Ministry of Irrigation and Water Resources

Hydraulics Research Centre, Sudan

Strengthening Drought Resilience for Smallholder Farmers and Pastoralists in The IGAD Region (DRESSEA Project)

Sudan's Drought Management Plan

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This work would not have been possible without the great efforts, cooperation, and dedication of many people who formed the team members.

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Acronyms

AU	*African Union*
DRESSEA	*Strengthening Drought Resilience for Smallholder farmers and Pastoralists in the IGAD region*
EWS	*Early Warning Systems*
EU	*European Union*
FGD	*Focus Group Discussion*
FAO	*Food and Agriculture Organization of the United Nation*
CC	Climate Change
GIS	*Geographic Information System*
RS	*Remote Sensing*
DMP	*Drought management plan*
INGOs	*International Non – Non-governmental organizations*
UN	*United Nations*
UNDP	*United Nations Development Program*
WB	*The World Bank*

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Report Summary

The Sahelian region of Sudan grapples with enduring challenges related to drought, which are intensified by environmental degradation and socioeconomic hardships, consequently impacting agricultural productivity and the livelihoods of pastoralist communities. Historical instances of drought have led to famine, compelled migration, and economic turmoil, as demonstrated by reduced agricultural yields, degraded grazing territories, and increased social discord, with smallholder farmers and pastoralists in western and central Sudan being particularly susceptible.

In response to these adversities, Sudan (represented by the Hydraulics Research Centre - Ministry of Irrigation and Water Resources) is executing the DRESS-EA initiative (Strengthening Drought Resilience for Smallholder Farmers and Pastoralists in the IGAD Region), which is financed by the Adaptation Fund and implemented by the Sahara and Sahel Observatory (OSS). The primary objective of this initiative is to bolster the resilience of communities across the IGAD region against the threats posed by climate change, with a concentrated emphasis on drought. As a result, a central goal of the initiative is to develop this Drought Management Plan aimed at alleviating the impacts of drought, fostering sustainable agricultural practices, and building community resilience in the country.

Drought in Sudan severely impacts agriculture, livestock, water resources, food security, and rural communities, leading to reduced productivity, economic instability, and increased poverty. Therefore, this proposed Drought Management Plan outlines a comprehensive framework aimed at enhancing the country's resilience to climate change-induced droughts. Recognizing the escalating frequency and severity of droughts, the plan articulates strategies that integrate scientific research, technological advancements, and sustainable practices. It emphasizes proactive management through improved drought monitoring, forecasting, and a robust communication protocol.

The drought-risk assessment in Sudan identifies three regions—high, medium, and low-risk—based on factors like precipitation shortfalls and socio-economic vulnerability.

High-risk areas include Northern, Eastern, Western, and Central Sudan. These areas, particularly Northern and Eastern regions and Darfur suffer from erratic rainfall and socio-economic challenges, leading to severe drought impacts. Key factors contributing to high-risk classification are significant precipitation deficits, vegetation degradation due to overgrazing and unsustainable practices, and socio-economic vulnerabilities such as poverty and reliance on subsistence farming. These challenges exacerbate water shortages, decrease agricultural productivity, and heighten economic hardships during droughts, especially for rural communities.

Key recommendations include identifying high-risk areas where interventions may take place, implementing effective response actions, and ensuring the active involvement of stakeholders including communities and particularly gender-sensitive groups through continuous engagement. Also, the plan underscores the need for substantial financial resources from both domestic and international partners to successfully implement these proposed initiatives. It also highlights the importance of research and development in strengthening institutions capable of predicting drought incidence and supporting climate-resilient agricultural systems.

Furthermore, the plan advocates for regular updates and revisions every 3-5 years to adapt to evolving environmental and socio-economic conditions, ensuring that strategies remain aligned with national and international policies. By focusing on sustainable strategies and identifying vulnerable sectors, the plan aims to mitigate the adverse impacts of drought on Sudan's economy and population, ultimately fostering a path toward a resilient and sustainable future.

