitigated or adapted to. It encompasses both economic losses, such as damage to infrastructure, agriculture, and property, and non-economic losses, including loss of lives, cultural heritage, biodiversity, and ecosystems.
Nature-based Solutions	Actions that protect, manage, and restore natural ecosystems to harness their capacity to help communities adapt to climate change impacts and address residual loss and damage.
Resilience	The ability of a system (people, community, state, and country) to cope with and recover from climate-related disturbances while maintaining its basic structure and functions.
Sensitivity	Refers to the degree to which a system (community, state, and country) is positively or negatively affected by climate-related changes or variability. It describes how vulnerable a system is to changes in temperature, precipitation, extreme weather events, or other climate-related factors.
Vulnerability	The degree to which a system (people, community, state, and country) is susceptible to, or unable to cope with, the adverse effects of climate change. It is influenced by factors such as poverty, infrastructure quality, and geographic location.

1.0 BACKGROUND

Current global emissions trends, coupled with little financial investment to mitigate climate change, reveal we are currently on a path to a 4°C to 5°C warmer world by 2100[4]. Africa, for instance, was projected as one of the regions most affected by the effects of climatic changes[5]. Published in 2001, the third Assessment Report by the Intergovernmental Panel on Climate Change (IPCC)[6] highlighted the vulnerability and limitations of poor countries in adapting to climate change challenges. Africa's climate has warmed by 0.26°C per decade more than the global average since pre-industrial times. Likewise, the relative sea level rise along the coasts of the continent has been higher than the global rate, resulting in a rising incidence and magnitude of coastal flooding and erosion in low-lying areas. The continent is expected to face a very high intensity and frequency level of extreme climate change events, which include slow onset, heat waves, more frequent and intense floods and droughts, food insecurity, human migration, rising temperature, more frequent storms, and socio-economic losses and damages[7].

The economic development and long-term prosperity of many nations globally are challenged by climate change, and Africa is no exception, given the real and potential effects of climate variability and change that have endangered the most vulnerable industries and populations. The complex weather patterns surrounding the African climate, including extreme events and slow onset events, are expected to cause more severe changes in rainfall patterns, rising sea levels, and higher temperatures in African countries. These changes are expected to have an impact on public health, agricultural production, food security, and water availability, among other things. The largest desert in the world, the Sahara has the earth's deepest layer of extreme heat. Sub-Saharan Africa (SSA) is characterized by rapid economic growth in a diverse ecological environment with different climates and demographics[8]. Its population is estimated to reach above 2 billion by 2050 and above four billion by the year 2100[9]. The region is home to thousands of climate change biodiversity hotspots where a great deal of work is done with regard to the impact of climate on biological diversity. It was forecasted that people will have to flee their homes in sub-Saharan Africa in larger numbers in the future due to climate-related disasters: in 2021, about 2.6 million people were displaced[10]. The World Bank estimates a further 216 million could migrate within their countries because of the gradual onset of climate change effects by

[4]IPCC SIXTH ASSESSMENT REPORT 2023: Working Group I – The Physical Science Basis, 2023
[5] IPCC (2014) Summary for policymakers: Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and Sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
[6] IPCC Third Assessment Report (2001). Accessed on https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf. (accessed May 23 2023)
[7] Compared to AR5, and when taking into account emissions since AR5, estimates in AR6 are about 300–350 GtCO2 larger for the remaining carbon budget consistent with limiting warming to 1.5°C; for 2°C, the difference is about 400–500 GtCO2
[8] NASAC (2015) Climate change adaptation and resilience in Africa. Recommendations to policymakers. Network of African Science Academies
[9] UN Department of Economic and Social Affairs (2013) World population prospects: The 2012 revision. Volume I: comprehensive tables. New York, USA.
[10] AIMÉE-NOËL M. (2022) East Africa and the Horn light the way for climate migrants; Institute for Security Studies. Assessed at https://issafrica.org/iss-today/east-africa-and-the-horn-light-the-way-for-climate-migrants (Assessed May 24 2023)

2050[11]. This will affect the quality of life of the people and increase a weak adaptation structure in the region. Some of the recent examples of climate-related events in these biodiversity hotspot areas include the drought that occurred in 2017 in the Horn of Africa, subjecting more than 17 million people in Uganda, Kenya, Eritrea, Somalia, Ethiopia South Sudan, and Djibouti to seek urgent intervention and immediate attention[12].

Climate change impacts have manifested in a number of ways on non-human and human systems. Predictions for climate change in this area show that the climate will get warmer, particularly in the interior sub-tropics, and it will become drier and be exposed to more frequent and more intense heat waves as well as changes in rainfall patterns. Southern Africa will have a decrease in rainfall while East Africa will have an increase in rainfall. Under a 4°C warming scenario, the region could also experience a sea-level rise of up to one meter by the end of this century. Modeling has revealed that regional rates for extreme weather and slow-onset events in SSA will be higher compared to a world without climate change[13]. The rain-fed agricultural systems under which most people in the region depend for their livelihoods are the most sensitive to these climatic changes.

The rate of rural-urban migration might be expected to rise as farming becomes increasingly untenable, which with millions of people already on the move across African cities, will boost the continent's already high urbanization rate. Based on the IPCC's Representative Concentration Pathway (RCP) 4.5 and RCP8.5, the future consequences of changes in precipitation, temperature, and extremes of weather have been projected to lead to declining Rangeland Net Primary Production (the quantity of organic material – biomass – that plants in rangeland ecosystems create through photosynthesis) and a forecasted loss of between 42% and 46% for many SSA countries by 2050[14]. The reports also note that in a 4-degree warming scenario, Sub-Saharan African countries would experience several difficulties in growing their food systems. With regard to the future consequences of climate change in SSA, climate change impacts are expected to differ from country to country. Details and frequency of these climate impacts are yet to be clarified[15]. Due to the presence of many variables in modeling predictions[16], it remains difficult to anticipate precise future effects, and future adaptation measures specific to SSA. There is no conclusive consensus among the various climatic models given that visible signs of climate change-induced Loss and Damage (LD) are evident.

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[13] Serdeczny, O., Adams, S., Baarsch, F. et al. Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. Reg Environ Change 17, 1585–1600 (2017), https://doi.org/10.1007/s10113-015-0910-2 [Assessed 16 May 2023]

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[16] Gummadi, S., Rao, K., Seid, J., Legesse, G., Kadiyala, M., Takele, R., Amede, T., Whitbread, A., 2018. Spatio-temporal variability and trends of precipitation and extreme rainfall events in Ethiopia in 1980–2010. Theor. Appl. Climatol. 134, 1315–1328

Projections for sea-level rise are not consistent around the world. Existing studies in SSA tend to focus on latitudes 15°N and 35°S. Local sea-level rise predictions on the Sub-Saharan coast are on average 10 percent higher than the international average because the region is mostly tropical – characterized by warm and hot temperatures all year round. Higher sea level increases the probability of disasters that result from coastal flooding, in parallel to tropical cyclone activities in SSA. Climate change has also direct and indirect effects on human health causing fatalities and injuries due to extreme weather events such as flooding, or landslides. In addition, long-term exposure to high ambient temperatures can impair outdoor human activities and cause heat exhaustion, heat stroke, and death[18].

Young people, pregnant women, and the elderly were found to be particularly vulnerable to extreme heat leading to heat stress and mortality in some countries in SSA[17]. Drought has also been linked to diseases like trachoma, scabies, conjunctivitis, and diarrhea as it affects the availability and quality of water[19]. While some underlying factors enhance health and well-being, malnutrition also increases susceptibility to other diseases, putting people at risk of secondary or indirect health effects[20]. Climate change also negatively impacts agriculture, affecting food affordability and accessibility, which affects human health. Although the proportion of the undernourished population is already high in Sub-Saharan Africa, projections show that if temperatures rise by 1.2–1.7°C by 2050, the proportion may increase by 25-90% from the current level[21]. In 2020, an estimated 264.2 million people in Sub-Saharan Africa were malnourished. It accounts for around 24.1% of the total population, which is the highest rate anywhere in the world[22].

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1.1 Trends and impact of climate change-induced loss an.d damage and disasters in SSA

Losses and damages from disasters brought on by climate change and people's susceptibility to risks are rising throughout Africa[23]. The SSA region, like the rest of Africa, is vulnerable to several climate risks and disasters that go beyond the adaptation capacity of the people in the SSA region. Climate disasters of any type are a threat to almost all SSA nations. Floods, droughts, heat waves, epidemics, pest infestations (which happen frequently, but less frequently and occasionally more severely), cyclones, hurricanes, earthquakes, and tsunamis can all have disastrous effects on the subcontinent. SSA disaster profile is directly tied to the susceptibility of its population and economy and the population's often-limited capacity to cope with natural disasters[24, 25]. The region is distinguished by various cultural, social, and natural resource varieties. Several SSA countries are confronted to considerable governance issues in responding to disasters and adopting risk mitigation measures[26, 27] to tackle climate change-induced loss and damage. Due to high levels of poverty, reliance on rain-fed agriculture, and weak institutional capacity in SSA, the effects of disaster events are exacerbated by inadequate coping capacity[28]. For instance, the Food and Agricultural Organization[29] showed that, overall, 22% of the economic impacts of climate change-induced disasters is specific to agriculture. It is well known that the most vulnerable population groups in SSA suffer the worst effects of climate change hazards in terms of socioeconomic losses.

Most disasters in SSA are caused by hydrometeorological and related climate phenomena, which include floods, droughts, tropical cyclones and strong winds, storm surges, extremely high temperatures, forest fires, sand or dust storms, and landslides[30]. The main challenge with the subcontinent hydrological and climatological risks is climate variability, which is related to changing weather and climate patterns[31]. Consequently, the frequency and intensity of extreme weather events are likely to increase due to climate change events. For instance, El Nino-Southern Oscillation (ENSO) is associated with many of the extreme hydrometeorological events in SSA[32]. Flooding and drought are the two hydrometeorological phenomena that have the most significant impact on SSA: together, they are responsible for 80% of all fatalities and 70% of all economic losses associated with climate change catastrophes[33].

The most intense El Nio in decades hit the area in 2015–2016, causing drought and flood disasters. Figure 1 below shows the number of reported catastrophes and those impacted by each type of disaster from 1970 to 2014[34].

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[23] World Bank. (2016). Striving toward disaster resilient development in sub-Saharan Africa: Strategic framework 2016– 2020. Washington, DC: World Bank Group.
[24] Van Niekerk, D. (2015). Disaster risk governance in Africa: A retrospective assessment of progress against the Hyogo Framework for Action (2000–2012)<http://doi.org/10.1108/DPM-08-2014-0168>. Disaster Prevention and Management, 24(3), 397–416.
[25] World Bank. (2010). Report on the status of disaster risk reduction in sub-Saharan Africa. Washington, DC: World Bank Group
[26] Hewitt, K. (2013). Disasters in "development" contexts: Contradictions and options for a preventive approach<http:// dx.doi.org/10.4102/jamba.v5i2.91>. Jàmbá: Journal of Disaster Risk Studies, 5(2)
[27] World Bank. (2016). Striving toward disaster resilient development in sub-Saharan Africa: Strategic framework 2016– 2020. Washington, DC: World Bank Group.
[28] Mulugeta, G., Ayonghe, S., Daby, D., Dube, O. P., Gudyanga, F., Lucio, F., & Durrheim, R. (2007). Natural and human-induced hazards and disasters in sub-Saharan Africa. Seychelles: International Council for Science (ICSU) Regional Office for Africa.
[29] Food and Agriculture Organization (FAO). (2015a). The impact of natural hazards and disasters on agriculture and food security and nutrition: A call for action to build resilient livelihoods. Rome, Italy: FAO.
[30] Mulugeta, G., Ayonghe, S., Daby, D., Dube, O. P., Gudyanga, F., Lucio, F., & Durrheim, R. (2007). Natural and human-induced hazards and disasters in sub-Saharan Africa. Seychelles: International Council for Science (ICSU) Regional Office for Africa.
[31] Manyena, B. (2016). After Sendai: Is Africa bouncing back or bouncing forward from disasters? International Journal of Disaster Risk Science, 7(1), 41–53
[32] Mulugeta, G., Ayonghe, S., Daby, D., Dube, O. P., Gudyanga, F., Lucio, F., & Durrheim, R. (2007). Natural and human-induced hazards and disasters in sub-Saharan Africa. Seychelles: International Council for Science (ICSU) Regional Office for Africa.
[33] Field, C. B., Barros, V., Stocker, T. F., Qin, Dokken, D. J., Ebi, K. L., . . . Midgley, P. M. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press

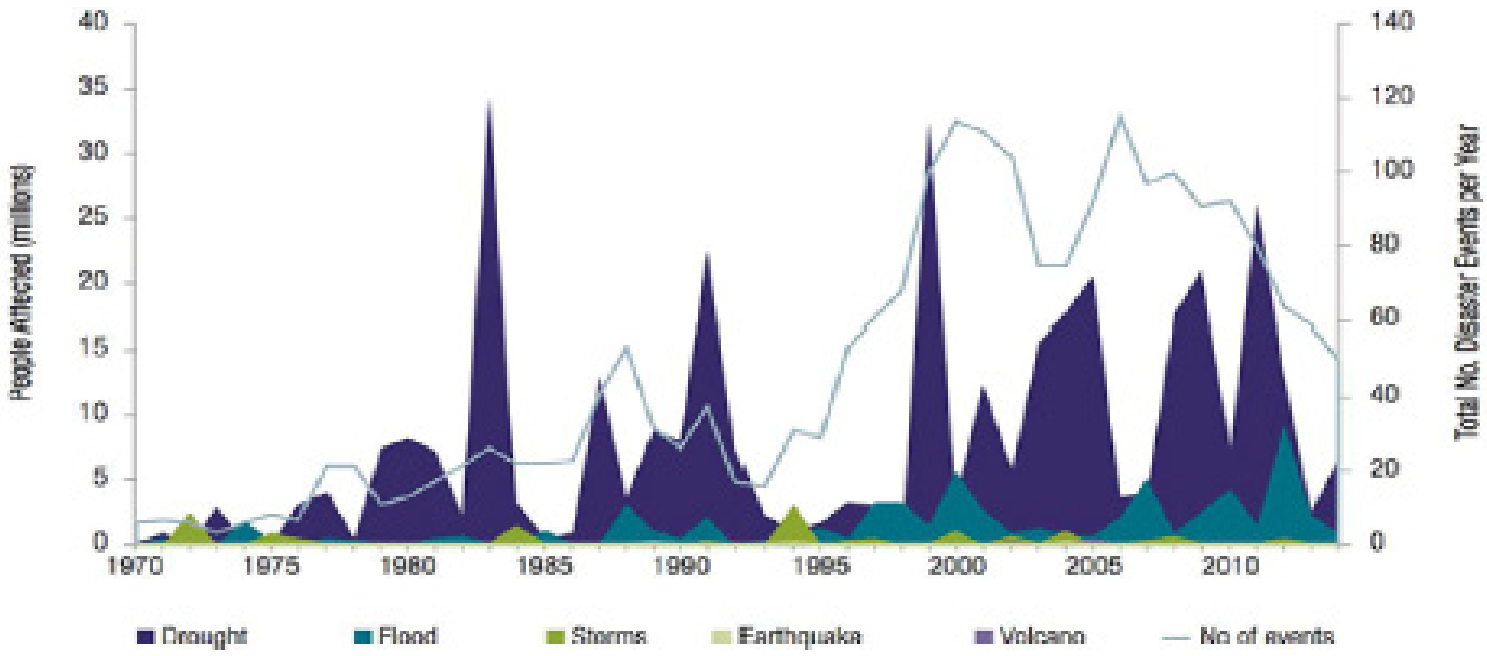

Figure I. Disasters reported in SSA and the number of victims affected by each category of catastrophe[35].

1.1.1 Flood

A significant proportion of global flood-risk areas are located in the SSA region. The possibility of flooding poses a particular threat to human settlements in floodplains[36]. There are several kinds of floods, including fluvial floods, flash floods, and floods caused by glacial lake outbursts. Flooding is a common occurrence in SSA during periods of heavy precipitation and is an inevitable result of tropical cyclones and storm surges[37]. In larger river basins, fluvial floods are most frequently caused by prolonged, intense rain. Short-duration, high-intensity rainfall may create flooding in smaller basins. Extreme rainy seasons and recurring flooding in Africa seem to coincide with El Nino events, which cause substantial economic losses[38]. As a result, several meteorological factors, most notably precipitation (including its severity, length, amount, timing, and phase), all have an impact on floods.

The topographical and geological features of a region, including drainage basin conditions, soil characteristics, and status, and the presence of dikes, dams, and reservoirs also determine the likelihood of flooding. Flooding can cause landslides, mudslides, and debris flows where land has been cleared of trees, particularly in regions with steep sloped, and unstable soils. Land degradation, deforestation of catchment areas, increased population density along riverbanks,

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[34] World Bank. (2016). Striving toward disaster resilient development in sub-Saharan Africa: Strategic framework 2016– 2020. Washington, DC: World Bank Group.
[35] World Bank. (2016). Striving toward disaster resilient development in sub-Saharan Africa: Strategic framework 2016– 2020. Washington, DC: World Bank Group.
[36] Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Salinas, J. L., & Blöschl, G. (2013). Socio-hydrology: Conceptualising human-flood interactions. Hydrology and Earth System Sciences, 17(8), 3295
[37] Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., & Muir-Wood, R. (2014). Flood risk and climate change: Global and regional perspectives. Hydrological Sciences Journal, 59(1), 1–28.
[38] Field, C. B., Barros, V., Stocker, T. F., Qin, Dokken, D. J., Ebi, K. L., . . . Midgley, P. M. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press

poor land-use planning, zoning, and control of floodplain development, inadequate drainage, particularly in cities, and inadequate management of river reservoir discharges are just a few additional human-induced causes of flooding. Floods primarily occur along the bigger river basins in the SSA region, with flash floods primarily damaging metropolitan areas.

Flooding frequently causes instantaneous fatalities and injuries, infectious diseases like malaria, and exposure to harmful substances in individuals[39]. Among the most dangerous natural hazards in SSA, flash floods, which are brought on by tropical cyclones and powerful storms, are particularly destructive. As with the rest of the African continent, the number of people killed by floods and the resulting economic losses has substantially increased during the past 50 years in SSA[40]. For instance, the Mozambique floods of 2000 claimed the lives of over 700 individuals, affected over 500,000 people, and caused $500 million in economic losses[41]. Over 72 million people have been affected by 937 reported flood occurrences between 1900 and 2016, with over 28,000 deaths and $8 billion in economic losses[42].

Flood-associated damage is a consequence of the depth, speed, and persistence of the water as well as the dissolved and suspended load (debris flow) that flood water carries[43], and these could have an impact on human communities[44]. Extreme rainfall and the ensuing floods in the Horn of Africa's semiarid and arid regions raise the danger of epidemic and vector-borne diseases like malaria, cholera, Rift Valley fever, dengue fever, and hantavirus pulmonary syndrome[45]. Weak flood protection, poor urban drainage, and increased runoff as a result of land degradation all worsen the effects of floods[46].

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[39] Gemeda, D. O., & Sima, A. D. (2015). The impacts of climate change on African continent and the way forward<http:// dx.doi.org/10.5897/JENE2015.0533>. Journal of Ecology and the Natural Environment, 7(10), 256–262.
[40] Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Salinas, J. L., & Blöschl, G. (2013). Socio-hydrology: Conceptualising human-flood interactions. Hydrology and Earth System Sciences, 17(8), 3295
[41] Mulugeta, G., Ayonghe, S., Daby, D., Dube, O. P., Gudyanga, F., Lucio, F., & Durrheim, R. (2007). Natural and human-induced hazards and disasters in sub-Saharan Africa. Seychelles: International Council for Science (ICSU) Regional Office for Africa.
[42] CRED-MDAT (2016). What is the human cost of weather-related disasters (1995–2015)? Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED).
[43] Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., & Muir-Wood, R. (2014). Flood risk and climate change: Global and regional perspectives. Hydrological Sciences Journal, 59(1), 1–28.
[44] Field, C. B., Barros, V., Stocker, T. F., Qin, Dokken, D. J., Ebi, K. L., . . . Midgley, P. M. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
[45] United Nations International Strategy for Disaster Reduction (UNISDR) Regional Office for Africa. (2014). Disaster risk reduction in Africa: Status report on implementation of Africa Regional Strategy and Hyogo Framework for Action. Nairobi, Kenya: UNISDR Africa Regional Office
[46] CRED-MDAT (2012). Disaster data: A balanced perspective. Issue No. 28. Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED)

1.1.2 Drought

In SSA, drought is a persistent issue. According to estimates, over 220 million people are exposed to the risk each year and one-third of Africans live in areas that are prone to drought[47]. Between 2003 and 2013, 27 nations and almost 150 million people in SSA were afflicted by drought[48]. According to FAO[49], crop and livestock production losses due to these droughts totaled USD 23.5 billion, or around 77% of all production losses brought on by droughts globally over the same period. Given that not all losses are documented, the output losses brought on by the drought in SSA are likely much more significant. Drought has developed as a regular, recurring aspect of the climate in SSA due to its frequent occurrence characterized by an extended period of abnormally dry weather that results in serious hydrological imbalances[50]. While a lack of precipitation is the primary cause of droughts, other factors such as increased evapotranspiration-induced enhanced radiation, wind speed, and a vapor pressure deficit all play a significant role in developing dry conditions[51].