Chapter one

Introduction

1.1. Climate Change, Drought, and Types of Droughts:

Climate change, delineated by global warming and modifications in precipitation patterns, intensifies both the frequency and severity of droughts(Mazdiyasni et al. 2021). Droughts can be broadly classified into four distinct categories: meteorological, agricultural, hydrological, and economic socioeconomic (Noureldeen et al., 2020). Meteorological drought transpires because of extended durations of subnormal rainfall. Agricultural drought has detrimental effects on crop yield due to deficits in soil moisture, whereas hydrological drought adversely influences the availability of water resources within reservoirs and river systems. Socio-economic drought incorporates the extensive ramifications on human activities and communities stemming from the previously mentioned categories of drought (Elhag and Zhang 2018). As the effects of climate change advance, these droughts become increasingly severe and more complex to manage.

1.2. Sudan’s Vulnerability to Drought:

Situated in the Sahel region of Africa, Sudan exhibits pronounced vulnerability to drought, primarily attributable to its dependence on rain-fed agriculture(Mohmmed, Li et al. 2018), its arid and semi-arid climatic conditions, and ongoing socio-political instability. The nation's economic framework is predominantly reliant on agriculture, which employs a substantial fraction of the populace. Given the limited access to technological innovations and essential infrastructure, Sudan's resilience against climatic perturbations is significantly hindered. Furthermore, regional conflicts and governance challenges further amplify its susceptibility, complicating the implementation of effective drought mitigation measures.

1.3. Historical Occurrences of Drought in Sudan:

Throughout its history, Sudan has encountered numerous severe droughts, particularly notable during the 1980s and the early 2000s. The drought event of 1984-1985 was especially catastrophic, resulting in widespread famine and displacement among the population. These historical occurrences underscore the region's vulnerability to extended periods of aridity and highlight the urgent need for attention from both national and international stakeholders. As reported by the Sudan's National Drought Plan (NDP, 2018), the phenomenon of drought and desertification predominantly impacts geographical regions situated between latitudes 10° and 18° N, encompassing a myriad of ecological zones within Sudan, specifically Northern Darfur, Kordofan, the Northern Region, and the states of Eastern Sudan. These territories have experienced profound repercussions from drought conditions since the late 1960s, resulting in considerable ecological and socioeconomic transformations. For example, regions in central Sudan have documented eighteen years characterized by drought within the past fifty years, which has markedly affected vegetation and soil quality. Moreover, climate models forecast escalating temperatures alongside declining precipitation patterns, indicating that prospective drought events in Sudan may be even more disastrous if not sufficiently addressed.

1.4. Impacts of Drought in Sudan:

The repercussions of drought in Sudan are multifaceted, significantly influencing food security, water accessibility, and livelihoods. Prolonged drought conditions precipitate crop failures, thereby diminishing food production and instigating food shortages. This scenario, in turn, exacerbates malnutrition rates and imposes additional burdens on already precarious health systems. Water scarcity heightens inter-communal conflicts over resources and disrupts daily life, particularly for women and children, who are frequently tasked with water collection. Moreover, displacement induced by drought exerts pressure on urban centers and elevates the risk of societal tensions.

1.5. Importance of Proactive Drought Management in the Context of Climate Change:

Considering climate change, the implementation of proactive drought management strategies is imperative for enhancing Sudan's resilience. Developing early warning systems, enhancing water management practices, and investing in climate-smart agricultural methodologies are pivotal strategies. Additionally, fortifying institutions and governance frameworks to efficiently coordinate drought response initiatives is of equal importance. International collaboration and support regarding technology transfer, financial assistance, and capacity-building initiatives can play a critical role in strengthening Sudan's adaptability to climate change. Community-based approaches that integrate indigenous knowledge and practices also demonstrate potential for fostering sustainable drought management.