The Sahel countries, the Horn of Africa, and southern Africa are particularly vulnerable to drought since these regions have semi-arid and subhumid climates with a marked dry season in part of the year. A considerable chunk of SSA is susceptible to drought[52]. The alternating wet and dry seasons on yearly and decadal timescales are the fundamental characteristics of these arid and semiarid climates. Additionally, drought is exacerbated by human-induced problems, including desertification, land degradation, and deforestation, which limit rainfall and the capacity of the soil to retain moisture. On the other hand, drought worsens environmental degradation by causing deforestation, overgrazing by livestock, soil erosion, wildfires, a loss of biodiversity, and excessive groundwater resource extraction, which became apparent and pronounced in several SADC (Southern African Development Community) countries in 2015 and 2016[53]. In contrast to other extreme weather events, droughts are slow-onset events that affect large geographic areas for months or years at a time. Over 400 million people were affected by over 309 recorded drought occurrences between 1900 and 2016, resulting in 860,000 fatalities and over $5 billion in economic losses[54].

Additionally, droughts frequently intensify detrimental effects on hygienic standards and human health – increasing the occurrence of illnesses like cholera[55]. Additionally, as the UNISDR Regional Office for Africa noted in 2014, where unfavorable political or market conditions exist, drought can result in famine. Food shortages brought on by drought also have a negative influence on the nutritional quality of the afflicted populations. SSA is expected to see even more severe droughts due to the unknowable effects of climate change.

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[47] United Nations Framework Convention on Climate Change (UNFCCC). (2007). Climate change: Impacts, vulnerabilities and adaptation in developing countries. Bonn, Germany: Climate Change Secretariat.
[48] Food and Agriculture Organization (FAO). (2015b). Resilient livelihoods: Disaster risk reduction for food and nutrition security. Rome, Italy: FAO
[49] Food and Agriculture Organization (FAO). (2015a). The impact of natural hazards and disasters on agriculture and food security and nutrition: A call for action to build resilient livelihoods. Rome, Italy: FAO.
[50] Field, C. B., Barros, V., Stocker, T. F., Qin, Dokken, D. J., Ebi, K. L., Midgley, P. M. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
[51] Field, C. B., Barros, V., Stocker, T. F., Qin, Dokken, D. J., Ebi, K. L., . . . Midgley, P. M. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
[52] Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. Weather and Climate Extremes, 3, 67–79.
[53] CRED-MDAT (2016). What is the human cost of weather-related disasters (1995–2015)? Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED).
[54]CRED-MDAT (2016). What is the human cost of weather-related disasters (1995–2015)? Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED).
[55] United Nations International Strategy for Disaster Reduction (UNISDR) Regional Office for Africa. (2014). Disaster risk reduction in Africa: Status report on implementation of Africa Regional Strategy and Hyogo Framework for Action. Nairobi, Kenya: UNISDR Africa Regional Office

The majority of SSA is already at risk of 10 to 40% of seasons underperforming during the primary planting period[56]. This is attributable to the reality that drought formation and intensity are both influenced by inter- and intra-annual climate variability, which is especially vulnerable to the agricultural sector in SSA. As a result, famine often follows drought throughout Africa. The number of individuals reportedly affected by disasters in 2011 was 93% higher than normal due to food insecurity and famine brought on by drought[57].

1.1.3 Heatwaves

The World Bank[58] defines heat extremes as temperatures that are 3 and 5 standard deviations above the historical average (also known as 3- and 5-sigma events). According to Coumou and Robinson[59], monthly mean summer temperatures greater than the 3-standard-deviation threshold (also known as 3-sigma events) can be used as proxies for dangerous heat waves. Since 1950, most parts of the world have experienced an increase in daily temperatures that are extreme[60]. Extended regions have experienced monthly temperatures 3 standard deviations above the local mean due to extreme heat waves in many parts of the world[61]. Through the 21st century, it is anticipated that there will be more hot days, warm nights, and heat waves everywhere[62].

Sub-Saharan Africa is expected to experience more frequent and intense heat extremes as global temperatures rise, particularly under high-emission scenarios. These heat waves pose significant risks to human health, infrastructure, ecology, and agriculture. Direct health impacts include heat exhaustion, heat stroke, and increased mortality rates, with rural populations being particularly vulnerable due to inadequate nutrition and reliance on outdoor activities. The agricultural sector in SSA faces severe challenges from rising temperatures. Extreme heat events are likely to negatively impact crop yields, threatening food security in a region heavily dependent on agriculture for food, income, and employment. Even if global warming is limited to 2ºC, food production in SSA is expected to face significant risks. Additionally, extreme heat and drought conditions could lead to substantial livestock losses in rural areas, further exacerbating the region's vulnerability to climate change impacts.

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[56] Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. Weather and Climate Extremes, 3, 67–79.
[57] CRED-MDAT (2012). Disaster data: A balanced perspective. Issue No. 28. Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED)
[58] World Bank. (2013). Turn down the heat: Climate extremes, regional impacts, and the case for resilience. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC: World Bank Group
[59] Coumou, D., & Robinson, A. (2013). Historic and future increases in the global land area affected by monthly heat extremes. Environmental Research Letters, 8(3), 1–6
[60] Brown, S. J., Caesar, J., & Ferro, C. A. (2008). Global changes in extreme daily temperature since 1950. Journal of Geophysical Research: Atmospheres, 113(D5), 1–11.
[61] Coumou, D., & Robinson, A. (2013). Historic and future increases in the global land area affected by monthly heat extremes. Environmental Research Letters, 8(3), 1–6
[62] Steffen, W., Hughes, L., & Perkins, S. (2014). Heatwaves: Hotter, longer, more often. Climate Council of Australia Limited.

1.1.4 Tropical Cyclones

Tropical cyclones affecting SSA often develop in the Indian Ocean from April to December. Cyclones are among the most severe and devastating of all meteorological hazards because they frequently combine powerful winds with massive rainfall (storm surges), inflicting significant damage to social and economic infrastructure, significant household relocation, and fatalities[63]. The Indian Ocean islands and the coastlines of Eastern and Southern Africa are the regions of SSA that experience cyclone activity the most regularly. The infrastructure along the coast as well as maritime interests like offshore and fishing are seriously threatened by tropical cyclones. The Southwest Indian Ocean Basin experiences the formation of 12 to 16 tropical cyclones annually, of which roughly 25% make landfall and storms are responsible for about 35% of damages and losses because of the relatively high cyclone activity from November to May[64].

1.2 Climate Change Sensitivity, Vulnerability, and Adaptation

Human-induced climate change adds significant pressure to already-existing climate stresses and pressures on ecosystems and socio-economic sectors in Sub-Saharan Africa. For instance, the ecological and socioeconomic system of sub-Saharan Africa is susceptible to even small changes in climate due to the convergence of existing climate stress and recent extreme events in the area. Part of the main factor contributing to African agriculture's extreme sensitivity to climate change is low investment in the sector[65]. The effect of sensitivity involves the overall effect of climate change on yields of major cereal crops in the African region, which is very likely to be negative, with significant regional variation[66]. Sensitivity in this context includes the potentiality for significant negative consequences in the scenario in which adaptation capacity is weak, particularly because of poverty. For instance, it is implied that Sub-Saharan Africa, with its continued reliance on nature (natural resources), low levels of innovative responsive investment in agriculture, infrastructure, and directly productive capital goods, is unable to mitigate the effects of climate change. Therefore, SSA cannot benefit from the changes brought about by climate change due to its weak and limited adaptation capacity.

SSA is considered one of the most climate-vulnerable regions in the world. Climate change vulnerability could be referred to as the degree to which climate change could cause loss or damage to a system, and the degree of vulnerability is influenced by a system's capacity for adaptation as well as its sensitivity to be resilient to new situations. While Sub-Saharan Africa

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[63] United Nations International Strategy for Disaster Reduction (UNISDR) Regional Office for Africa. (2014). Disaster risk reduction in Africa: Status report on implementation of Africa Regional Strategy and Hyogo Framework for Action. Nairobi, Kenya: UNISDR Africa Regional Office

[64] World Bank. (2016). Striving toward disaster resilient development in sub-Saharan Africa: Strategic framework 2016– 2020. Washington, DC: World Bank Group.

[65] IPCC (1999): Climate Change Impacts, Adaptations and Mitigation of Climate Change: Scientific–Technical Analysis. Cambridge University Press.

[66] Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J, Urquhart P (2014) Africa. In: Climate change 2014: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

has the highest level of vulnerability than other regions in the world, natural systems such as ecosystems, hydrology, water resources, food production, and infrastructures including industry, energy, transportation, and health sectors suffer adaptation issues due to weak adaptation systems, resulting to a high level of vulnerability of the natural systems and infrastructure.

The existing institutional arrangements to address L&D in the Global South, particularly in Africa, cannot address permanent and noneconomic losses and damages as well as economic losses and damages of sudden and slow-onset events in a very limited and emergency manner. As a result, there have been many gaps in developing the adaptive capacity of communities in the Global South. Hence, there has been great dependence on funding arrangements for loss and damage from the international community which is different from adaptation funds aimed at supporting the adaptive capacity of climate-vulnerable communities to enable them to build resilience and strengthened adaptation approaches to reduce the impact of climate change.

Current trends indicate continued increases in scale, frequency, and affected populations in the future vulnerable to climate change-induced crises, calling for urgent prompt interventions to reduce the vast scale of climate change disasters leading to L&D which requires a more systematic and in-depth innovative scale-up of climate resilient and adaptation interventions for climate-vulnerable communities, especially most affected people, and areas.

2.0 STUDY GOAL AND OBJECTIVE

This research aims to enhance understanding of climate change impacts and adaptive strategies in Sub-Saharan Africa, informing policy and community-level interventions for improved resilience and intervention to climate change-induced loss and damage.

2.1 Study Objectives

The study's main objective is to assess climate change impacts, vulnerabilities, and adaptive responses in selected Sub-Saharan African countries, evaluate their effects on living standards, and propose country-specific recommendations for enhancing adaptive capacity and addressing LD.

Specifically, the study seeks to:

1. Assess the climate change impact, vulnerability, and adaptive responses in selected Sub-Saharan African countries (Liberia, Mozambique, Nigeria, Sudan, and Uganda)
2. Evaluate climate change's effects on living standards in climate-vulnerable communities in the selected Sub-Saharan African countries.
3. Analyze the adaptation responses in the selected Sub-Saharan African countries and differentiate between climate change-induced loss and damage and adaptation capacity
4. Propose country-specific recommendations for addressing climate change-induced loss and damage and improving the adaptive capacity of the study area.

2.2 Research Questions

1. What are the primary climate change impacts, vulnerabilities, and adaptive responses observed in Liberia, Mozambique, Nigeria, Sudan, and Uganda?
2. How has climate change affected the standard of living in climate-vulnerable communities in the selected Sub-Saharan African countries?
3. What adaptation plan, strategies, and solutions have the selected countries implemented in response to climate change, how effective have these strategies been, and what is the relationship between climate change-induced loss and damage and adaptation capacity in the selected countries?
4. What country-specific measures can be implemented to improve adaptive capacity and address LD due to climate change disasters?

2.3 Significance of Study

According to a study by Wainwright[67], Sub-Saharan Africa is a region, which is known as the most vulnerable climate region to multiple extreme climatic risks in the world. Countries in the region have poor coping mechanisms and hence experience massive loss and damage. This dire situation necessitates a study of the region. As a result, this study provides in-depth knowledge about L&D as well as the region's adaptation capacity. Thus, filling a knowledge gap and assisting policymakers and stakeholders in identifying key priority areas of intervention.

2.4 Scope of Study

This study covered specific countries of the Sub-Saharan region of Africa, particularly Mozambique, Sudan, Nigeria, Uganda, and Liberia while examining the impacts of climate change disasters and adaptation capacities in these countries. The study's target audience includes men, women, children, and youth aged 10 to 60. The study also looks at some predominant impacts of climate change in the region such as floods, droughts and cyclones (Storms) majorly from 2014 to 2024[68]. The study is guided through reviews of articles, publications, journals, and reports focused on the impacts of climate change-induced disasters and adaptation capacities to climate change among the countries under study in the Sub-Saharan region of Africa.

[67] Wainwright, C.M., Finney, D.L., Kilavi, M., Black, E., Marsham, J.H., 2021b. Extreme rainfall in East Africa, October 2019–January 2020 and context under future climate change. Weather 76, 26–3

[68] While the study scope primarily focused on the last decade (2013-2024) timeline, the literature review includes published journals, reports, etc. before the last decade. This is to explore historical trends and patterns for holistic findings.

3.0 STUDY METHODOLOGY

This study employs a cross-sectional research design to examine recent research on extreme climate events and climate change adaptation capacities in SSA through a systematic literature review, empirical data, and case studies. The research report is framed within the "integrationist school of thought" of the Climate Justice model, which emphasizes that climate change exacerbates existing disparities, disproportionately hurting poorer and more vulnerable groups, and is thus linked to distributive justice issues[69, 70], and should be understood interjectionally with socioeconomic and political challenges.

This perspective highlights how climate change exacerbates existing inequalities, disproportionately affecting vulnerable communities in developing countries, such as those in SSA, which have contributed the least to global greenhouse gas emissions. By adopting this approach, the study recognizes that climate change is not just an environmental issue but also a matter of distributive justice. It acknowledges that extreme climate events intensify issues related to human rights, economic development, resource allocation, and access to necessities like food, water, and healthcare. In this context, the research evaluates how climate change impacts in SSA are intertwined with broader societal vulnerabilities, particularly in the case study countries of Liberia, Mozambique, Nigeria, Sudan, and Uganda.

The study employs the IPCC assessment framework to assess the exposure, hazards, vulnerability, impact, and adaptation capacities of the study area, while also considering how climate policies and interventions affect land use, economic growth, and social equity. A comprehensive search of peer-reviewed articles and reputable organizational reports published within the last decade was conducted. Key databases such as Web of Science and Africa Journals Online were systematically searched using predefined terms including "climate change," "extreme weather events," "climate vulnerable communities," "loss and damage," "nature-based solutions," "adaptation," and "Sub-Sahara Africa." The inclusion criteria prioritized English-language publications specifically addressing climate change impacts and adaptation strategies in SSA countries.

Thematic analysis of the selected literature was carried out to identify recurring patterns, trends, and gaps in current knowledge. A structured data extraction form was developed to systematically collect and organize information from each source, including the IPCC assessment framework and reports on climate change events related to the study area. This approach examines the findings of the spatial and temporal patterns of climate extremes in SSA, as well as primary risks and adaptation capacities across different countries under study. The analysis also focused on identifying areas requiring further research or intervention, providing a compre-

[69] Caney, S. (2005). Cosmopolitan Justice, Responsibility, and Global Climate Change. Leiden Journal of International Law, 18(4), 747–775

[70] Caney, S. (2018). Justice and Future Generations. Global Justice: Theory Practice Rhetoric, 11(1), 75–91.

hensive overview of the current state of climate change response and adaptation in targeted countries. This methodological review contributes to a deeper understanding of SSA's climate challenges and informs future adaptation strategies and policies.

To further uncover the impact of climate change-induced L&D beyond the five target countries, case studies of other selected countries were developed and embedded into this study using qualitative research methodology.

4.0 CONCEPTUAL FRAMEWORK

The conceptual framework provides a detailed understanding of the impact of effects of climate change in Sub-Saharan Africa using the integrationist Climate Justice Model and the IPCC Assessment Framework to explore the intersectionality between the socio-economic factors of climate change impacts and the dimensions of assessing climate change impacts.

4.1 IPCC Assessment Framework

The study framework primarily addresses vulnerability (coping level) and sensitivity (impact level) to climate change and extreme events. The distinction between these concepts often remains implicit. This understanding is crucial as vulnerability exhibits specific characteristics: it is multi-dimensional and differential, varying across physical spaces and social groups; scale-dependent, affecting different units of analysis from individuals to entire systems; and dynamic, with its characteristics and driving forces evolving over time (Vogel and O'Brien, 2004)[71].

Given that vulnerability and sensitivity are not static conditions but rather dynamic states, understanding their trends becomes a critical aspect of climate change analysis. This recognition helps inform more effective adaptation strategies and policy responses, acknowledging that different social groups and regions may experience varying levels of impact from similar climate hazards. This dynamic perspective enables a more comprehensive approach to addressing climate change challenges across different scales, dimensions, and contexts.

[71] Vogel, C. and K. O'Brien, 2004: Vulnerability and Global Environmental Change: Rhetoric and Reality. AVISO 13, Global Environmental Change and Human Security Project, Ottawa, Canada

4.1.1 Environmental Dimension

The environmental dimension within the IPCC Conceptual Framework encompasses potentially vulnerable natural systems, including coastal zones, drylands, and mountain regions, along with their impacts, causal mechanisms, and adaptive responses. The environmental dimension recognizes that the environment and human beings form a socio-ecological system[72] that behaves in nonlinear ways, being strongly coupled, complex, and continuously evolving[73]. This understanding emphasizes the critical links between development, disaster reduction, and climate adaptation strategies, particularly in addressing the vulnerability of natural systems and their associated communities[74].

The environmental dimension also highlights the crucial role of regulating ecosystem services and functions that directly impact human well-being, especially for social groups heavily dependent on these services for their livelihoods. This dependency is particularly pronounced in developing countries and countries in transition, where poorer rural communities often rely entirely on ecosystem services to meet their basic needs. Environmental vulnerability in this context means that hazardous events can severely impact community access to essential resources, as demonstrated by the 2004 Indian Ocean tsunami, where well-salinization had devastating consequences for communities lacking alternative freshwater sources. This interconnection between environmental systems and human well-being underscores the importance of considering both ecological and social factors in vulnerability assessments.

4.1.1.1 Physical Dimensions

Physical vulnerability within environmental contexts encompasses the specific geographical and locational characteristics that shape human-environment interactions[75] and to the material world (built structures). While many communities have historically settled in hazard-prone areas for their associated benefits[76], climate change is expanding the spatial reach of natural hazards such as floods, droughts, and coastal salinization, increasing physical exposure in numerous regions. However, exposure alone doesn't automatically translate to vulnerability; communities may possess resilience capabilities against extreme events. The physical dimension of vulnerability considers multiple elements: the relationship between natural phenomena and affected populations, geographical characteristics, settlement patterns, and infrastructure conditions. This involves built structures in risky locations, as well as their structural integrity. Importantly, physical vulnerability has a temporal aspect, which requires evaluation methodologies that include both spatial and temporal dynamics in human-environment systems.

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4.1.1.2 Geography, Location and Place

The relationship between geography, location, and place reveals significant disparities in exposure and vulnerability between developing and developed countries. Developing countries face greater impacts with more vulnerable populations who struggle to adapt to changes in temperature, water resources, agricultural production, human health, and biodiversity[77]. Despite some adaptation efforts in these regions, progress has been limited, often focusing on public awareness and policy development rather than implementation[78]. Direct biophysical and economic influences cause vulnerability levels in developed countries to differ spatially. The investigation of 'disaster hotspots' shows that, while flood risks are ubiquitous, drought and cyclone risks follow different geographical patterns, with cyclone risk being closely related to climatological trends. Development does not ensure invulnerability; it might damage ecosystem resilience while also providing income, which may boost society's resilience if dispersed evenly[79]. This complex relationship emphasizes that indirect impacts, unequal vulnerabilities, and assumptions about adaptation capabilities in rich countries can lead to unforeseen setbacks[80], emphasizing that geography and development status together shape climate change vulnerability patterns.

4.1.2 Social Dimensions

The social dimension of vulnerability is multifaceted and interwoven, encompassing both collective societal and individual experiences. It largely focuses on broader social organization and takes into account individual-level repercussions, notably in understanding psychological trauma and family disruption during catastrophes[81]. This level consists of a variety of factors, including population patterns, migratory trends, education levels, health conditions, cultural features, and governance systems, all of which influence a community's vulnerability to climatic impacts.

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[77] IPCC, 2001: IPCC Third Assessment Report. Synthesis Report, Cambridge University Press, Cambridge, UK.
[78] UN/DESA, 2010: Trends in Sustainable Development in Small Island Development States. United Nations, New York, NY, USA, 40 pp. ISBN 978-92-1-104610-6
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[80] O'Brien, K., S. Eriksen, L. Sygna, and L.O. Naess, 2006: Questioning complacency: Climate change impacts, vulnerability, and adaptation in Norway. Ambio, 35(2), 50-56.
[81] Few, R., 2007: Health and climatic hazards: framing social research on vulnerability, response and adaptation. Global Environmental Change, 17, 281-295.

4.1.2.1 Demography

Different population groups experience varying levels of vulnerability to climate extremes based on demographic characteristics[82]. Age is an important influence, with children, women, pregnant women, and the elderly being more vulnerable to extreme weather events, particularly heat. Population aging trends at the community and national levels have an impact on a variety of susceptibility characteristics such as health status, social connections, economic capacity, family structures, and mobility. However, it is vital to remember that vulnerability is not static; rather than labeling specific groups as vulnerable, we must acknowledge that people's situations and resilience levels change over time.

4.1.2.2 Migration and Displacement

Migration patterns in response to climate-related events reveal complex dynamics of vulnerability and adaptation. Despite an increase in the number of hydrometeorological disasters from 1990-2009, their impact on international migration remained limited, with displacement typically being temporary and regional due to the financial constraints of affected people[83]. Displacement limits people's connections to their material and cultural resources[84], affecting access to housing, livelihoods, and common property resources, with particularly severe impacts on Indigenous communities whose identity and survival are intrinsically linked to their land. Although migration has historically served as an environmental coping mechanism and does not inevitably lead to negative outcomes[85], displacement often disrupts crucial social networks that vulnerable populations depend on for resource access during stress periods[86]. While climate variability influences population movement, establishing direct causal relationships and predicting affected populations remains challenging, highlighting the complex interplay between environmental change and human mobility.

4.1.3 Health and Wellbeing Dimension

Health vulnerability in the context of extreme weather events includes numerous dimensions of physical, physiological, and mental health consequences across areas and socioeconomic groups[87]. The impact of extreme occurrences on individuals and communities is influenced by both risk and protective variables[88]. This vulnerability extends to healthcare infrastructure

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[82] Gosling, S., G. McGregor, and J. Lowe, 2009: Climate change and heat-related mortality in six cities – part 2: climate model evaluation and projected impacts from changes in the mean and variability of temperature with climate change. International Journal of Biometeorology, 53(1), 31-51.
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[87] Costello, A., M. Abbas, A. Allen, S. Ball, S. Bell, R. Bellamy, S. Friel, N. Groce, A. Johnson, M. Kett, M. Lee, C. Levy, M. Maslin, D. McCoy, B. McGuire, H. Montgomery, D. Napier, C. Pagel, J. Patel, C. Patterson, J.A. Puppim de Oliveira, N. Redclift, H. Rees, D. Rogger, J. Scott, J. Stephenson, J. Twigg, and J. Wolff, 2009: Managing the health effects of climate change. The Lancet, 373(16), 1693-1733.
[88] Balbus, J.M. and C. Malina, 2009: Identifying vulnerable subpopulations for climate change health effects in the United States. Journal of Occupational and Environmental Medicine, 51, 33-37.

and service provision, which may be compromised during disasters through structural damage or access limitations. Particularly vulnerable populations include children, the elderly, pregnant women, disabled individuals, those in local traditional communities, culturally diverse groups, people without transport access, and those with chronic medical conditions or medication dependencies. Expected public health impacts from climate-related disasters range from worsening chronic illnesses to toxic exposures and fatalities, with severity varying by context and development level[89]. Effective public health response requires robust systems including disease surveillance, safe water access, food security, waste management, healthcare infrastructure maintenance, mental health services, shelter provision, and early warning systems.

4.1.4 Cultural Dimension

Culture shapes vulnerability through its diverse influences on societal behavior, perceptions, and responses to climate risks and disasters. This multifaceted concept encompasses risk perception, organizational responses, preventive actions, and the development of safety and adaptation practices within communities. Traditional cultural practices sometimes increase vulnerability such as through gender inequalities or outdated environmental practices. Conversely, Indigenous knowledge and local traditions enhance resilience and reduce risk[90]. Cultural aspects of vulnerability are often nuanced and complex, as demonstrated by early hazard studies that identified how culturally-embedded fatalism could lead to inaction in the face of disasters. Understanding these cultural dimensions is crucial for developing effective climate adaptation and adaptive management strategies that respect and incorporate local values while addressing potentially harmful traditional practices that may increase vulnerability to extreme events.

4.2 Climate Justice Model

The Climate Justice model explores how climate change affects countries disproportionately and how to mobilize resources for developing countries to respond to climate change events, especially countries or communities that are particularly vulnerable such as the Small Island Developing States (SIDS) and Least Developed Countries (LDCs). While these challenges require global action and pose significant threats to biodiversity, human health, and economies

[89] Keim, M.E., 2008: Building human resilience: the role of public health preparedness and response as an adaptation to climate change. American Journal of Preventive Medicine, 35, 508-516.
[90] Gaillard, J.C., 2007: Resilience of traditional societies in facing natural hazard. Disaster Prevention and Management, 16, 522-544.

worldwide, it is important to highlight that the climate change crisis significantly affects millions in the Global South. It remains a human-induced issue largely driven by developed countries, which massively contribute to greenhouse gas emissions. What responsibility do the top emitters have in mobilizing resources for those most affected by climate change due to their activities? This question is crucial in addressing the climate crisis.

To address climate change-induced loss and damage using the Climate Justice model, it is essential to point out that the Climate justice model has two distinct schools of thought known as Isolationism and Integrationism[91]. The Isolationist viewpoint holds that ethical issues surrounding climate change should be evaluated separately from broader social justice issues such as poverty, migration, and global inequality[92]. According to isolationists, isolating climate justice from ethical issues would simplify climate negotiations and eliminate the complications surrounding the ideas of justice[93]. The isolationist perspective contends that limited emphasis on climate justice with other ethical challenges could lead to more concrete answers to addressing climate change crises which would help prevent misleading conversation and information on climate change conversations with additional ethical layers[94].

Integrationists, on the other hand, believe that climate justice must be considered alongside other socioeconomic and political challenges. Integrationists argue that climate change overlaps with human rights, economic development, and resource allocation, affecting basic needs like food, water, and health. Climate change exacerbates existing disparities, disproportionately hurting poorer and more vulnerable groups, and is thus linked to distributive justice issues[95, 96]. Scholars like Simon Caney argued extensively for this integrationist approach to climate justice[97]. Caney's work contends that addressing climate change requires grappling with questions of responsibility - who has contributed to the problem, and who bears the burden of the impacts? Additionally, he asserts that climate justice must consider obligations to future generations who will inherit the effects of current climate change. Caney's research underscores how climate change intersects with intergenerational equity and the unequal distribution of environmental harm across societies.

From this perspective, attempting to address climate change without acknowledging its broader implications is both impractical and likely to result in unfair outcomes, as climate policies have an impact on land use, economic growth, and cultural rights[98]. It is on this argument and perspective that this research is built on as detailed below.

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[91] Caney, S. (2021). Climate justice. In E. N. Zalta (Ed.), The Stanford Encyclopedia of Philosophy (Winter 2021 Edition). Retrieved from https://plato.stanford.edu/archives/win2021/entries/justice-climate/
[92] Gosseries, A. (2005). On Future Generations' Future Rights. The Journal of Political Philosophy, 13(3), 281-294
[93] Blomfield, M. (2019). Global justice, natural resources, and climate change. Oxford University Press.
[94] Caney, S. (2018). Justice and Future Generations. Global Justice: Theory Practice Rhetoric, 11(1), 75–91
[95] Balbus, J.M. and C. Malina, 2009: Identifying vulnerable subpopulations for climate change health effects in the United States. Journal of Occupational and Environmental Medicine, 51, 33-37.
[96] Caney, S. (2018). Justice and Future Generations. Global Justice: Theory Practice Rhetoric, 11(1), 75–91.
[97] Caney, Simon, "Climate Justice", The Stanford Encyclopedia of Philosophy (Winter 2021 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/win2021/entries/justice-climate.
[98] Leichenko, R., & O'Brien, K. (2008). Environmental Change and Globalization: Double Exposures. Oxford University Press

4.2.1 Impacts of Climate Change-Induced Loss and Damage on Standard of Living of Study Areas

The research investigates the impact of climate change on the quality of life in communities that are especially vulnerable to environmental changes. It explores a range of factors, including food security, access to clean water, housing stability, health outcomes, and economic opportunities for these populations. The analysis encompasses both direct effects, such as extreme weather events, and indirect consequences, like shifts in agricultural productivity and emerging disease patterns.

4.2.1.1 Climate Change Impacts on Livelihoods and Food Security:

Numerous studies have shown that the agricultural industry in Sub-Saharan Africa is highly vulnerable to extreme weather patterns such as shifting rainfall patterns, heat waves, and rising temperatures. These continue to have a significant impact on the region's agricultural productivity, food security, and living conditions of people.

In Mozambique, floods and cyclones have caused displacement and decreased agricultural output[99]. Sudan has experienced droughts and irregular rainfall, reducing agricultural and livestock productivity[100]. Nigeria faces similar challenges, with temperature and rainfall shifts impacting agricultural yields and rural livelihoods[101]. These impacts particularly affect vulnerable communities such as coastal populations, smallholder farmers, and pastoralists, leading to increased food insecurity, loss of assets, and restricted market access across various countries in the region.

The impacts of climate change affect vulnerable communities such as coastal populations, smallholder farmers, and pastoralists in countries, including Uganda and Liberia[102, 103]. Developing climate-resilient farming systems, improving access to capital and markets, and implementing sustainable agricultural practices are crucial for enhancing resilience in the face of climate change.

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[99] Archer, E.R., et al. (2019). Climate change impacts in Mozambique: Implications for policy and action. Climatic Change, 154(3-4), 391-407
[100] Abdelhay, A., et al. (2020). Climate change and its implications for the Sudanese agriculture sector: An assessment of vulnerability and adaptive capacity. Climate, 8(2), 28
[101] Adetunji, M.O., & Ajayi, V.O. (2019). Climate change and agricultural productivity in Nigeria: A review. Journal of Earth Science and Climate Change, 10(2), 493.
[102] Lusah, F., et al. (2020). Climate change impacts on agriculture in Liberia: A review of vulnerability, adaptation, and mitigation strategies. Journal of Sustainable Development, 13(5), 39-50.
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4.2.1.2 Health and Well-being Challenges

In Sub-Saharan Africa, vulnerable groups' health and well-being are significantly impacted by climate change. It impacts community access to clean water and sanitation, spreads vector-borne diseases, and exposes more people to hunger and foodborne infections. According to Cissé[104], climate-related disasters like floods and cyclones have caused displacement in Mozambique and exposed vulnerable communities to malaria, the loss of clean water sources, damage to the sanitation infrastructure, and an increase in health issues like malnutrition and waterborne diseases. The threats to health and challenges associated with water scarcity are stressed in the text's consideration of the effects of climate change on water quality and availability[105]. Case studies highlight the health threats that underprivileged groups face. Water resource management, enhanced sanitation and hygiene, integrated water and health policies, climate-resilient infrastructure, community participation, and early warning systems should be advocated as mitigation and adaptation approaches[106]. A study by El-Tahir & Akur[107], claimed that in Sudan, a lack of clean water and inadequate sanitation continue to influence the health and well-being of disadvantaged people as Climate change is causing an increase in vector-borne diseases including malaria and dengue fever as well as the development of waterborne ailments. Climate change is linked to health issues in Nigeria, particularly for young people. Oduwaye[108], asserted that climate-related variations in temperature and rainfall patterns have an impact on food availability, nutritional quality, and agricultural output, increasing vulnerability to malnutrition and associated health complications. Malaria and other illnesses have also emerged in Uganda as a result of changing climatic patterns.

Improved access to healthcare services, disease surveillance and control, and community-based adaptation strategies that support resilient health systems are just a few of the integrated approaches required to address these health concerns[109].

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[104] Cissé, G., et al. (2018). The impact of climate change on health in Mozambique: A historical analysis of malaria cases from 1991 to 2014. Journal of Environmental and Public Health, 2018, 7628462.
[105] Pereira, L. S., Cordery, I., & Iacovides, I. (2009) Coping with water scarcity: Addressing the challenges. Springer Science & Business Media.
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[108] Oduwaye, L.O., et al. (2020). Impacts of climate change on health and well-being in Nigeria: A systematic review. Environmental Science and Pollution Research, 27(24), 30761-30775.
[109] Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014) Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. Weather and climate extremes, 3, 67-79. https://doi.org/10.1016/j.wace.2014.04.004

4.2.2.3 Infrastructure and Mobility

Urbanization, migration, and displacement are all linked to climate change. Climate-induced displacement occurs when people are compelled to leave their homes due to environmental factors[110]. This displacement has both social and economic consequences for livelihoods and social cohesion. Migrants and their host communities face two issues: integration and availability of necessities. Policies that address displacement and promote sustainable urbanization should prioritize resilience, assistance for migrants and host communities, sustainable urban environments, and international cooperation. Climate hazards should be considered, while essential assistance and services offered, and inclusive and eco-friendly urban planning should be supported through these policies[111]. Mozambique's coastline is particularly susceptible to flooding and sea level rise, which endangers homes and other essential infrastructure. In their research[112], found that flooding damages roads, bridges, and other transportation infrastructure, further limiting access to vital services. Sudan has frequently encountered increased flooding episodes, particularly in susceptible locations, which impede transportation, damaged roads, and endanger critical infrastructure. The provision of sanitary facilities and clean water services is impacted by the risk to the nation's water and sanitation systems[113]. Uganda's infrastructure is also susceptible to climate-related disasters, which often affect housing, water supply systems, and road networks. According to Byaruhanga & Waiswa[114], poor infrastructure resilience exacerbates the difficulties marginalized people experience and restricts their access to public services and job opportunities. Gargule[115], maintains that disadvantaged coastal communities in Liberia confront considerable obstacles when trying to access essential services and support sustainable livelihoods attributed to the infrastructure being deteriorated by coastal erosion, leading to increased floods, and sea level rise.

Investments in climate-resilient infrastructure, support for sustainable urban design, and adoption of adaptable measures that protect vital infrastructure from the effects of climate change are necessary to raise the standard of living and resilience of vulnerable areas[116].

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[110] Wilkinson, E., Kirbyshire, A., Mayhew, L., Batra, P., Milan, A., (2016). Climate-Induced Migration and Displacement: Closing the Policy Gap. Overseas Development Institute (ODI), London.
[111] Leochico, C. F. D., Di Giusto, M. L., & Mitre, R. (2021) Impact of scientific conferences on climate change and how to make them eco-friendly and inclusive: A scoping review. The Journal of Climate Change and Health, 4, 100042. https://doi.org/10.1016/j.joclim.2021.100042
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[113] Abdelhay, A., et al. (2020). Climate change and its implications for the Sudanese agriculture sector: An assessment of vulnerability and adaptive capacity. Climate, 8(2), 28.
[114] Byaruhanga, J., & Waiswa, D. (2020). Climate change impacts on infrastructure and the built environment in Uganda. International Journal of Environmental Science and Sustainable Development, 6(1), 18-24.
[115] World Bank. (2022). Climate-Resilient Infrastructure Officer Handbook. https://ppp.worldbank.org/public-private-partnership/library/climate-resilient-infrastructure-officer-handbook
[116] Gargule, A. (2019). Climate change impacts on coastal areas of Liberia: Vulnerability assessment and adaptation strategies. Journal of Environmental Science and Sustainable Development, 3(2), 15-25.

4.2.1.4 Ecosystem Degradation and Biodiversity Loss

In terms of ecosystem degradation and biodiversity loss, climate change poses significant concerns in Sub-Saharan Africa[117]. Shifting climate patterns disrupt ecosystems, resulting in the extinction of species and the loss of biodiversity. This has a negative impact on livelihoods that rely on ecological services like farming and fishing. Conservation and restoration measures are crucial to stop ecological degradation. These measures include preserving ecosystems, establishing protected areas, and restoring damaged habitats[118]. Community involvement and sustainable resource management are critical to bringing conservation in line with local practices and requirements and ensuring the sustainability of these programs. In SSA, addressing biodiversity loss and environmental degradation is crucial for preserving livelihoods and advancing sustainable development.

[117] Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. Weather and Climate Extremes, 3, 67–79.
[118] Mackey, B. G., Watson, J. E., Hope, G., & Gilmore, S. (2008) Climate change, biodiversity conservation, and the role of protected areas: an Australian perspective. Biodiversity, 9(3-4), 11-18.

5.0 VULNERABILITY AND COPING MECHANISM OF STUDY AREAS

5.1 Liberia Climate Change Impact and Vulnerability

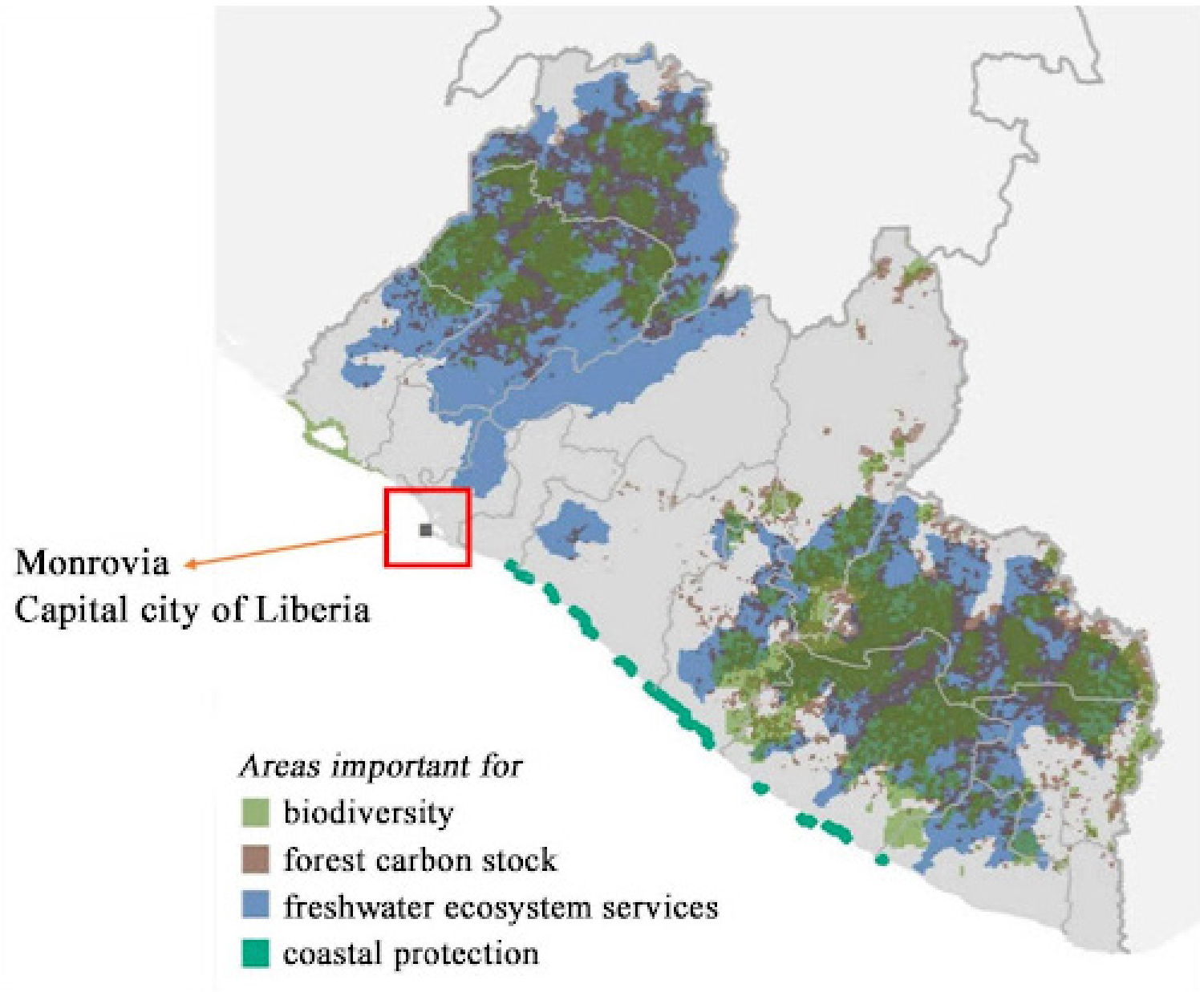

Figure 2. Climate change vulnerability map of Liberia[119]

[119] Togbah, C.F. (2014). An Analysis of Liberia's Vulnerability to Climate Change in the Context of Least Developed Countries (LDCs): A Review', AJCC, 3(2), p. 013. DOI: 10.4236/ajcc.2024.132013.