Chapter Two

Principles and Plan Development Process for Drought Management

2.1. Principles of the Plan:

The fundamental principles guiding drought management, as reflected in the Horn of Africa Drought Management Plan, can be adapted for Sudan. These principles include:

- *Proactive Approach*: Transitioning from reactive responses to proactive planning and preparedness to mitigate drought impacts.
- *Integrated Management*: Ensuring that drought management is part of a broader integrated approach that considers various sectors such as agriculture, water resources, and community development.
- *Community Involvement*: Engaging local communities in the planning and implementation processes to ensure relevant and effective strategies.
- *Sustainability*: Focusing on sustainable practices that enhance resilience against future droughts while considering environmental impacts.
- *Collaboration*: Promoting partnerships among government, NGOs, and local stakeholders to leverage resources and expertise.

2.2. Objectives of the Plan:

The objectives of a Drought Management Plan, particularly in communities where farmers and pastoralists are predominant, are crucial for enhancing resilience and ensuring sustainable livelihoods. Here are the key objectives that can be anticipated:

1. *Enhancing Drought Preparedness*

- Risk Assessment: Assessing the vulnerability and risk of drought to implement timely measures that limit impacts on farmers and pastoralists.

- Early Warning Systems: Establishing systems to provide timely information about drought conditions to help communities prepare and respond effectively.

2. *Promoting Sustainable Agricultural Practices*

- Water Conservation Techniques: Encouraging the adoption of water-saving irrigation methods and practices that enhance soil moisture retention.
- Crop Diversification: Promoting the cultivation of drought-resistant crop varieties to reduce dependency on a single crop and enhance food security.

3. *Supporting Livestock Management*

- Pasture Management: Implementing strategies for sustainable grazing and pasture management to ensure livestock health during drought periods.
- Supplementary Feeding Programs: Establishing programs to provide additional feed and water resources for livestock during critical drought times.

4. *Community Engagement and Capacity Building*

- Training and Education: Providing training for farmers and pastoralists on best practices for drought management and resilience building.
- Involving Local Knowledge: Integrating indigenous knowledge and practices into drought management strategies to enhance community ownership and effectiveness.

5. *Policy Development and Implementation*

- Framework for National Policies: Formulating and adopting national drought policies that provide a proactive, risk-based management approach to drought events.
- Collaboration with Stakeholders: Engaging various stakeholders, including government, NGOs, and community groups, to ensure a coordinated response to drought challenges.

6. *Monitoring and Evaluation*

- Establishing mechanisms for monitoring drought impacts and evaluating the effectiveness of implemented strategies to adapt and improve future responses.

2.3. Plan Development Process:

The development process for a Drought Management Plan typically involves several key stages, which can be outlined as follows:

1. Assessment and Analysis
    - Data Collection: Gathering historical data on drought occurrences, impacts, and community vulnerabilities.
    - Risk Assessment: Identifying areas and sectors most at risk from drought to prioritize interventions.
2. Stakeholder Engagement
    - Consultation: Engaging with local communities, farmers, pastoralists, and other stakeholders to gather input and build consensus on the plan's objectives and strategies.
    - Capacity Building: Providing training and resources to stakeholders to enhance their understanding of drought management.
3. Strategy Development
    - Action Planning: Formulating specific strategies and actions to address identified risks, including water conservation, crop management, and livestock support.
    - Integration of Best Practices: Incorporating international best practices and lessons learned from other regions, such as the Horn of Africa, into the plan.
4. Implementation Framework
    - Resource Allocation: Identifying and securing funding and resources necessary for implementing the plan.

- Roles and Responsibilities: Defining the roles of various stakeholders in executing the plan to ensure accountability and effectiveness.

5. Monitoring and Evaluation

- Performance Indicators: Establishing metrics to evaluate the effectiveness of the drought management strategies and actions.
- Feedback Mechanisms: Creating channels for ongoing feedback from stakeholders to adapt and improve the plan over time.

Chapter Three

Relationship to Other Plans and Policies

3.1. Related National and Sectoral Policies and Regulations:

Sudan has established various legal frameworks and policies related to different natural resources that play a critical role in drought mitigation and planning. These include:

1. **Forest Policy**: Aimed at the sustainable management, conservation, and development of forest resources, this policy emphasizes the role of forests in environmental stability, climate regulation, and biodiversity conservation. It supports afforestation and reforestation initiatives, encouraging community participation in forest management, and seeks to balance development with conservation efforts.