In Liberia, coastal erosion has an adverse effect on residents and the overall population[120,121,122,123]. It results in the erasure of cultural traditions, the dislocation of infrastructure, an increase in groundwater salinity, and food shortages[124]. Liberia is negatively impacted by flooding influenced by climate change, endangering both populations and the country's economy[125]. Over half of Liberia's population interacts with the ocean and lives in precarious conditions, making the country's coastal erosion problem particularly significant[126]. Due to the low-lying coastline, the nation is particularly susceptible to climatic extremes[127]. Already, erosion has destroyed thousands of properties and displaced people to live in poorer conditions[128].

According to studies, a one-meter increase in sea level will have terrible consequences in the future and render the area even more vulnerable and unable to prepare for or reduce future storm surges[129, 130]. Coastal erosion has been linked to anthropogenic processes such as sea level rise, the destruction of mangroves, and unlawful sand mining[131, 132]. In Liberia, nine out of fifteen counties, or more than 58% of the country's population, were found to have experienced and continue to experience coastal erosion[133]. When factors like substandard housing and living conditions are taken into account, it gives a better understanding of the severity and veracity of the disaster in addition to other sea level rise impacts like catastrophic flooding experienced by residents in the country[134].

5.1.1 Adaptive Responses to Impacts of Climate Change in Liberia

The Liberian government has tried to implement measures to reduce flood risks and coastal erosion, such as building revetment walls around the worst-affected areas[135]. These efforts were ineffective as they lacked adequate research and community stakeholder engagement in the mitigation and adaptation plan[136]. These efforts were ineffective as they lacked adequate

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[120] Williams, A. T., Rangel-Buitrago, N., Pranzini, E., & Anfuso, G. (2018). The management of coastal erosion. Ocean & Coastal Management, 156, 4–20. https://doi.org/10.1016/j.ocecoaman.2017.03.022
[121] Buser, M. (2020). Coastal Adaptation Planning in Fairbourne, Wales: lessons for Climate Change Adaptation. Planning Practice & Research, 1–21. https://doi.org/10.1080/02697459.2019.1696145.
[122] Tourlioti, P. N., Portman, M. E., Tzoraki, O., & Pantelakis, I. (2021). Interacting with the coast: Residents' knowledge and perceptions about coastal erosion (Mytilene, Lesvos Island, Greece). Ocean & Coastal Management, 210, 105705. https://doi.org/10.1016/j.ocecoaman.2021.105705
[123] Strain, E. M. A., Kompas, T., Boxshall, A., Kelvin, J., Swearer, S., & Morris, R. L. (2022). Assessing the coastal protection services of natural mangrove forests and artificial rock revetments. Ecosystem Services, 55, 101429. https://doi.org/10.1016/j.ecoser.2022.101429
[124] Tourlioti, P. N., Portman, M. E., Tzoraki, O., & Pantelakis, I. (2021). Interacting with the coast: Residents' knowledge and perceptions about coastal erosion (Mytilene, Lesvos Island, Greece). Ocean & Coastal Management, 210, 105705. https://doi.org/10.1016/j.ocecoaman.2021.105705.
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[126] Awange, J. L., Saleem, A., Konneh, S. S., Goncalves, R. M., Kiema, J. B. K., & Hu, K. X. (2018). Liberia's coastal erosion vulnerability and LULC change analysis: Post-civil war and Ebola epidemic. Applied Geography, 101, 56–67. https://doi.org/10.1016/j.apgeog.2018.10.007
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[130] UNDP Climate. (2018). Defending the Coast by UNDP Climate on Exposure. https://undp-climate.exposure.co/defending-the-coast.
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Audit: Auditing for Sustainable Development. Www.youtube.com. https://www.youtube.com/watch?v=6Wk6gtMnJ4Q&ab_channel=GIZ
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[133] UNDP-Liberia. (2021). The Mayor of Monrovia launches GCF-financed climate resilience project | UNDP Climate Change Adaptation. Www.adaptation-Undp.org. https://www.adaptation-undp.org/node/6802
[134] Wilson, E. T. (2021). Liberia's Coastal Zone -TNA Report, Republic of Liberia Coastal Zone's Technology Needs Assessment for Climate Change Adaptation https://c2e2.unepccc.org/wp-content/uploads/sites/2/2021/08/website-tna-tap-final-coastal-zone-liberia-e-tenesee-wilson.pdf
[135] UNDP-Liberia. (2021). The Mayor of Monrovia launches GCF-financed climate resilience project | UNDP Climate Change Adaptation. Www.adaptation-Undp.org. https://www.adaptation-undp.org/node/6802
[136] UNDP-Liberia. (2021). The Mayor of Monrovia launches GCF-financed climate resilience project | UNDP Climate Change Adaptation. Www.adaptation-Undp.org. https://www.adaptation-undp.org/node/6802

research and community stakeholder engagement in the mitigation and adaptation plan. The government was compelled to develop and implement intervention strategies for afflicted areas impacted by severe floods that devastated homes and animals and uprooted communities[137]. They were ineffective and short-lived since they were rushed[138]. Based on research done in three communities—the Borough of New Kru Town, West Point, and Buchanan—within two coastal counties—Montserrado and Grand Bassa— the study examined the effectiveness of the coastal intervention projects established by the Liberian government in response to environmental issues faced by the three communities[139]. The findings revealed that coastline erosion contributed to the massive destruction of properties and displacement of thousands of people in the three communities. According to a separate study, West Point's population fell from about 85,000 to 50,000 in less than ten years due to erosion, which damaged schools, sewage facilities, a soccer field, and coconut palm groves along the shoreline[140], putting residents' health and welfare in danger[141].

According to a study by Casell and Casell[142], flooding has continued to be a persistent hazard in Liberia, while droughts are expected to intensify over time.

Figure 3. Subdivision of Liberia pointing to the study areas[143]

[137] Wilson, E. T. (2021). Liberia's Coastal Zone -TNA Report, Republic of Liberia Coastal Zone's Technology Needs Assessment for Climate Change Adaptation https://c2e2.unepccc.org/wp-content/uploads/sites/2/2021/08/website-tna-tap-final-coastal-zone-liberia-e-tenesee-wilson.pdf
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[139] FPA Staff Reporter. (2019). Liberia: Atlantic Ocean Washes Away 72 Homes in West Point. FrontPageAfrica. https://frontpageafricaonline.com/news/liberia-atlantic-ocean-washes-away-72-homes-in-west-point/
[140] FPA Staff Reporter. (2019). Liberia: Atlantic Ocean Washes Away 72 Homes in West Point. FrontPageAfrica. https://frontpageafricaonline.com/news/liberia-atlantic-ocean-washes-away-72-homes-in-west-point/
[141] Williams, Maria-Rhoda. (2022). "Investigating the impact of coastal erosion at coastal communities in Liberia". World Maritime University Dissertations. 2094. https://commons.wmu.se/all_dissertations/2094.
[142] Cassell, L. T., & Cassell, (2019) A. Response to Public Health Disaster-A Review of Preparedness to Disasters in Liberia.
[143] Williams, Maria-Rhoda. (2022). "Investigating the impact of coastal erosion at coastal communities in Liberia". World Maritime University Dissertations. 2094. https://commons.wmu.se/all_dissertations/2094.

As illustrated in Figure 3, between 1969 and 2009, several counties of Liberia experienced severe climate-induced disasters, causing significant damage to properties and loss of life. In 2007, Margibi County saw 2,500 people affected, with an inadequate response to the situation; in 2009, Nimba, Sinoe, Grand Cape Mount, and Lofa counties faced the destruction of houses, trees, livestock, and banana plants, with insufficient support from the government to strengthen adaptive measures and climate-induced disaster intervention programs. Balehweh experienced an intense erosion that washed 250 square meters of beach land since 1969. Monrovia also faces a mid-June climate event that displaces an average of 600 people every year. However, efforts to address these issues have remained inadequate[144].

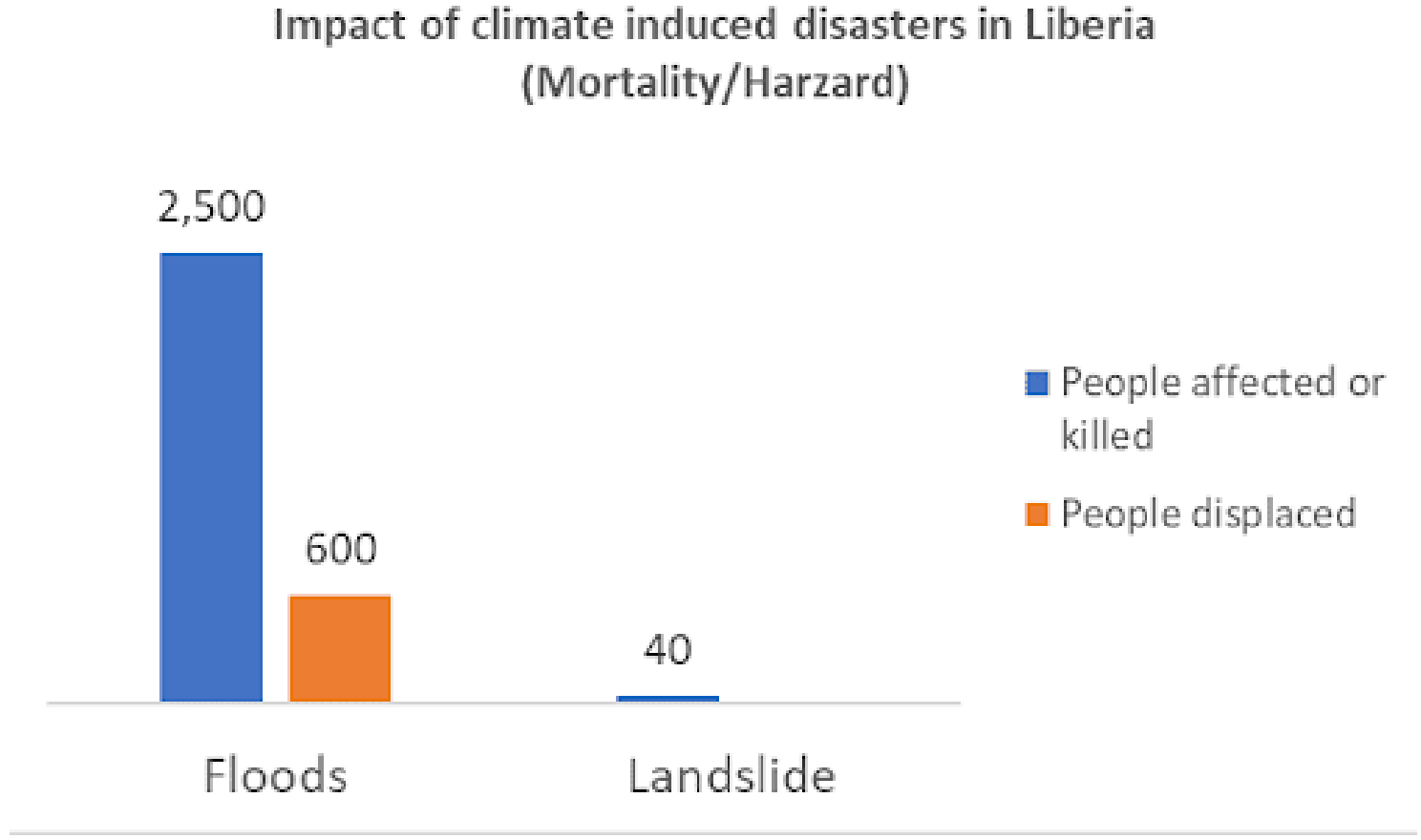

Figure 4. Impact of Climate Change Disasters in Liberia[145]

[144] Cassell, L. T., & Cassell, (2019) A. Response to Public Health Disaster-A Review of Preparedness to Disasters in Liberia

[145] Cassell, L. T., & Cassell, (2019) A. Response to Public Health Disaster-A Review of Preparedness to Disasters in Liberia

5.2 Mozambique Climate Change Impact and Vulnerability

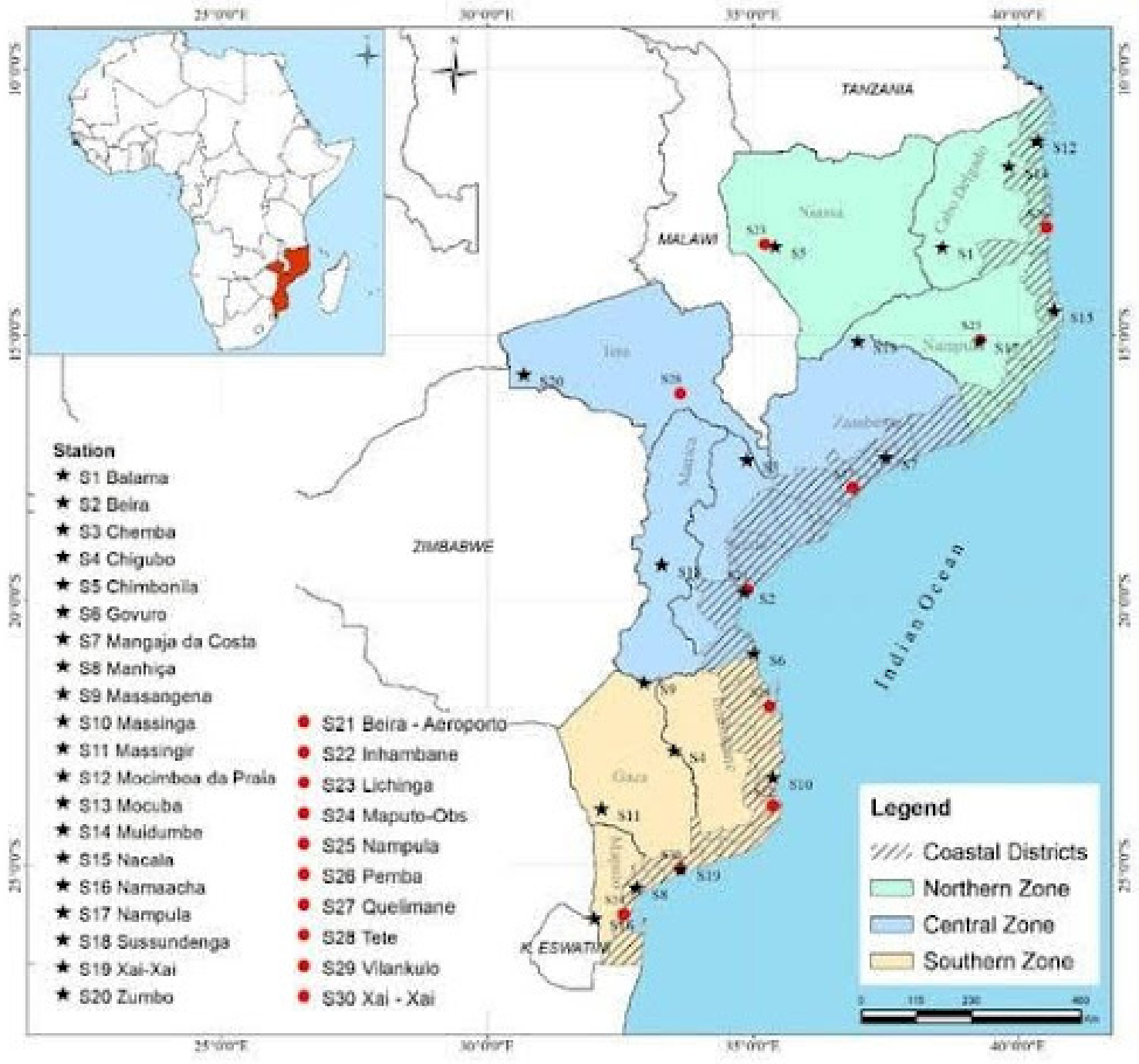

Figure 5: Climate Change Impact and Vulnerability Map of Mozambique[146]

[146] Mavume, A.F., Banze, B.E., Macie, O.A., and Queface, A.J. (2021) 'Analysis of Climate Change Projections for Mozambique under the Representative Concentration Pathways', Atmosphere, 12(5), p. 588. Available at: https://doi.org/10.3390/atmos12050588.

Following the severe droughts in 2015–2016, Mozambique was struck by the deadliest and most destructive cyclones ever recorded, Ida and Kenneth, respectively[147]. In 2015 and 2016, Mozambique had the worst drought ever recorded in more than three decades of below-average rainfall with a significant impact on the agricultural sector[148]. An estimated 648 people were killed, 420,000 were displaced, 1,700 were injured, and over 2 million people were in urgent need of humanitarian aid as a result of the cyclones: Idai and Kenneth[149]. In addition, over 280,000 buildings, 3000 classrooms, and 100 healthcare facilities were destroyed[150, 151] It was considerably more challenging to give relief to victims because of the extended blackouts and lack of

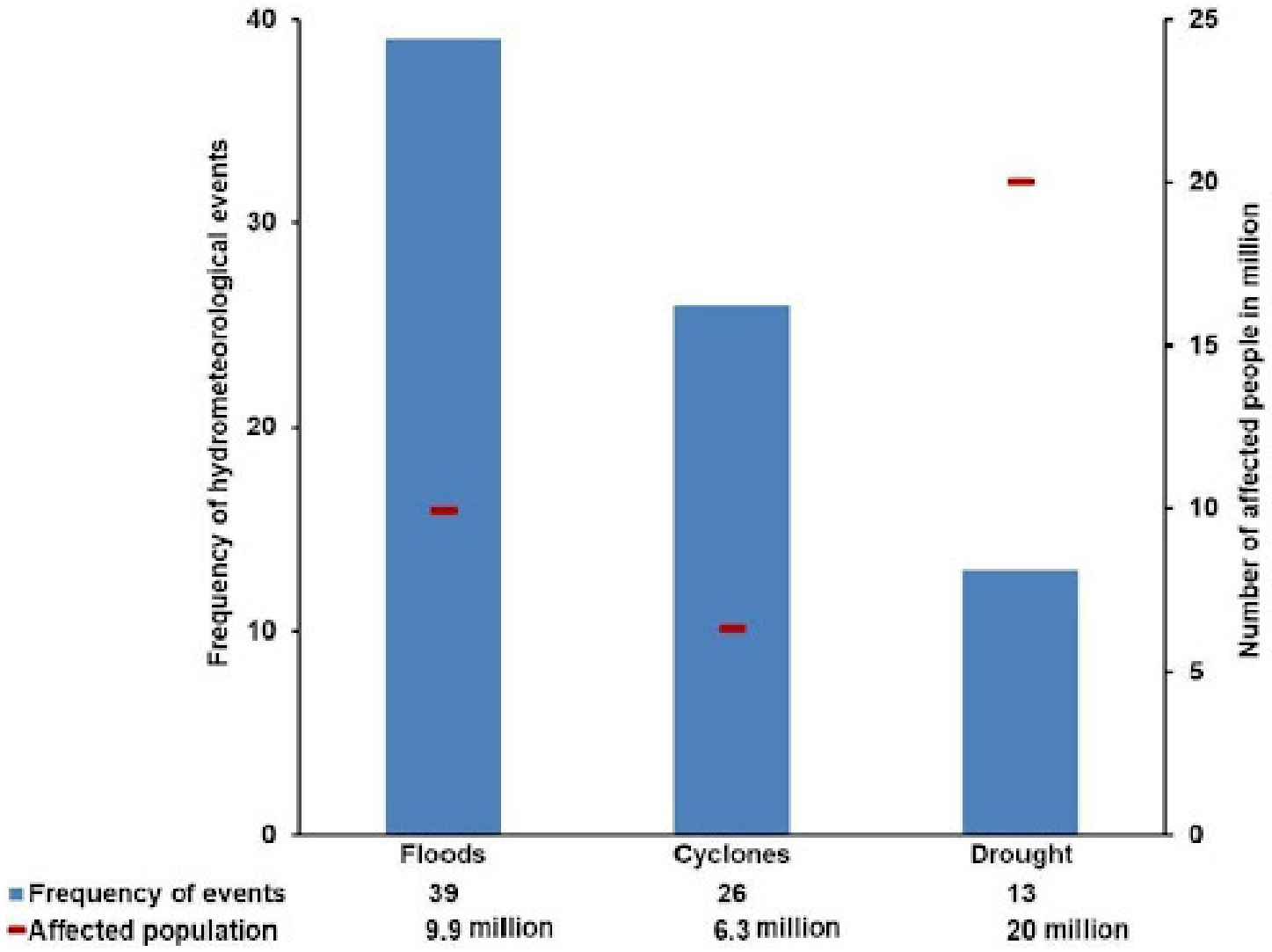

Figure 6: Frequency of hydrometeorological events and the number of people impacted in Mozambique between 1956 and 2020[157]

[147] Mugabe, V. A., Gudo, E. S., Inlamea, O. F., Kitron, U., & Ribeiro, G. S. (2021). Natural disasters, population displacement and health emergencies: multiple public health threats in Mozambique. BMJ global health, 6(9), e006778. https://doi.org/10.1136/bmjgh-2021-006778

[148] WFP. (2017). Report on the RIASCO Action Plan for the El Niño – Induced Drought in Southern Africa. https://reliefweb.int/report/world/report-riasco-action-plan-el-ni-o-induced-drought-southern-africa-20162017

[149] MISAU, INS O. (2019).Tropical Cyclones Idai and Kenneth Mozambique – National Situation Report 4. https://www.afro.who.int/publications/tropical-cyclones-idai-and-kenneth-mozambique-national-situation-report-4 [Accessed 14 June 2023].

[150] OCHA. (2019). Southern Africa: Tropical Cyclone Kenneth Flash Update No. 7. https://reliefweb.int/report/mozambique/southern-africa-tropical-cyclone-kenneth-flash-update-no-7-2-may-2019 [Accessed 14 June 2023].

[151] HCT (Humanitarian Country Team) & United Nations Resident, Mozambique CO in. (2019). 2018-2019 Mozambique Humanitarian Response Plan Revised following Cyclones Idai and Kenneth, May 2019 (November 2018

[157] Mugabe, V. A., Gudo, E. S., Inlamea, O. F., Kitron, U., & Ribeiro, G. S. (2021). Natural disasters, population displacement and health emergencies: multiple public health threats in Mozambique. BMJ global health, 6(9), e006778. https://doi.org/10.1136/bmjgh-2021-006778

electricity to operate the telecommunications, numerous locals experienced severe damaging and unavoidable losses[152]. According to Mugabe[153], the overall L&D resulting from the Idai and Kenneth cyclones evaluated in 2019 was roughly $2.8 billion, and the total amount needed for recovery was predicted to be about $3.2 billion. The Idai and Kenneth cyclones exacerbated the deficiencies in WASH service provision, resulting in an increased risk of infection and disease outbreaks[154]. According to studies, following cyclone Idai, diarrhea cases spiked across numerous regions ranging from 1.2 to 3.8 times compared to the same period last year[155]. Following both cyclones, there was an increase in malnutrition, particularly among children aged 6 to 59 months[156].

The vulnerabilities were further exacerbated in 2021 when hailstorms, with hail of varying sizes (0.5 cm to 4.5 cm) severely damaged the Northern districts of Matulo and Mapotu. As a result, prices of food and vegetables surged[158], leading to harsh drought and acute food insecurity for more than 2.1 million people[159, 160]. Whenever hailstorms and other climate-induced catastrophes occur, vulnerable communities in Mozambique record large economic losses, notably in agriculture[161, 162]. The country's ability for resilience has been seriously undermined by these events, among other factors, and the rising population densities in some locations have only made matters worse. Over the past two decades, these disasters' effects and severity have grown, and it is anticipated that they will get worse over the coming years[163].

5.2.1 Adaptive Response of Climate Change Impact in Mozambique

Mozambique has attempted to address climate change issues by incorporating specific climate change plans into the country's national development plans and policies. Among these initiatives, is the 2012 National Climate Change Adaptation and Mitigation Strategy for 2013 to 2025[164] aims to promote crop resilience and conserve agricultural lands. Additionally, the Ministry of Agriculture and Food Security developed the Climate Smart Agriculture Plan; to boost productivity and seed resilience by improving knowledge management and enabling farmers to adopt climate-smart

[152] SADC. (2019). SADC Regional Humanitarian Floods Appeal in Response to Tropical Cyclone IDAI. https://reliefweb.int/report/mozambique/sadc-regional-humanitarian-floods-appeal-response-tropical-cyclone-idai-enptMugabe, V. A., Gudo, E. S., Inlamea, O. F., Kitron, U., & Ribeiro, G. S. (2021). Natural disasters, population displacement and health emergencies: multiple public health threats in Mozambique. BMJ global health, 6(9), e006778. https://doi.org/10.1136/bmjgh-2021-006778 [Accessed 14 June 2023].

[153]Mugabe, V. A., Gudo, E. S., Inlamea, O. F., Kitron, U., & Ribeiro, G. S. (2021). Natural disasters, population displacement and health emergencies: multiple public health threats in Mozambique. BMJ global health, 6(9), e006778. https://doi.org/10.1136/bmjgh-2021-006778

[154] UNICEF. (2017), Water, sanitation and hygiene (WASH): https://www.unicef.org/mozambique/en/water-sanitation-and-hygiene-wash [Accessed 14 June 2023.

[155] Gujral L., Sema C., Rebaudet S., (2013). Cholera epidemiology in Mozambique using national surveillance data. J Infect Dis 2013;208 Suppl 1:S107–14.

[156] WHO., MISAU., INS. (2019). Early Warning and Response System (EWARS). https://malert.ins.gov.mz/login?next=/advanced-query [Accessed 14 June 2023].

[158] Bernardo, B. J., Nhambire, E., Freia, A., de Jesus, O. M., Guambe, J. J. J., Ombe, Z., & Dgedge, G. (2022b). Impacts of hailstorm on urban agriculture in Northern Maputo City and Matola (Mozambique)-An analysis from a climate change perspective: An analysis from a climate change perspective. Cadernos de Geografia, (46), 51-64.

[159] Sida. (2019). Mozambique multidimensional poverty analysis: status and trends. https://sidase-wp-files-prod.s3.eu-north-1.amazonaws.com/app/uploads/2020/12/01095839/mozambique-mdpa.pdf [Accessed 10 June 2023].

[160] CARE. (2016). El Niño Drought Crisis in Southern Africa. Vol. 75. https://www.care-international.org/files/files/18082018SouthernAfricaRegionalFactsheet.pdf [Accessed 10 June 2023].

[161] Gelcer, E., Stevens, F. R., Montone, V. & Fraisse, C. W. (2016). Effects of El Niño Southern Oscillation (ENSO) On Agroclimatic Zoning for Tomato in Mozambique. University of Florida.

[162] Finger, R., Lehmann, N. (2012). The influence of direct Payments on farmers' hail insurance decisions. Agricultural Economics, 43(3), 343–354. https://doi.Org/10.1111/j.1574-0862.2012.00587.

[163] Manuel, L., Chiziane, O., Mandhlate, G., Hartley, F., & Tostão, E. (2021). Impact of climate change on the agriculture sector and household welfare in Mozambique: an analysis based on a dynamic computable general equilibrium model. Climatic Change, 167, 1-18.

[164] Monjane R, King P, Rasmussen J (2018) Mozambique: Peasant farmers adaptation to climate change. https://viacampesina.org/fr/wp-content/uploads/sites/4/2018/06/report_mozambique_english_print.pdf

techniques[165]. Despite several adaptable measures that were put in place to lessen the effects of hail on crops, including tree belts that operate as hail interceptors and anti-hail nets placed over crops, all have proved to be ineffective[166]. Also, some monitoring and detection systems have been developed to observe meteorological events. However, due to their inefficiency and the characteristics of hail, there are still several difficulties to be overcome[167, 168, 169].

5.3 Climate Change Impacts and Vulnerability in Nigeria

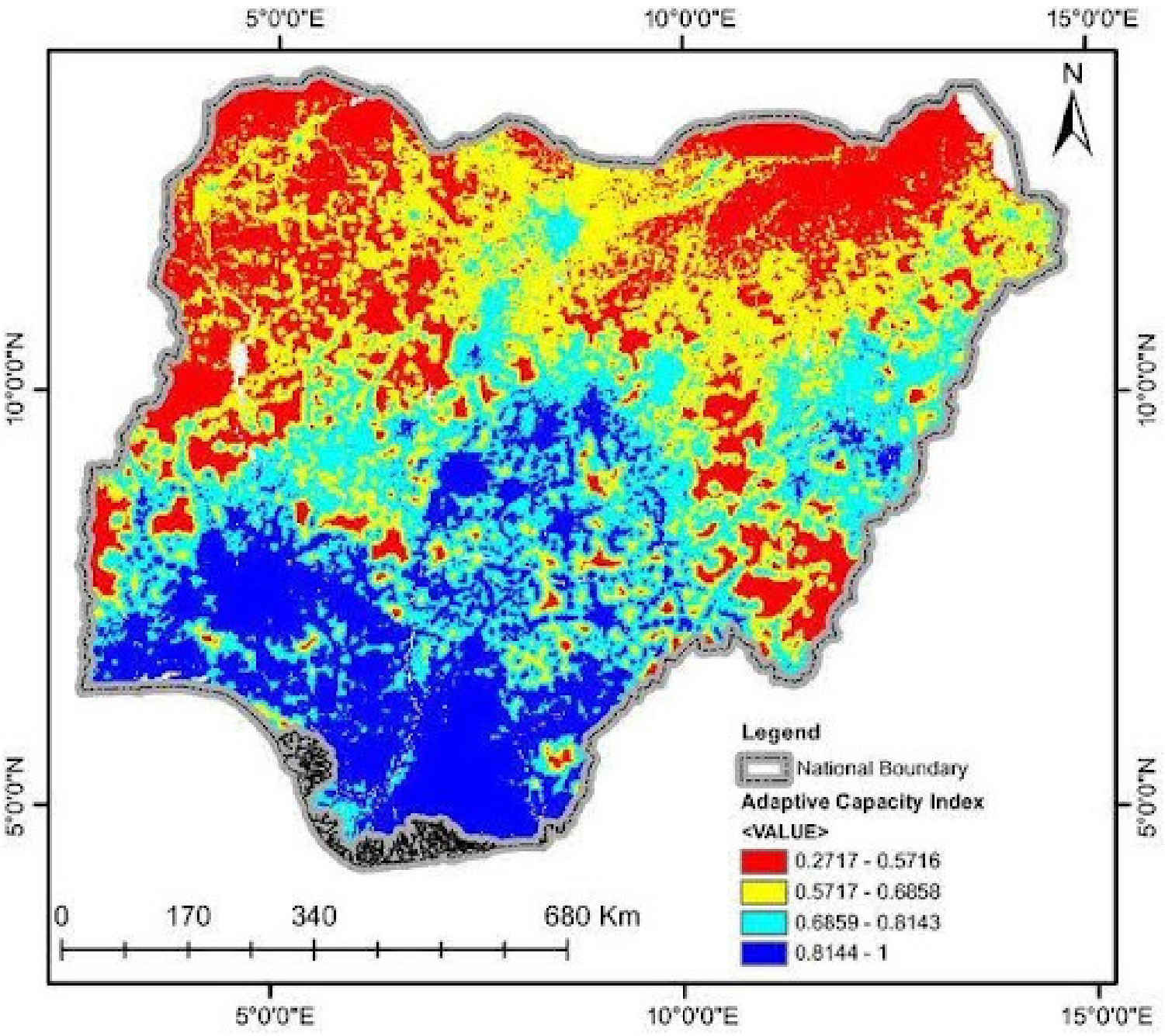

Figure 7. Climate change disaster and impact map of Nigeria[170]

[165] Ministério da Agricultura e Segurança Alimentar/MASA. (2020). Plano de Acção para Adaptação da Agricultura às Mudanças Climáticas, 2015-2020. Maputo

[166] Bal, S. K., Saha, S., Fand, B. B., Singh, N. P., Rane, J. &M P. S. (2014). National Institute of Abiotic Stress Management Hailstorms: Causes, Damage and Post-hail Management in Agriculture. Technical Bulletin No. 5, National Institute of Abiotic Stress Management, Malegaon, Baramati. https://doi.org/DOI:10.13140/2.1.4841.7922

[167] Martins, J. A., Brand, V. S., Capucim, M. N., Felix, R. R., Martins, L. D., Freitas, E. D., & Cecil, D. J. (2017). Climatology of destructive hailstorms in Brazil. Atmospheric Research, 184, 126–138. https://doi.org/10.1016/j.atmosres.2016.10.012

[168] Caldana, N. F. Da S., Silva, G. M. F. Da, Martelócio, A. C., Nitsche, P. R. & Caramori, P. H. (2020). Caracterização Das ocorrências de precipitação de granizo e seus Impactos socioeconômicos no estado do Paraná. Agrometeoros , 27(2), 271–28 4. https://doi.org/10.31062/agrom.v27i2.26455

[169] Blair, S. F., Laflin, J. M., Cavanaugh, D. E., Sanders, K. J., Currens, S. R., Pullin, J. I., & Mallinson, H. M. (2017). High-resolution hail observations: Implications for NWS warning operations. Weather and Forecasting, 32 (3), 1101–1119. https://doi.org/10.1175/WAF-D-16-0203.1

[170] Lawal, O. & Adesope, O. (2021) 'Geospatial Analysis of Maize Yield Vulnerability to Climate Change in Nigeria', GeoJournal. DOI: 10.1007/s10708-019-10099-x.

Recent studies have highlighted Nigeria's increasing vulnerability to climate change impacts, particularly along its coastal regions. Merem[171] identified Nigeria as one of four Sub-Saharan African nations with substantial storm surge zones, emphasizing that the risk to coastal populations from rising sea levels and violent storms will increase in the coming decades. The study also noted that several southern states, including Bayelsa, Rivers, Lagos, Delta, and Cross Rivers, are at higher risk of submersion due to a sea-level rise.

Climate change-induced events have led to severe consequences in Nigeria. Study by Shiru[172] projected that temperatures across all Nigerian ecological zones may increase, leading to aggravated drought severity in the northeast and more frequent steep rainfall in the southeast and southern regions. The 2022 flood, described as the most severe in the past decade, affected 33 of Nigeria's states, as reported by the International Federation of Red Cross and Red Crescent Societies[173]. This disaster resulted in over 2,000 deaths, 2,500 casualties, and the displacement of over 2 million people, significantly impacting access to safe water, transportation, sanitation, health, and food security.

Furthermore, recent research has also reported the compounding effects of climate change on human security and socio-economic conditions. Ani[174] noted that climate crises have led to resource scarcity, resulting in conflicts and forcing groups like herdsmen to arm themselves for protection. Ajimobi, in a research[175] emphasized that poor regulations, inadequate adaptive capacity, and weak mitigation frameworks, when combined with climate change impacts, exacerbate flood-related losses and damages. The study also reported on the severe floods of 2018 which led to increased vulnerability for millions of people in Nigeria. In addition, the Nigerian government reported that the 2022 flood alone displaced over 2 million people, destroyed more than 82,000 homes, and submerged about 332,327 hectares of land.

5.3.1 Adaptive Response of Climate Change Impact in Nigeria

Nigerians have developed various adaptive strategies at both community and individual levels in response to climate change-induced loss and damage disasters. Many rural communities have adjusted their agricultural practices, adopting drought-resistant crop varieties and diversifying their farming activities to reduce vulnerability to erratic weather patterns. In urban areas, residents have begun implementing rainwater harvesting systems and constructing flood barriers to mitigate the impacts of increased flooding. Some coastal communities have started relocating to higher ground or reinforcing existing structures to withstand rising sea levels and storm surges.

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[171] Merem, E. C., Twumasi, Y., Wesley, J., Alsarari, M., Fageir, S., Crisler, M., ... & Washington, J. (2019). Regional assessment of climate change hazards in Southern Nigeria with GIS. Journal of safety engineering, 8(1), 9-27
[172] Shiru, M. S., Shahid, S., Dewan, A., Chung, E. S., Alias, N., Ahmed, K., & Hassan, Q. K. (2020). Projection of meteorological droughts in Nigeria during growing seasons under climate change scenarios. Scientific reports, 10(1), 1-18
[173] International Federation of Red Cross and Red Crescent Societies (IFRC) Nigeria | Flood (2023). https://www.ifrc.org/media/52079
[174] Ani, K. J., Anyika, V. O., & Mutambara, E. (2022). The impact of climate change on food and human security in Nigeria. International Journal of Climate Change Strategies and Management, 14(2), 148-167
[175] Ajumobi, VE, Womboh, SB; Ezem, SB (2023). Impacts of the 2022 Flooding on the Residents of Yenagoa, Bayelsa State, Nigeria. Greener Journal of Environmental Management and Public Safety, 11(1): 1-6.

The Nigerian government has also taken steps to support these adaptive responses by establishing the Department of Climate Change within the Federal Ministry of Environment responsible for coordinating national climate change efforts. The government has initiated programs to promote climate-smart agriculture, improve early warning systems for extreme weather events, and enhance disaster preparedness. Additionally, Nigeria has been actively seeking international support and funding for climate adaptation projects, recognizing the need for significant resources to address the growing challenges posed by climate change-induced disasters.

5.4 Climate Change Impacts and Vulnerability in Sudan

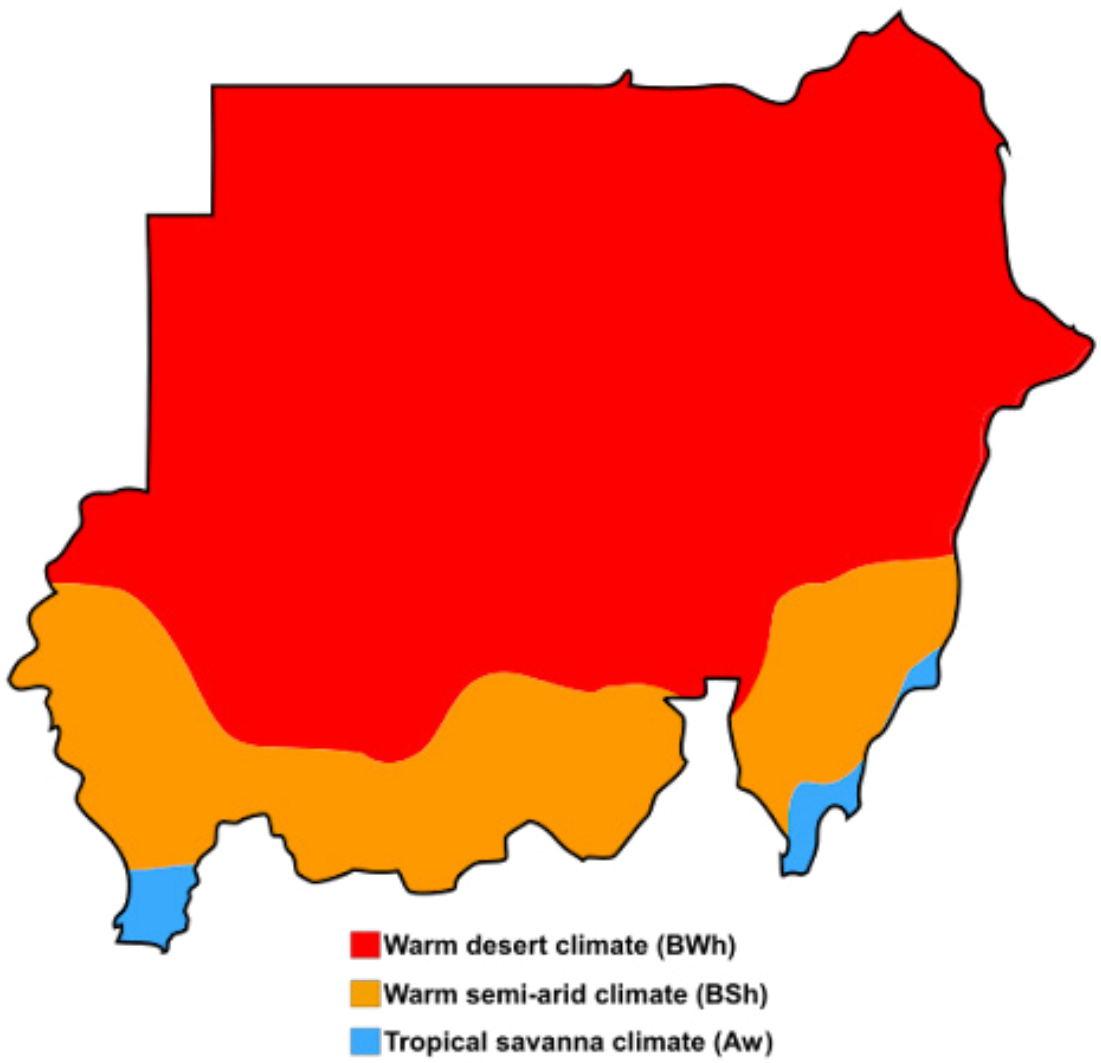

Figure 8. Climate Change Vulnerability and Impact Map in Sudan[176]

[176] Searcy, K. (2018) Sudan in Crisis', Origins. Available at: https://origins.osu.edu/article/sudan-darfur-al-bashir-colonial-protest?language_content_entity=en (Accessed: 13 December 2024).