2. **Wildlife Policy**: Focuses on conserving the rich biodiversity of Sudan by protecting wildlife habitats and endangered species. The policy encourages sustainable use and management of wildlife resources, including community-based wildlife conservation programs. It also emphasizes the importance of wildlife in promoting ecotourism and generating national income.

3. **Range Policy**: Supports sustainable management of rangelands to ensure their productivity and biodiversity are maintained. It aims to improve pastoral livelihoods by promoting integrated livestock and rangeland management, enhancing water and pasture access, and mitigating land degradation. The policy also encourages research and technology transfer to improve rangeland management practices.

4. **Agricultural Policy**: Encompasses strategies for increasing agricultural productivity and food security. It supports sustainable agricultural practices, diversification of crop and livestock production, and improved irrigation and water management techniques. The policy seeks to address climate change's impacts

on agriculture and promote private sector involvement in agricultural development.

5. **Livestock Management and Mobility Policies**: These policies prioritize strengthening local government capacity to legislate livestock routes and provide integrated services along these routes. They aim to improve access to pastures and grazing grounds and enhance road networks, including feeder roads in pastoral areas. Traditional institutions play a vital role in managing livestock mobility, aligning with the African Union pastoral policy framework. The plan also emphasizes the improvement of the quarantine system and facilities along livestock routes.

6. **Microfinance and Financial Sector Policies**: The policies promote rural finance and savings schemes to support rural and pastoral communities, calling for the establishment of micro-finance institutions in these areas. Sudan's experiences with microfinance facilities, such as those from the MDTF projects, serve as valuable lessons for broader initiatives.

7. **Market Development and Infrastructure Policies**: The Agricultural Revival Program (AREP) supports states in developing rural infrastructures like feeder roads, livestock markets, and storage facilities. The government encourages the formation of market associations and community participation in maintaining these infrastructures to ensure sustainability. Public employment programs are proposed to build and maintain infrastructure, creating job opportunities, particularly for women and youth.

8. **Veterinary Services and Livestock Health Policies**: These policies focus on securing integrated services, including water, fodder, feeds, and pasture along stock routes to markets. There's an emphasis on encouraging Community Animal Health Workers (CAHWs) and public-private partnerships to provide consistent veterinary services and essential livestock drugs to support CAHWs' active engagement.

9. **Water Policy:** Advocates for the efficient use of water in agriculture and increased groundwater use for irrigation. In the following table (table 1) we provide the notable Sudanese Water Acts that relate to drought management, adapted from Sudan's National Drought Plan of 2018.

Table (1): The Sudanese Water Acts related to drought management, adapted from Sudan's NDP (2018)

No.	Name of Act/Policy	Year	The objective of the Policy
1	**Nile Pumps Control Act**	1939	Regulated the use of Nile water and control of water pumps.
2	**Subsequent Regulations**	1951	Updated regulations for managing water pump operations from the Nile.
3	**Civil Transaction Act**	1984	Linked land rights to development and access to water resources; regulated public access to water through licensing; addressed water rights transfer.
4	**Irrigation and Drainage Act**	1990	Provided directives for irrigation and drainage management to optimize water use and address issues in water distribution systems.
5	**Water Resources Act**	1995	Reformed management of Nilotic and non-Nilotic water resources, and groundwater;

			centralized water policy oversight; established State Water Corporations.
6	**Groundwater Regulation Act**	1998	Assigned responsibility for groundwater resource management and issuing construction permits to the Groundwater and Wadis Directorate.
7	**Public Water Corporation Act**	2008	Gave central government authority over national water planning, investments, and water development policy and legislation.
8	**National Water Resources Management Strategic Transformation Plan**	2021	Organized national water planning and provided a strategic vision for water use.