Sudan has a savannah climate and is located in the Nile Valley's middle and upper reaches, with an annual precipitation rate of about 175mm[177]. Sudan has a history of consistent and severe floods. Many Sudanese districts, including the capital city of Khartoum, have witnessed devastating flash floods caused by extreme weather occurrences[178]. The situation is exacerbated by the country's high level of vulnerability to climate change-induced disaster, as well as the country's weak disaster preparedness and infrastructure.

The flood disaster in central Sudan in 1999 destroyed over 30,000 houses, damaged over 64000 structures, impacted over 1.8 million people, and relocated many people[179]. In 2007, a flood affected over 420,000 people, displaced over 84000, killed around 153 individuals, and left many more injured and exposed to extreme vulnerability[180]. In 2019, a flood killed around 78 people, affected over 426,000 people, destroyed over 49,000 dwellings damaged approximately 35,000 houses, and forcibly displaced many people, leading to even greater vulnerability and cutting off assistance and relief services to over 132 villages[181].

Figure 9. Photographic images of climate change-induced flood Disaster impact on Khartoum Sudan[182]

[177] Hamid Abdel, H. T., Wenlong, W., & Qiaomin, L. (2020). Environmental sensitivity of flash flood hazard using geo-spatial techniques. Global Journal of Environmental Science and Management, 6(1), 31-46.
[178] Elagib, N. A., Al Zayed, I. S., Saad, S. A. G., Mahmood, M. I., Basheer, M., & Fink, A. H. (2021). Debilitating floods in the Sahel are becoming frequent. Journal of Hydrology, 599, 126362.
[179] Williams, M., Nottage, J., 2006. Impact of extreme rainfall in the central Sudan during 1999 as a partial analogue for reconstructing early Holocene prehistoric environments. Quatern. Int. 150, 82–94
[180] Boyd, E., Cornforth, R.J., Lamb, P.J., Tarhule, A., L´el´e, M.I., Brouder, A., (2013). Building resilience to face recurring environmental crisis in African Sahel. Nat. Clim. Chang. 3, 631–637.
[181] Assayha, 2019. https://www.assayha.net/.
[182] Hamid Abdel, H. T., Wenlong, W., & Qiaomin, L. (2020). Environmental sensitivity of flash flood hazard using geo-spatial techniques. Global Journal of Environmental Science and Management, 6(1), 31-46

In 2019, the government of Sudan announced that cholera and waterborne disease outbreaks were a result of the collapse of about 21,000 pit latrines. Contamination of water resources, which adversely impacted water supplies in almost 13 states. In addition, the 2020 Sahel flood claimed the lives of over 400 people, destroyed over 180,000 homes, and displaced over 2 million people[183]. Over 2.2 million hectares of agricultural land were destroyed, contributing to increased food shortage, malnutrition, and food insecurity.

Floods in Sudan are known to be caused by temperature oscillations, seasonal variations of precipitation, unprecedented rainfall, and which are some of the influencing factors of flood in Sudan, leading to displacements and disease outbreaks[184]. According to a study by Ibrahim[185] on climate change impacts and adaptation options for agriculture in Sudan, the lack of water, population displacement, and resource competition have all been exacerbated by climate change. These factors tend to increase social tensions and conflicts, particularly in Sudan's vulnerable communities. Additionally, Mulugetta[186] addressed the impact of climate change on the health of vulnerable people, including but not limited to malnutrition and water-borne diseases in Sudan, in his paper on climate change vulnerability and adaptation assessment in Sudan.

5.4.1 Adaptive Measures of Climate Change Impacts in Sudan

Sudan has been implementing several measures to adapt to the exacerbated impacts of climate change to reduce vulnerability and enhance and promote resilience and sustainable development. Sudan has been able to handle the effects and threats posed by climate change with the use of early warning systems, water collecting techniques, community-led natural resource management, and sustainable agriculture Elhag[187]. To promote traditional knowledge and improve adaptive capacity, international support, and accessible financing mechanisms are fundamental, particularly for rural and coastal community dwellers who are directly exposed to the effects of climate change disasters[188].

[183] Elagib, N. A., Al Zayed, I. S., Saad, S. A. G., Mahmood, M. I., Basheer, M., & Fink, A. H. (2021). Debilitating floods in the Sahel are becoming frequent. Journal of Hydrology, 599, 126362.
[184] Hamid Abdel, H. T., Wenlong, W., & Qiaomin, L. (2020). Environmental sensitivity of flash flood hazard using geo-spatial techniques. Global Journal of Environmental Science and Management, 6(1), 31-46.
[185] Ibrahim, H.A. (2020). Climate change impacts and adaptation options for agriculture in Sudan. Environmental Science and Pollution Research, 27(35), 44031-44042
[186] Mulugetta, Y., et al. (2019). Climate change vulnerability and adaptation assessment of agricultural systems in Sudan. Climate Risk Management, 26, 1-14
[187] Elhag, M. (2017). Climate change impacts on water resources in Sudan: A review. Arabian Journal of Geoscienc-es, 10(22), 484.
[188] Doma, M.K. (2019). Analysis of climate change impacts and adaptation strategies in Sudan. Environmental Sci-ence and Pollution Research, 26(14), 13985-13999.

5.5 Climate Change Impacts and Vulnerability in Uganda

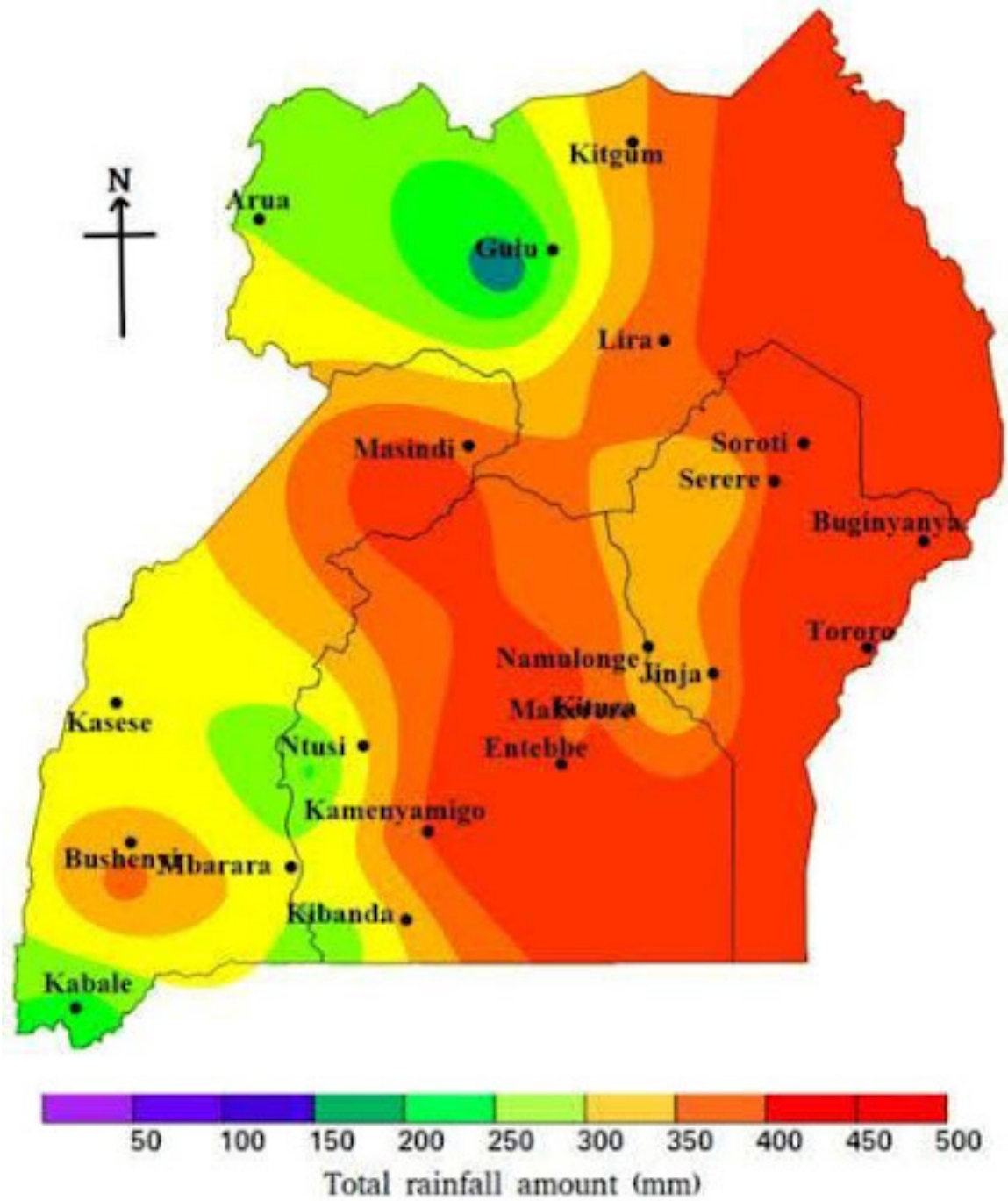

Figure 10. Climate change sensitivity and vulnerability map in Uganda[189]

[188] Mugume, I., Mesquita, M.D.S., Bamutaze, Y., Ntwali, D., Basalirwa, C., Waiswa, D., Reuder, J., Twinomuhangi, R., Tumwine, F., Ngailo, T.J., and Ogwang, B.A. (2018) 'Improving Quantitative Rainfall Prediction Using Ensemble Analogues in the Tropics: Case Study of Uganda', Atmosphere, 9(9), p. 328. Available at: https://doi.org/10.3390/atmos9090328.

Africa's tropical and sub-Saharan nation of Uganda has been proven to be particularly susceptible to disasters brought on by climate change, which can have significant negative effects on both the economic and non-economic spheres[190]. The nation's primary source of income is agriculture, which is primarily rainfed. The climate is primarily dry and wet seasons with temperatures ranging from 20 degrees Celsius to 25 degrees Celsius between November and March[191]. The vegetation is primarily tropical, and between March and May and between October and November, rainfall ranges from about 500 to 2000 millimeters[192].

As a result of climate change, Uganda has faced several detrimental weather events, including flood disasters, unpredictable rainfall that causes landslides, crop infections, environmental degradation, accidents, droughts, earthquakes, famines, and diseases that affect people, animals, and the environment[193]. Other impacts of climate change effects include the melting of the Rwenzori mountain's glaciers and snow caps, increased food insecurity influenced by subpar crop yields, waterborne diseases, declining availability and accessibility of freshwater sources, and conflicts over limited resources[194]. Extreme weather events like floods, which are frequently caused by climate change and have become more frequent and intense over the past few decades, have contributed a great negative impact on the Ugandan socioeconomic system[195].

In 2018, about 12,000 people were heavily impacted by the landslides and flooding in the Bududa district as a result of intense rainfall which led to the loss of over 40 lives and the displacement of over 850 people[196]. Uganda has also experienced severe floods which occurred due to frequent intense rainfall causing the rivers in the Kasese districts of Mobukuto and the Nyamwamba to burst their banks and resulting in the death and displacement of people, loss of livelihood, and destruction of infrastructure[197]. The Northern region of Uganda has been buffeted by climate change disasters like hailstorms, landslides, heavy rainfalls, prolonged droughts, heightened variability in rainfalls, and abundant release of nitric oxide into the atmospher. According to a published report, over 300,000 people have been relocated and millions have been affected by climate change-related floods affecting the lives, livelihoods, mental health, and well-being of the afflicted people in the country[198]. In 2018, the Uganda National Meteorological Authority[199] issued a report on the level of landslides and floods occurring in both Uganda's low-lying and mountainous terrains. There has also been heavy flooding and landslides across several regions such as Kasese, Bududa, Wakuso, Kisoro, Rubanda, Bundabugyo, and Kabele. After a flash flood in the Wakuso district of Uganda, marine police declared some people missing, rescued others, and retrieved some corpses[200].

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[190] Okaka, W. T. (2020). Climate Change-Induced Flood Disaster Policy Communication Issues for Local Community Adaptation Resilience Management in Uganda: Climate Information Services for Effective National Flood Risk Assessment Decision Communication. In Decision Support Methods for Assessing Flood Risk and Vulnerability (pp. 230-249). IGI Global

[191] CEPA. (2019). Agriculture as a backbone of Uganda. https://cepa.or.ug/agriculture-ugandas-key-to-sustainable-growth-and-development/

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[194] International Council for Science Regional Office for Africa (ICSU-ROA). (2008). Science plan: Global environmental change (including climate change and adaptation) in sub-Saharan Africa. Pretoria, South Africa: ICSU-ROA

[195] Government of Uganda. (2010b). The National Policy for Disaster Preparedness and Management. Kampala, Uganda: Government of Uganda

[196] ACAPS Briefing Note, (2018). Uganda - Flooding and Landslides in Bududa District. Kampala, Uganda: ACAPS.

[197] Adebayo, B., & Ntale, S. (2018). Uganda mudslides, floods spur deaths, destruction. Mbale, Uganda: https://edition.cnn.com/2018/10/12/africa/uganda-mudslides-40-dead/index.html

[198] Ngwomoya, A. (2018). Why Kampala keeps flooding. The Daily Monitor newspaper report published on 09 March 2018. Kampala, Uganda: The Nation Group. https://reliefweb.int/report/uganda/why-kampala-keeps-flooding

[199] Uganda National Meteorological Authority. (2018). The seasonal rainfall outlook for june to august 2018 over Uganda. http://envalert.org/wp-content/uploads/2018/06/JJAS-2018-Seasonal-Rainfall-forecast-for-Uganda.pdf

[200] Okaka, W. T. (2020). Climate Change-Induced Flood Disaster Policy Communication Issues for Local Community Adaptation Resilience Management in Uganda: Climate Information Services for Effective National Flood Risk Assessment Decision Communication. In Decision Support Methods for Assessing Flood Risk and Vulnerability (pp. 230-249). IGI Global

5.5.1 Adaptive Measures of Climate Change Impact in Uganda

The government of Uganda has established a national flood disaster preparedness and management policy to implement strategies that emphasize integrated disaster management, effective frameworks for flood assessment, monitoring, and evaluation, information services to collect, store, analyze, and disseminate data, and legal frameworks to support implementation[201]. Despite these efforts, Uganda cannot effectively influence global climate change debates in favor of the country's interests. Okaka[202], maintains that there are still challenges that prevent Uganda from effectively assessing flood disasters, including lack of media coverage of climate change, policy issues, poor public awareness and information dissemination, lack of prioritization and resource allocation for goals related to mitigation and adaptation, and competing priorities and interests of the various parties and stakeholders. For successful actions and results, the institutional policy framework in Uganda on catastrophe assessment, such as floods, at all levels (regional, local, and national), must be considerably reinforced.

5.6 Nature-Based Solutions applied in selected SSA countries.

The effects of climate change highlight the connections between the ecosystems that support the most vulnerable people and those communities themselves. Loss and damage is a matter of climate justice, which is characterized by the assertion that global mitigation strategies are neither sufficient nor quick enough, that historical global emissions are borne by a glaringly disproportionate share of humanity, and that certain nations, regions, communities, and especially marginalized groups are more vulnerable than others and as a result, experience a disproportionate amount of the impacts of climate change. Therefore, Nature-Based Solutions (NBS) are crucial for fostering adaptation capacity and can be seen as a tool for preventing, curtailing, and remediating loss and damage. However, the amount of its success is in jeopardy due to how climate change is affecting ecosystem integrity.

[201] World Bank. (2019). Ugandan Government Steps Up Efforts to Mitigate and Adapt to Climate Change. https://www.worldbank.org/en/news/feature/2019/05/31/ugandan-government-steps-up-efforts-to-mitigate-and-adapt-to-climate-change

[202] Okaka, W. T. (2020). Climate Change-Induced Flood Disaster Policy Communication Issues for Local Community Adaptation Resilience Management in Uganda: Climate Information Services for Effective National Flood Risk Assessment Decision Communication. In Decision Support Methods for Assessing Flood Risk and Vulnerability (pp. 230-249). IGI Global

The table below shows examples of some NBS that have been implemented to reduce climate change-induced loss and damage and enhance the adaptation capacity of countries in Sub-Saharan Africa.

Table 1. Examples of Nature-Based Solutions implemented in the Study Areas

COUNTRY	NBS PROJECTS	DETAILS
LIBERIA	Mapping Nature for People and Planet in Liberia: A Project to Create 'Maps of Hope'	Liberia's EPA in collaboration with the UNDP under the project Mapping Nature for People and Planet in Liberia, is mapping key biodiversity and climate areas. Twenty experts are creating "maps of hope" to identify vital conservation zones for maximum impact and inform global policy.
	Liberia Forest and Climate Resilience Forum	A high-level forum aims to advance the Liberia Pro-Poor Agenda for Prosperity and Development by fostering collaboration and reaffirming government commitments towards sustainable forest management.
	New GEF-Funded Project to protect threatened forests, boost agriculture production, and support livelihoods In Liberia	GEF approved $74.3 million ($7.3 million direct funding, $66.9 million co-financing) for a five-year forest protection project in northwest Liberia. Led by the Environmental Protection Agency and Conservation International under the FOLUR program, it combines sustainable land use with poverty reduction.

COUNTRY	NBS PROJECTS	DETAILS
MOZAMBIQUE	Nature-based flood and erosion protection in the urban context. 1- Detention Ponds - NBS for flood protection. 2- Ecologs – NBS for erosion protection	Mozambique is implementing nature-based solutions on a modest scale, primarily for erosion control through reforestation of mangroves and dune vegetation planting. These efforts often involve local communities. While national and municipal governments rarely use NBS for infra-structure, international funding supports larger pilot projects, such as the Chiveve Rehabilitation and Green Urban Infrastructure Project in Beira, which was carried out by the Administration for Water and Sanitation (AIAS) and funded by the German Cooperation (KFW) and World Bank[203].
	Que Banks on nature as a defense against climate change:	The Mozambican government launched a $6 million project to restore and conserve coastal ecosystems, protecting 3 million people in the Greater Maputo region from climate change effects. Funded by the Global Environment Facility and supported by UNEP, the initiative aims to utilize natural defense against storms, flooding, and salt intrusion. The project covers the municipalities of Maputo, Matola, and Boane, as well as the districts of Matutune and Marracuene. These areas host crucial coastal ecosystems providing services such as carbon sequestration, water purification, erosion control, and flood reduction. The project addresses the alarming deterioration of these habitats due to climate change and resource exploitation, which are vital for the community's livelihoods and well-being.
	Multi-purpose plantations, agroforestry, and forest and ecosystem restoration generate income for rural communities:	The Planted Forest Grant Scheme (PFGS) aims to restore forests in Zambézia, Zambia, through natural regeneration and plantations. Funded by the World Bank, PFGS supports ecological restoration and local income generation for large landowners, small businesses, and farmers.