The Ministry of Irrigation and Water Resources is tasked with:

- Formulating national water strategies
- Assessing and managing water resources for sustainable use
- Conducting research for efficient water management
- Managing Sudan's Nile water allocation
- Fostering cooperation among Nile Basin countries
- Evaluating non-Nile water sources
- Mitigating flood effects with advanced techniques

A significant challenge remains the integration of water management with other natural resource concerns, acknowledging that water functions within the broader ecosystem. The Desertification Control Unit, part of the Ministry of Agriculture and Forestry, plays a key role in:

- Collecting data on desertification and drought
- Updating project inventories within the National Plan
- Facilitating discussions within the Coordination Council
- Securing financial resources for project implementation
- Utilizing GIS for strategic planning
- Serving as a liaison with international desertification efforts
- Raising awareness and coordinating efforts to combat drought through education and workshops.

3.2. Existing Programs Addressing Issues of Drought:

Sudan, as a signatory to numerous international conventions such as the UNCCD, CBD, and UNFCCC, has been proactive in developing a range of national programs and plans to combat climate change, address land degradation, and prevent biodiversity loss. Through these efforts, Sudan aims to enhance resilience and sustainability in the face of these environmental pressures. This section highlights some of these initiatives and their contributions to mitigating drought-related challenges:

- *Sudan's National Action Program (SNAP) to Combat Desertification - 2006:*

Implemented by the UNDP's Global Environment Facility (GEF) in 2006, Sudan's National Action Program (SNAP) to Combat Desertification was crucial in addressing drought management and tackling the pressing challenges of land degradation. The program, developed through the National Drought and Desertification Control Unit (NDDCU), utilized a bottom-up approach and garnered international expertise to align strategies with the UN Convention to Combat Desertification (UNCCD). A task force focused on key features of the NAP, such as integrating stakeholder consultations, leveraging traditional knowledge, and promoting sustainable agricultural practices, underscored by robust capacity-building efforts like on-the-job training and nursery techniques. The program highlighted the critical state of Sudan's environmental conditions and the socio-economic impacts of recurring droughts, advocating for

coordinated efforts and established a National Desertification Fund (NDF) to secure financial resources. By prioritizing groundwater storage, improving research and documentation, and fostering institutional linkages, the NAP aimed to empower communities, aligning its projects with effective drought management strategies to enhance resilience and sustainable resource management.

- *National Adaptation Program of Action for Climate Change - 2007:*

The National Adaptation Program of Action (NAPA) for Sudan, developed in 2007 by the Higher Council for Environment and Natural Resources (HCENR) and implemented through the UNDP's Global Environment Facility (GEF) under the Least Developed Countries Fund (LDCF), addressed the urgent need for climate change adaptation, particularly in the face of severe droughts threatening vulnerable communities. By recognizing Sudan's status as a Least Developed Country, the program sought international collaboration to embed climate adaptation into development plans and infrastructure. Key adaptation needs identified included agriculture, forestry, and water management, with initiatives to improve groundwater access, enhance meteorological monitoring, provide micro-credit for water harvesting projects, and strengthen agricultural extension services. The NAPA also targeted improvements in public health through better sanitation, malaria prevention, and alternative water supply systems to bolster community resilience.

In its implementation, the NAPA emphasized stakeholder engagement and the creation of locally driven evaluation criteria to ensure that adaptation projects effectively addressed ecological zone-specific needs. Through national workshops, consensus on priority adaptation activities was built, focusing on sustainable agricultural practices and water harvesting. These efforts were part of a broader commitment to policy reform, which included rehabilitating water facilities, resolving conflicts between farmers and herders, and promoting the participation of women and civil society in adaptation initiatives. Overall, Sudan’s NAPA represented a comprehensive approach to strengthening resilience against increasing drought threats.

- *Sudan’s National Adaptation Plan (NAP) for Climate Change - 2016:*

Sudan's National Adaptation Plan (NAP, 2016), produced in 2016, addressed drought by highlighting the need for comprehensive vulnerability assessments, particularly in the agriculture sector, to identify high-risk areas and prioritize resilience-building actions. The plan seeks to enhance the capacity of Sudanese institutions to manage climate risks, ensuring effective implementation of adaptation strategies to mitigate the impacts of drought on communities and agricultural productivity. By integrating climate change adaptation strategies into existing policies and engaging local communities in the planning process, the NAP aims to ensure that these strategies are relevant and specifically tailored to the needs of those most vulnerable to drought.