[203] https://documents1.worldbank.org/curated/en/612051585284647951/pdf/Upscaling-Nature-Based-Flood-Protection-in-Mozambique-s-Cities-Enabling-Environment.pdf

COUNTRY	NBS PROJECTS	DETAILS
NIGERIA	Nigeria Erosion and Watershed Project (NEWMAP):	Nigeria's increasing rainfall has worsened floods and erosion. NEWMAP (2012-2022) addressed these challenges through community-based approaches, benefiting over 12 million people across 23 states by combining poverty reduction with environmental protection.
	Programme for Integrated Development and Adaptation to climate change in the Niger Basin (PIDACC/NB):	The Niger Basin has seen 20-40% less rainfall in 60 years. A six-year PIDACC/NB project focuses on building climate resilience through sustainable resource management, targeting river silting, and promoting better forestry and land use practices.
SUDAN	Sudan Sustainable Natural Resources Management Project (SSNRMP) Additional Financing:	The Sudan Sustainable Natural Resources Management Project (SSNRMP) helps communities in Sudan adapt to climate change and manage scarce resources like land and water. Funded by GEF, and SSNRMP, the project is targeted at 110,000 people.
	Ecosystem-Based Adaptation (EbA) in Sudan:	The Sudan EbA project aims to help people in the White Nile State adapt to climate change by restoring ecosystems and promoting drought-resistant agriculture. The project objective is to provide water resources and teach climate-proof farming techniques to 6,800 households.
	The Great Green Wall Initiative:	The 8000 km-long Great Green Wall project has had only modest success, frequently due to tensions between pastoralists and sedentary people. Having started operations in Ethiopia, WeForest's program is well-positioned to expedite and scale up the African Great Green Wall[204].

[204] https://wedocs.unep.org/bitstream/handle/20.500.11822/29989/NBS_Examples_final-EN.pdf?sequence=1&isAllowed=y

COUNTRY	NBS PROJECTS	DETAILS
UGANDA	WWF Launches a new project for green jobs and Nature-based Solutions[205]:	WWF's new project in Uganda is geared towards creating green jobs and reducing poverty in the Rwenzori Landscape. The project adopted nature-based solutions and a community resilience approach to implementation.
	Building Resilient Communities, Wetland Ecosystems, and Associated Catchments in Uganda[206]:	In Uganda, a grant-funded project is being implemented from 2017-2025 to help subsistence farmers manage climate impacts on wetlands. The project focuses on improving livelihoods and resilience, especially for vulnerable women, by protecting wetlands and implementing early warning systems.

[205] GREEN JOBS & NATURE BASED SOLUTIONS PROJECT | WWF wwfuganda https://www.wwfuganda.org/?39582/GREEN-JOBS--NATURE-BASED-SOLUTIONS-PROJECT#:~:text=Innovative%20and%20Gender%20sensitive%20Nature-based%20Solutions%20for%20Resilience%20and%20Green

[206] Building Resilient Communities, Wetland Ecosystems and Associated Catchments in Uganda | UNDP Climate Change Adaptation (adaptation-undp.org) https://www.adaptation-undp.org/projects/green-climate-fund-building-resilient-communities-wetland-ecosystems-and-associated

6.0 CASE STUDIES AND COMMUNITY-BASED RESPONSES TO LOSS AND DAMAGE EVENTS

6.1 Case studies

This section highlights climate change-induced loss and damage, coping measures, lessons learned, and support needed in East African countries. The case studies from Tanzania, Kenya, and Zimbabwe underscore the urgent need for climate action and finance to address devastating impacts like flooding and droughts, particularly in vulnerable coastal and rural areas. The studies revealed the interconnected nature of economic and non-economic losses, emphasizing how climate disasters disproportionately affect marginalized communities, especially women and children. The importance of comprehensive, community-engaged resilience strategies that combine locally-led adaptation mechanisms with scientifically proven approaches was demonstrated. Key findings include the need for accessible early warning systems, robust funding mechanisms to address loss and damage, and the integration of climate resilience into broader development planning. Collectively, emphasis was placed on the critical importance of international cooperation, climate finance, and locally tailored solutions in building resilience and supporting sustainable development in these vulnerable regions.

6.1.1 Rising Tides, Resilient People: Tanzania's Coastal Climate Crisis

Tanzania's coastal region, encompassing Tanga, Lindi, Mtwara, Pwani, and Dar es Salam, faces severe challenges due to climate change. Home to approximately 15 million people, representing 25% of Tanzania's population, this area is increasingly vulnerable to extreme weather events such as cyclones, heavy rainfall, and rising sea levels. Dar es Salam, the county's commercial hub, stands at particular risk, with $5.3 billion in assets threatened by flooding alone. The impact of climate-induced flooding is profound and multifaceted. Economic losses are staggering, with extensive damage to critical infrastructure, including water supply systems, electricity networks, roads, bridges, schools, and hospitals. The agricultural sector, a cornerstone of the local economy, has been hit hard, with flood-affected areas reporting a 34% in crop production value. This decline extends to agricultural machinery and livestock damage, further undermining food security and livelihoods.

Figure 11: Cross section of flood-affected areas causing displacement and loss of livelihoods

Equally devastating are the non-economic losses, which, while less quantifiable, have far-reaching consequences. Health risks have escalated, with a surge in waterborne diseases like cholera and typhoid due to contaminated water supplies. The psychological toll on communities is significant, with recurring displacement and loss of livelihoods leading to increased stress and anxiety. Educational setbacks, particularly for young girls who often drop out of school to support their families during crises, have long-term implications for social and economic development. Moreover, the loss of cultural heritage, biodiversity, and ecosystem services profoundly affects communities' social and cultural fabric, especially indigenous whose traditions and livelihood are intimately tied to their natural environment.

Several factors compound the vulnerability of these coastal communities. High population density coupled with unplanned urban development – with over 70% of urban development in Dar es Salam being unplanned significantly intensifies the impact of flooding. Rising temperatures and sea levels exacerbate the situation, leading to land salinization and shifting fishing grounds. The degradation of natural barriers like mangroves and coral reefs, which traditionally mitigate storm surges, increases coastal exposure to flooding and erosion.

In response, communities are employing various coping strategies including rainwater harvesting, soil and water conservation techniques, and climate-smart agriculture practices such as adopting drought-resistant crops. Where available, social safety nets and cash transfers provide crucial support. However, these efforts are often hindered by financial constraints and inadequate governmental support. Both intermediate and long-term support are crucial such as enhancing infrastructure resilience, providing financial aid to displaced families, improving early warning systems, and implementing comprehensive urban planning. Investments in sustainable agriculture and stronger social safety nets are also vital. International cooperation and non-debt-increasing climate finance, including access to the loss and damage fund, will play a critical role in supporting these initiatives.

Emerging key learnings include integrating climate resilience into urban planning and development, adapting a multifaceted approach addressing both intermediate and long-term needs, and engaging local communities in decision-making processes. Furthermore, increased climate finance and investment in adaptation and mitigation strategies are essential for building resilience and supporting sustainable development in these vulnerable areas.

Figure 12. Youth advocacy for LD

6.1.2 Adapting Amidst Adversity: Kenya's Climate Change Struggle and Path Forward

Kenya, an East African nation heavily dependent on tourism and agriculture, faces severe challenges due to climate change, particularly from increased rainfall and flooding. Between 1900 and 2020, flash floods and riverine floods caused an estimated USD 136,5 million in damages. The May 2024 floods alone resulted in over 170 deaths and significant infrastructure damage, exacerbating socioeconomic inequalities. These events have had far-reaching impacts on food security, education, the environment, and transportation. In Nairobi County, 20 livestock were lost, while in Kitui East, severe soil erosion occurred. The Thogoto area saw landslides destroy a railway line, leading to hospitalizations.

The Tana Delta region exemplifies the localized impacts of climate change. Communities dependent on coastal mangrove forests for economic activities face declining resources due to inconsistent rainfall. This particularly affects low-income households, widening the wealth gap. Flooding in lowland areas has led to displacement, migration, and crop failures, severely impacting annual yields and the overall quality of life for residents.

Households have developed various coping mechanisms to deal with these climate-induced challenges. Financial strategies predominantly rely on cash savings (92%), with minimal use of loans or formal financial institutions. Non-financial coping methods include reduced food consumption, longer working hours, and livestock sales. Notably, there is a low insurance uptake, particularly for livestock and crops, attributed to low financial literacy, high costs, and perceived lack of benefits.

Key lessons from Kenya's experience highlighted the need for improving disaster preparedness and emergency infrastructure, encouraging livelihood diversification in vulnerable communities, enhancing financial literacy, and promoting insurance services. Strengthening institutional efficiency to implement climate change policies and developing robust early warning mechanisms are also crucial steps identified for building resilience against climate impacts.

Kenya has taken significant legal and political steps to address climate change, including mainstreaming the Paris Agreement within the Climate Change Act and integrating climate objectives at each level of governance. However, financing remains a critical issue, as highlighted in the Nairobi Declaration at the Africa Climate Summit. The country's efforts to achieve its adaptation goals and create more resilient communities are hindered by this financing gap.

The Fund for Responding to Loss and Damage could play a crucial role in supporting Kenya's effort in addressing loss and damage. By equipping the government with tools to implement necessary projects and addressing the current financing gap, the fund could significantly enhance Kenya's ability to adapt to climate change impacts.

6.1.3 Cyclone idai's Aftermath in Rural Zimbabwe: Chabata Village's Struggle and Resilience in the Face of Climate Disaster

Chabata village, nestled in the mountainous region of Bikita District in southeastern Zimbabwe, exemplifies the profound impact of climate-induced disasters on vulnerable communities. Home to 259 people across 57 households, this isolated village has long grappled with geographical challenges that have hindered development and accessibility. The village's economy primarily relies on rainfed agriculture and livestock rearing, with crops like maize, sorghum, and vegetables forming the backbone of local livelihoods.

In March 2019, Cyclone Idai struck Chabata Village with devastating force, unleashing over 200 km/hr winds and dumping 400 mm of rainfall in just 8 hours. The cyclone's impact was catastrophic, causing significant loss and damage to this already vulnerable community. The newly constructed community bridge, a symbol of the villagers' collective effort towards development, was washed away, isolating the village and disrupting the education of 67 primary school children. The flooding submerged nearly 40 hectares of cropland, primarily affecting maize, the staple crop. The disaster also destroyed four houses, collapsed two pit latrines, and claimed the lives of numerous livestock, including goats, turkeys, and chickens. The total physical losses amounted to a staggering USD N 55,000, a severe blow to this small, resource-constrained community.

The severity of Cyclone Idai's impact was exacerbated by the village's high vulnerability and inadequate coping mechanisms. The community-built infrastructure, including the bridge and road, lacked the engineering expertise and resources necessary to withstand such extreme weather events. Many buildings in the village were constructed with unburnt earthen bricks and lacked proper reinforcement, making them susceptible to collapse under severe conditions.

Despite the overwhelming challenges, the people of Chabata Village demonstrated remarkable resilience and ingenuity in their response to the disaster. They quickly implemented short-term solutions, such as constructing a temporary footbridge using tree logs, and adopted mid- to long-term strategies like strengthening contour ridges in fields and improving building techniques. These locally-led adaptation efforts showcase the community's determination to build resilience against future climate shocks.

The Cyclone Idai incident underscores the urgent need for immediate and long-term support in Chabata Village. Priority should be given to constructing a robust bridge and paving the access road to improve connectivity and enable better transportation of goods and services, including emergency medical care.

6.1.4 When the Lake Rises: Documenting Climate Change Devastation in Eastern DRC

The escalating impacts of climate change have become increasingly evident in the Democratic Republic of Congo (DRC), particularly along the shores of Lake Tanganyika in the territories of Fizi and Uvira. This case study examines the devastating effects of rising lake waters on local communities and infrastructure, highlighting the urgent need for both immediate intervention and long-term resilience strategies.

Recent years have witnessed an unprecedented increase in natural disasters worldwide, with developing nations bearing the heaviest burden. According to the Centre for Research on the Epidemiology of Disasters (CRED), the number of people affected by climate-related disasters in developing countries rose dramatically from 50 million in the late 1970s to over 250 million in the early 2000s. 94% of natural disaster fatalities occurred in developing nations, with Africa experiencing an average annual increase of extreme climate events.

The impact has been particularly severe in the specific context of Lake Tanganyika's littoral zone. The study area encompasses the territories of Fizi and Uvira, with Fizi containing over 150 kilometers of coastline and Uvira extending approximately 35 kilometers along the lake. Through direct interviews with affected residents, consultations with local authorities, and field observations, research reveals the extensive damage caused by rising water levels during 2020-2021. The flooding has resulted in the displacement of approximately 70,000 people, with over 5,581 houses either completely or partially destroyed. A significant portion of the affected population – nearly 40,000 people – has been forced to seek refuge in collective sites, including 34 schools, while others have found shelter with host families.

The impact extends beyond immediate displacement. Critical infrastructure has been severely compromised, including damage to National Route 5, flooding of border posts, and disruption of major market operations in Kavimvira, Maendeleo, and Soko Zaïrois. The destruction has severely affected local economic activities, education, and healthcare services. Additionally, environmental degradation, uncontrolled coastal development, and deforestation have exacerbated the community's vulnerability to climate-related disasters.

Findings indicate an urgent need for a dual approach to addressing this crisis. Immediate humanitarian assistance is required to support displaced populations and restore essential services. However, this must be coupled with long-term strategies focused on building community resilience. Key recommendations include developing climate-resilient urban planning frameworks, strengthening environmental protection enforcement, and establishing robust disaster response mechanisms at the local level.

Figure 13. Community displacement due to floods

Figure 14. Community forced displacement due to extensive flooding

6.1.5 Upstream Decisions, Downstream Consequences: Climate Change and Water Politics in Pakistan's Indus Basin

The Indus River Basin (IRB), a vast water system spanning 1.1 million square kilometers across four nations, stands as a critical case study of how climate change amplifies existing environmental and geopolitical tensions. This analysis reveals how Pakistan, despite contributing merely 0.3% to global emissions, bears a disproportionate burden of climate change impacts, creating a perfect storm of humanitarian, economic, and political challenges.

The August 2022 floods in Pakistan serve as a stark illustration of the basin's vulnerability. Triggered by unprecedented rainfall—exceeding 350% of the 20-year average—and accelerated glacial melt, these floods claimed over 1,700 lives and displaced nearly 8 million people. The economic toll surpassed US$16 billion, with 9.4 million acres of agricultural land inundated and 1.2 million livestock lost. Women faced particularly severe impacts due to limited access to survival training and increased gender-based vulnerabilities during the crisis.

Yet floods represent only one facet of the challenges. The IRB faces a paradoxical future of both too much and too little water. Climate projections suggest that while short-term glacial melt may temporarily increase water availability, long-term depletion of Himalayan glaciers could reduce river flows by up to 40% by the century's end. This looming water scarcity threatens Pakistan's agricultural sector, which depends on the IRB for 90% of its irrigation needs and contributes to 70% of the country's GDP. Political dynamics further complicate the crisis at multiple levels. Domestically, Pakistan grapples with provincial tensions over water allocation, particularly between upstream Punjab and downstream Sindh. Internationally, the historic Indus Water Treaty of 1960 between India and Pakistan faces unprecedented strain as water scarcity intensifies. India's dam construction on allocated rivers and threats to unilaterally terminate the treaty have elevated tensions between these nuclear-armed neighbors.

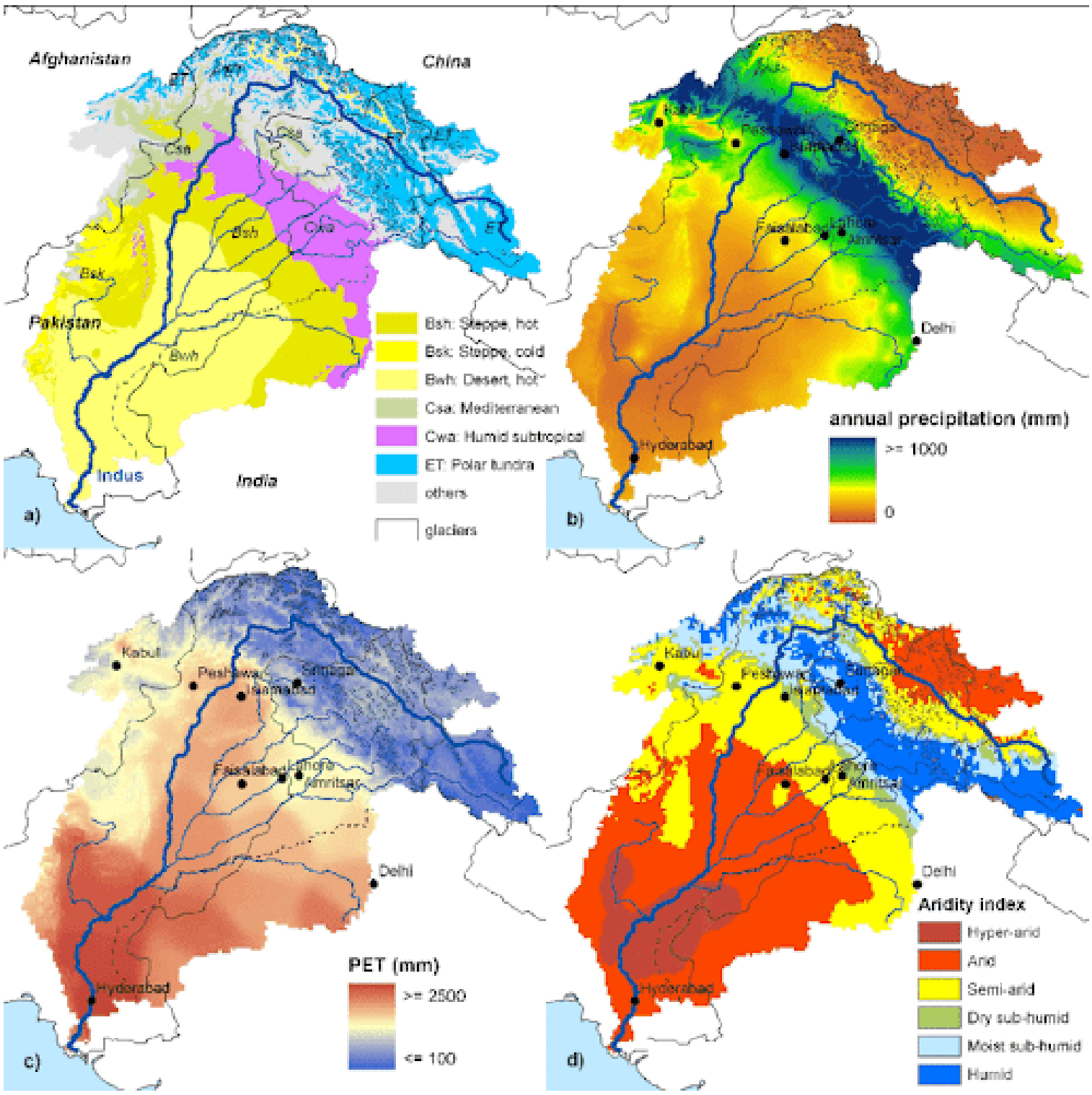

Figure 15. Climatic Conditions of Indus River Basin

Current coping strategies reveal a complex interplay between traditional engineering solutions and emerging sustainable approaches. While the government continues to invest in dams and flood control infrastructure—spending PKR 5.7 billion on repairs following the 2022 floods—experts increasingly advocate for nature-based solutions. These include establishing natural inundation zones and supporting programs like Pakistan's Ten Billion Tree Tsunami, which recognize the river's natural dynamics rather than attempting to control them.

The path forward requires a multi-faceted approach. International support must focus on developing early warning systems, transitioning away from water-intensive agriculture, and building capacity in water governance.