Moreover, the 2016 NAP emphasizes investment in resilience through sustainable agricultural practices, improved water management systems, and enhanced food security, aiming to reduce populations' vulnerability to drought. It also incorporates ongoing monitoring and evaluation mechanisms to track drought impacts and assess the effectiveness of adaptation measures. This allows strategies to be adjusted in line with changing conditions and emerging drought-related challenges.

- *Sudan's National Drought Management Plan (NDMP) – 2018:*

In 2018, the National Council for Combating Desertification developed Sudan's National Drought Management Plan (NDMP) to transition from reactive humanitarian responses to a comprehensive disaster risk management strategy to enhance resilience against drought and desertification. This plan was part of the broader Policy Framework for Disaster Risk Management (DRM), which emphasized protecting lives and livelihoods through a coordinated national drought policy. The NDMP addressed the severe impacts of historical droughts that had caused food shortages and social disruptions by focusing on accountability, coordinated execution across sectors, and integrating gender and poverty considerations in line with the UNCCD. With desertification affecting 67.2% of the country, the NDMP prioritized improving water management, livestock productivity, and community engagement in resource regeneration. It also emphasized developing effective communication protocols, early warning systems, and regional cooperation for transboundary water resources management. The plan sought to empower women by ensuring access to resources and promoted infrastructure

development, pest protection, aquaculture, and market expansion to diversify income and build resilient ecosystems against ongoing drought and desertification challenges.

- *The Second National Biodiversity Strategy and Action Plan (NBSAP) – 2015 - 2020*:

Sudan's revised National Biodiversity Strategy and Action Plan (NBSAP), formulated in 2015, emphasizes the nation's abundant biodiversity—essential for sustainable development and food security—by aligning with the goals established by the Convention on Biological Diversity (CBD). The NBSAP delineates an extensive framework aimed at conserving biodiversity, encouraging sustainable practices, and ensuring equitable benefit-sharing, with a particular focus on education and awareness to advance these objectives. Among its strategic imperatives are the enhancement of educational outreach, the fortification of conservation legislation, and the mobilization of financial resources for effective implementation by the year 2020.

A notable element of the NBSAP is its emphasis on how drought intensifies biodiversity degradation, especially within Sudan's varied ecosystems, which encompass deserts and savannahs. The plan accentuates the necessity of alleviating pressures on biodiversity, which is pivotal in addressing the ramifications of drought, by advocating for sustainable resource utilization and participatory planning. It highlights the urgent requirement for capacity building to improve biodiversity management in the face of climate-related challenges. The strategy is a foundational reference for forthcoming policies, advocating for comprehensive environmental policies and legislative frameworks designed to mitigate the adverse effects of land use and enhance ecosystem resilience against drought-induced pressures.

3.3. National and Sectoral Projects related to Drought Management in Sudan:

Here we outline various Sudan projects aimed at addressing drought, climate change adaptation, and enhancing community resilience over the past decade (2014–2024). These projects are implemented in collaboration with international organizations, such as the Global Environment Facility, UNDP, and others (table 2). Key initiatives include the Resilience of Pastoral and Farming Communities to Climate Change in North Darfur,

the Butana Integrated Rural Development Project, and the Great Green Wall for the Sahara and Sahel Initiative. These projects focus on sustainable natural resource management, capacity building, climate change mitigation, and improving agricultural and water sector resilience. The document highlights Sudan's commitment to reducing vulnerability to climate impacts through targeted national strategies and international cooperation.