6.1.6 Beyond Environmental Impact: Climate Change and the Social Fabric of Rural Nigeria

In the heart of Nigeria's Anambra State, the Omor community stands as a stark testament to climate change's ripple effects on society. Far beyond environmental impacts, this community exemplifies how shifting weather patterns can unravel the social fabric of traditional societies, transforming resource management challenges into complex socio-economic conflicts. The research case study reveals the cascading effects of climate crises which include unpredictable

Figure 16. Aftermath of resource conflicts years after the incident in Omor, Anambra State Nigeria.

rainfall patterns and prolonged droughts – significantly diminished water availability and agricultural productivity, influencing intense competition for dwindling resources. This scarcity has particularly exacerbated tensions between farming communities and pastoral herders, leading to violent confrontations resulting in substantial loss of life and property. Historical resource disputes further complicate these contemporary climate-driven conflicts.

Climate migration emerges as a critical amplifying factor in this dynamic. As environmental conditions deteriorate, forced displacement creates new pressure points in neighboring regions, stretching already limited resources and social cohesion. This migration pattern has created a ripple effect of inter-community tensions, extending beyond the traditional farmer-herder paradigm to encompass broader social relationships.

The Omor community has demonstrated remarkable resilience through locally initiated adaptation strategies such as establishing informal conflict resolution mechanisms, implementing water conservation measures, and adopting climate-resilient agricultural practices. However, while temporary security measures provide short-term stability, the absence of sustained governmental support highlights a critical gap in institutional response. Hence, this case study emphasizes the urgent need for comprehensive intervention strategies. Key recommendations include: establishing formal conflict resolution frameworks, implementing integrated water and land management systems, developing community-centered climate adaptation plans, leveraging international loss and damage funding for technological advancement, and considering climate reparations from high-emission nations. Without targeted intervention and support, communities like Omor face an escalating cycle of environmental degradation, economic hardship, and social instability.

6.2 Coping strategies and adaptation responses of the study areas

The following part analyzes the adaptation tactics utilized in Liberia, Mozambique, Nigeria, Sudan, and Uganda, with an emphasis on locally driven and community-based strategies that comply with each country's specific vulnerabilities and context.

Sustainable agriculture, ecosystem restoration, and coastal resilience are the main areas of community-based adaptation in Liberia. In a study, local people were found to have utilized agroforestry practices and various farming systems to improve food security and adapt to

changing climatic circumstances[207]. Mangrove restoration initiatives and the creation of marine protected zones run by the community have strengthened coastal resilience and improved sustainable fisheries[208].

Community-based adaptation techniques have been essential in Mozambique's response to the effects of climate change. Local governments have put into place policies including building flood-resistant homes, setting up early warning systems, and encouraging climate-smart agricultural practices, according to Archer[209]. Furthermore, research by Sitoe[210] revealed that sustainable fishing methods and community-led initiatives for mangrove restoration had improved coastal resilience and supported livelihoods in coastal communities in Mozambique.

Initiatives geared toward sustainable agriculture, resource management, and climate-resilient livelihoods are part of Nigeria's community-level adaptation efforts. Adetunji and Ajayi[211] claim that smallholder farmers have adopted climate-smart agriculture practices including agro-forestry and conservation farming to increase productivity and cope with changing climatic conditions. Community-based forest management and reforestation initiatives have been put in place to maintain ecosystems and boost climate resilience; examples of these initiatives can be found in many places along the Atlantic[212].

Several community-based adaptation strategies have been developed in Sudan. The control of water in agricultural techniques has been a major success. According to Abdelhay[213], Indigenous tribes have used water-harvesting methods to deal with water scarcity, such as creating small reservoirs and drilling wells. Agricultural methods like enhanced irrigation infrastructure and the planting of drought-resistant crops have also been developed to increase food security and resistance to changing climate conditions[214].

Community-driven adaptation strategies in Uganda try to concentrate on disaster risk reduction, water management, and agriculture. Smallholder farmers have adopted climate-resilient agricultural techniques such as the use of drought-tolerant crop varieties and effective irrigation systems[215]. Community-led water management projects have also improved access to clean water and increased resistance to droughts, examples include rainwater collection and the development of water storage facilities[216].

The comparative analysis of adaptation strategies used in Liberia, Mozambique, Nigeria, Sudan, and Uganda demonstrates the variety of approaches taken by local communities to deal with the impacts of climate change. Community-based adaptation methods that are specially tailored to each local setting are crucial to improving resilience, guaranteeing food security, and protecting livelihoods in Sub-Saharan Africa.

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https://www.adaptation-undp.org/projects/green-climate-fund-building-resilient-communities-wetland-ecosystems-and-associated
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7.0 DISTINCTION BETWEEN CLIMATE CHANGE-INDUCED LOSS AND DAMAGE AND ADAPTATION CAPACITY

Adaptation capacity and climate change-induced L&D play key roles in understanding and addressing the effects of climate change. Table 2 below highlights the differences between the two concepts in terms of response timing, scale and scope of impact, financial mechanism and resources, and governance and measurement approaches.

Table 2: Differences Between Loss and Damage and Adaptation Capacity

Loss and Damage	Adaptation Capacity
Loss and Damage refers to the consequences that persist after unsuccessful attempts for climate adaptation or when extreme weather events such as floods, droughts, and rising sea levels overwhelm a system's or community's capacity for response. L&D are the adverse effects of climate change that cannot be adequately managed only through adaptation efforts[217]. It encompasses severe, irreversible impacts that exceed adaptation limits. Economic illustration of L&D includes damage to infrastructure, such as roads, buildings, and power grids, and financial losses in agriculture, and tourism)[218]. Examples of non-economic losses include community uprooting, ecosystem deterioration, and cultural heritage destruction[219].	Adaptation Capacity refers to a system, group, or society's ability to adjust to and deal with the effects of climate change[220]. This requires implementing strategies and plans to increase resilience and decrease vulnerability in the face of changing climatic circumstances such as putting early warning systems into place to improve preparedness, addressing changing precipitation patterns with better water management practices, incorporating climate considerations into land-use planning to lessen exposure to climate risks, diversifying livelihoods to lessen reliance on climate-sensitive sectors, and creating climate-resilient infrastructure[221, 222, 223].

[217] Chiba, Y., Shaw, R., & Prabhakar, S. (2017) Climate change-related non-economic loss and damage in Bangladesh and Japan. International Journal of Climate Change Strategies and Management.
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[220] Barry Smit And Olga Pilifosova (2018). Adaptation to Climate Change in the Context of Sustainable Development and Equity. https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARchap18.pdf
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[223] Brown, A., Dayal, A., & Rumbaitis Del Rio, C. (2012) From practice to theory: emerging lessons from Asia for building urban climate change resilience. Environment and Urbanization, 24(2), 531-556.

L&D focuses on managing and compensating for climate impacts that have already occurred or are unavoidable, such as the destruction from extreme weather events or permanent loss of territorial land. It requires specific mechanisms for assessment, compensation, and support after climate disasters strike. The concept emphasizes justice and accountability, often involving complex international negotiations about responsibility and compensation for climate-induced losses.	Adaptation Capacity, in contrast, is about building future preparedness and the ability to adjust to potential climate impacts before they happen. It involves developing skills, knowledge infrastructure, and systems that help communities and nations prepare for and respond to climate change. These include improving early warning systems, developing drought-resistant agriculture, or building flood defenses. The focus is on prevention and preparation rather than recovery and compensation.
L&D requires dedicated funds for compensation and recovery after impacts occur. It often involves complex international funding arrangements such as the United Nations Framework Convention on Climate Change (UNFCCC), the Warsaw International Mechanism for Loss and Damage, or newly emerging loss and damage funds.	Adaptation focuses on investment in preventive measures and system improvements beforehand. Adaptation funding can work through existing development channels. For example, the Green Climate Fund, or bilateral aid programs, supports initiatives like building flood defenses, enhancing agricultural resilience, or improving water management systems
L&D requires the creation of specific legal frameworks for liability and compensation, with detailed methods for assessing, verifying, and calculating damages (both economic and non-economic losses) after they occur and ensuring fair compensation for affected communities. For example, countries that have contributed significantly to global greenhouse gas emissions might be held accountable to provide financial support to countries that suffer the most from climate impacts.	Adaptation works within existing development frameworks, measuring potential and progress in building resilience before climate impacts hit. Instead of responding to losses, adaption capacity works to prevent or minimize those losses by making societies more resilient to climate risks. Legal frameworks for adaptation are often about promoting climate-resilient policies, infrastructure, and technology transfer.

8.0 RECOMMENDATIONS

The recommendations provided in this section aim to address unique L&D concerns experienced by the study areas which include Liberia, Nigeria, Mozambique, Sudan and Uganda as a result of climate change-induced disaster as well as building resilience and strengthening coping capacity of the study areas.

LIBERIA

1. Sector-specific climate change adaptation policy: Develop, implement, and enforce a comprehensive national policy that includes climate adaptation measures across sectors, particularly in health, agriculture, and infrastructure, while involving local communities in the planning process. This could include carrying out a comprehensive vulnerability assessment across key sectors, developing tailored adaptation strategies that integrate climate resilience measures into sectoral policies and plans, and focusing on strengthening sector-specific capacities, such as promoting climate-smart agriculture, building climate-resilient infrastructure, and improving health systems' preparedness, to ensure a holistic, coordinated approach to building community resilience.
2. Comprehensive climate-smart forest management program: Integrate forest conservation with sustainable livelihood opportunities, recognizing the dual role of forests as both a shield against climate impacts and a vital economic resource for local communities. The program must establish a robust governance structure that incentivizes forest conservation through eco-tourism, sustainable forestry practices, and carbon credit initiatives while strengthening land tenure rights for indigenous communities that host 43% of the Upper Guinean rainforest. Implementation should include a benefit-sharing mechanism from REDD+ initiatives and a robust monitoring system using both satellite technology and community-based surveillance, ensuring forest-dependent communities receive tangible rewards for their conservation efforts while enabling rapid response to deforestation threats.
3. National loss and damage fund: Establish a fund with dedicated financing mechanisms to support the rapid recovery and rehabilitation of communities affected by climate disasters, with a particular focus on informal settlements and rural communities.
4. Coastal protection infrastructure: Invest in coastal protection infrastructure, recognising the government has tried to implement measures to reduce flood risks and coastal erosion, such as building revetment walls around the worst-affected areas. Yet there remains a need to invest in building more and upgrading existing coastal defenses, such as seawalls and mangroves, to protect vulnerable communities from rising sea levels and coastal erosion.
5. Adoption of climate-smart agriculture practices: Promote training programs for farmers on climate-resilient agricultural practices, such as crop diversification, agroforestry, planting improved seeds, and improved irrigation techniques, to reduce vulnerability to climate impacts.
6. Early warning systems: Establish and improve meteorological services and early warning systems for extreme weather events, ensuring that communities receive timely information to prepare and respond effectively. This should be particularly focused on protecting Monrovia and other coastal settlements from sea-level rise and storm surges. This should include mangrove restoration and coastal defense structures.

MOZAMBIQUE

1. Disaster risk reduction frameworks: Create and implement a national disaster risk reduction Policy and strategy that integrates climate change adaptation into local development plans, focusing on capacity building at the community level. This can be achieved by strengthening early warning systems, improving data collection and risk analysis capabilities, and integrating disaster risk reduction strategies into national development plans and sectoral policies. Additionally, the government should invest in building the capacity of local communities and institutions to prepare for, respond to, and recover from climate-related hazards, while also establishing robust mechanisms for assessing and addressing the non-economic losses experienced by vulnerable populations.
2. Comprehensive flood management policy: Draft and implement a policy that includes both structural (flood protection infrastructure) and non-structural measures (land-use planning, watershed management), especially for the Zambezi and Limpopo River basins.
3. Sustainable fisheries management: Implement policies to protect marine ecosystems, promote sustainable fishing practices to support livelihoods, and ensure food security in coastal communities vulnerable to climate change.
4. Climate-resilient infrastructure: Prioritize the construction of climate-resilient infrastructure, including roads, bridges, and health facilities, ensuring they can withstand extreme weather events and support disaster recovery efforts.
5. Renewable energy investment: Increase investment in renewable energy projects, such as solar and wind, to provide sustainable energy solutions, reduce reliance on fossil fuels, and enhance resilience to climate impacts.
6. Dedicated climate migration support program: Introduce a holistic program to assist communities in low-lying areas and flood-prone regions with planned relocation, including the provision of alternative livelihoods and social support services.

NIGERIA

1. Climate adaptation and resilience fund: Introduce a fund to be used for four financing projects aimed at reducing vulnerability to climate change impacts. The fund could be focused on building climate-resilient infrastructure, such as flood defenses, improved irrigation systems, and enhanced disaster preparedness through early warning systems. Additionally, it would support sustainable land use practices and reforestation efforts to mitigate the effects of desertification and coastal erosion. The fund could be sourced from national budget allocations, international climate finance, and partnerships with private entities. This dedicated fund would ensure that long-term investments are made in critical areas that strengthen Nigeria's ability to adapt to climate challenges, reducing the severity of loss and damage in the future.
2. Climate insurance policy: Develop a policy that supports a national climate insurance program focusing on agricultural losses, for example in the northern regions, where desertification and irregular rainfall patterns are threatening food security. The policy should also be aimed at providing financial protection to vulnerable communities, especially smallholder farmers and coastal populations, who are disproportionately affected by climate-induced events like floods, droughts, and storms. This policy would compensate those impacted by extreme weather, allowing for quicker recovery and reducing the economic burden on the government and affected communities. The insurance scheme could be supported through a mix of public funds, international climate finance, and private sector participation. By shifting some of the financial risks from individuals and the government to the insurance mechanism, Nigeria would enhance resilience and better manage the economic consequences of climate-induced loss and damage.
3. Climate migration management policy: Create a policy and comprehensive implementation framework to manage climate-induced displacement and migration within Nigeria. This should include policies for planned relocation of vulnerable communities, integration support for climate migrants in host areas, and programs to build resilience in high-risk zones to reduce forced displacement.
4. National loss and damage fund: Create a dedicated financial mechanism to support communities affected by climate-related losses and damages. This fund could be financed through a combination of government allocations, international climate finance, and private sector contributions. It would provide rapid response funding for immediate relief and long-term support for recovery and adaptation.
5. Comprehensive early warning system: Domesticate a nationwide early warning system by integrating local climate data, local knowledge, and advanced forecast technologies. This system should provide timely, actionable information to communities at risk of climate-related hazards and enable proactive measures to minimize losses and damages.
6. Climate-resilient agriculture programs: Scale successful programs that support farmers in adopting climate-resilient agricultural practices. This could include drought-resistant crop varieties, promoting water-efficient irrigation techniques, and providing insurance schemes to protect against crop failures due to extreme weather events.
7. Urban resilience plans: Enforce plans to enable major cities, particularly Lagos, to address flooding, coastal erosion, and infrastructure damage, including improved drainage systems and climate-resilient building codes, already existing urban planning policies
8. Community policy for enhancing flood resilience and related climate-induced impacts: Initiate bottom-up strategies for building the climate resilience of local communities, encouraging and supporting Indigenous solutions and local knowledge in solving contextual climate vulnerabilities, with a focus on locally-led adaptation.

SUDAN

1. National climate loss and damage response mechanism: Prioritize rapid financial compensation and rehabilitation support for communities affected by drought-induced crop failures, floods, and extreme heat events, particularly in vulnerable regions along the Nile Basin and rain-fed agricultural zones. The framework must create a dedicated Loss and Damage Fund supported by both national budget allocations and international climate finance, with transparent mechanisms for damage assessment, claim processing, and direct disbursement to affected households, including special provisions for women-headed households and displaced communities. The policy should mandate the establishment of a Climate Loss and Damage Monitoring and Verification System that combines satellite data, ground-level assessments, and community reporting to track, document, and validate climate-induced losses while building institutional capacity for evidence-based compensation and adaptation planning.
2. Loss and damage risk transfer policy: Establish a nationwide parametric insurance scheme, providing automatic payouts when predetermined climate thresholds (such as rainfall levels, temperature extremes, or river flow rates) are breached, with subsidized premiums for vulnerable farmers and pastoralists, mandatory coverage for large agricultural enterprises, and innovative financing mechanisms including Islamic insurance (Takaful) to ensure cultural acceptability and wider adoption. This policy would specifically protect against losses from prolonged droughts, flash floods, and extreme heat events while creating a sustainable financial buffer against climate shocks.
3. Integrated water resource management: Develop a comprehensive water management strategy focusing on the Nile River basin. This could include improving irrigation efficiency, implementing water harvesting techniques, and establishing transboundary water-sharing agreements. Given Sudan's vulnerability to both floods and droughts, this strategy should also incorporate flood control measures and drought mitigation plans.
4. Pastoral resilience programs: Create programs specifically designed to support nomadic and semi-nomadic pastoralist communities, which are particularly vulnerable to climate change impacts. This includes establishing climate-informed migration corridors, developing drought-resistant grazing lands, and providing mobile veterinary services to maintain livestock health in changing climatic conditions.
5. Climate-resilient food security system: Develop a national food security system addressing climate-related crop failures and shortages. This could include creating strategic grain reserves, promoting drought-resistant crops like sorghum and millet, and establishing community-based food banks in vulnerable regions, particularly in Darfur and other conflict-affected areas.
6. Conflict-sensitive climate adaptation measures: Develop climate adaptation measures that are sensitive to conflict dynamics, given Sudan's history of conflict, often exacerbated by resource scarcity. This could include communities-based natural resource management programs, initiatives to promote equitable access to land and water resources, and conflict resolution mechanisms for climate-related disputes, particularly in areas like Darfur where climate change intersects with existing tensions.

UGANDA

1. Comprehensive climate loss and damage compensation policy: stablish clear protocols for assessing, documenting, and compensating both economic and non-economic losses from climate disasters, with particular focus on landslides in the Mt. Elgon region, floods in low-lying areas, and agricultural losses in the cattle corridor. The policy must create an automated rapid response mechanism that combines mobile money transfers with traditional relief systems to ensure swift financial support reaches affected communities within 72 hours of a verified climate disaster, supported by a robust verification system and community-based damage assessment teams. The framework should establish a multi-tier support system that addresses immediate relief needs while providing longer-term rehabilitation support, including livelihood restoration programs, climate-resilient housing reconstruction, and psychological support services for communities experiencing loss of cultural heritage and displacement.
2. Localized climate loss and damage support system: Decentralize response mechanisms to district and sub-county levels, empowering local governments to maintain emergency response funds, conduct rapid damage assessments, and provide immediate compensation through established community structures like savings groups and farmers' cooperatives, while integrating traditional knowledge systems and local coping strategies into formal loss and damage response protocols. The policy should include mandatory allocation of district development funds for loss and damage response, complemented by national matching grants and community-based early action protocols
3. Institutional policy framework on climate change impact assessment, such as floods, at all levels: Strengthen the institutional policy framework on catastrophe assessment by having the Ugandan government focus on enhancing coordination and collaboration across national, regional, and local authorities responsible for disaster management. This includes providing adequate funding and resources to build the capacity of government agencies and community stakeholders, as well as integrating disaster risk reduction and climate change adaptation strategies into development plans at all levels. Updating legal and policy frameworks to ensure clarity, enforceability, and community engagement is crucial, while simultaneously promoting knowledge-sharing platforms and strengthening partnerships with regional and international organizations to leverage expertise and resources.
4. Local governance and community engagement: Empower local governments and communities to take the lead in climate adaptation planning and implementation and ensure that interventions are tailored to local needs and vulnerabilities.
5. Water resource management and agroecological practices: Develop and implement integrated water resource management strategies that consider the impacts of climate change on water availability, ensuring equitable access for agricultural and domestic use. In addition, the promotion of agroecology as a sustainable farming approach by emphasizing indigenous knowledge adoption and local resources to enhance soil health, biodiversity, and resilience to climate variability.
6. Social safety nets: Create more and expand existing social protection programs that provide financial assistance and support for vulnerable populations affected by climate change impacts, helping them recover from losses and damages. A typical example is the Expanding Social Protection unit, which succeeded the social protection secretariat under the Ministry of Gender, Labour, and Social Development.

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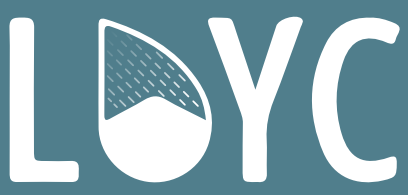

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