Table (2): Running projects in Sudan addressed issues of drought, climate change adaptation, and community resilience in the last ten years (2014 – 2024)

No.	Project	Duration	Donor / implementing agency
1	Resilience of Pastoral and Farming Communities to Climate Change in North Darfur	2021 – 2024	Global Environment Facility / FAO
2	Enhancing the resilience of communities living in climate change vulnerable areas of Sudan using Ecosystem Based approaches to Adaptation (EbA)	2017 – 2023	Funded by Global Environment Facility (GEF), Implemented by UNEP, and executed by HCENR
3	Butana Integrated Rural Development Project (BIRDP)	2016 – 2022	IFAD
4	BRIDGES - Boosting Restoration, Income, Development, Generating Ecosystem Services	2017 – 2020	Forest National Corporation (FNC), FAO
5	Sustainable Natural Resources and Livelihoods Program (SNRLP)	2019 – 2025	IFAD

6	Sudan Sustainable Natural Resources Management Project	2020 – 2022	Global Environment Facility
7	Gums for Adaptation and Mitigation in Sudan (GAMS)	2020 – 2026	GCF and FAO/FNC
8	The Great Green Wall for the Sahara and Sahel (GGW) Initiative	2018 – ongoing	GEF / Ministry of Agriculture
9	ACACIA- (Arabic Gum Value Chain in Sudan) Support SSGASS Phase two	2021 – 2026	Implemented by AFD through FNC
10	Adaptation to climate change project (Canadian support	2014 – 2018	Global Environment Facility and UNDP
11	Insurance against climate change risks for the sustainability of the agricultural sector	2014 – 2018	Global Environment Facility and UNDP
12	The third national communication project for climate change	2016 – 2019	UNDP
13	Global Project on Access and Benefit-sharing to build Human, legislative, and institutional capacities for Implementing the Nagoya Protocol	2017 – 2019	UNDP
14	The Biodiversity Database Project	2018 – 2016	UNDP
15	The draft of the sixth national report of the Convention on Biological Diversity	2018 – 2018	UNDP
16	Adaptation project for most vulnerable local communities to climate change to adapt to climate change White Nile State	2018 – 2021	Global Environment Facility

17	Capacity building project to benefit from the Green Climate Fund	2018 – 2020	Green Climate Fund
18	Initial Draft of Assessment of Possible Activities to Ratify the Minamata Convention to Reduce the Use of Mercury	2018 – 2020	Global Environment Facility through the United Nations Industrial Development Organization (UNIDO)
19	Adaptation of Rural Livelihoods to Climate Change Project in the Horn of Africa	2018 – 2021	Global Environment Facility – African Development Bank
20	Strengthening targeted national capacities to improve decision-making and mainstream global environmental commitments	2018 – 2022	Global Environment Facility (United Nations Development Program)

Chapter Four

Stakeholders and Assignment of Responsibilities

4.1. National Institutional Framework:

The Drought Management Plan of Sudan involves a variety of stakeholders, each playing significant roles in addressing the challenges of drought in the country. Here below is a brief description of the functions of these stakeholders from government, state, private sector, community, and NGO institutions:

1. Government Agencies:

Government entities, such as the Higher Council for Environment and Natural Resources (HCENR), lead the formulation of environmental policies, legislation, and strategic planning. HCENR acts as a coordination body across sectors, ensuring sustainable management of natural resources and compliance with environmental legislation. The Ministry of Irrigation and Water Resources is responsible for maintaining national water infrastructures and ensuring the efficient use of water resources. It offers specialized training and capacity development in water resource management and operates a Regional Water Harvesting Centre to raise awareness and provide resources. Additionally, the Directorate of Rangelands and Pasture and other agricultural directorates work closely with local and state bodies to implement project interventions and manage natural resources effectively. Finally, the National Civil Defense Council is also one of the entities concerned with disaster management.

2. State and Local Government:

These entities are mandated to execute drought management strategies at the state and local community level, ensuring the incorporation of local needs and contextual conditions, such as the White Nile state. They will also serve to facilitate programs aimed at community engagement and awareness.

3. Universities and Research Institutions:

National Research and Development Institutions are tasked with the rigorous investigation of drought patterns, their impacts, and strategies for mitigation. They will furnish essential data and analytical insights that inform policy formulation and enhance drought forecasting capabilities.

4. Non-Governmental Organizations (NGOs):

Community-based organizations are poised to assume a crucial role in mobilizing community resources, providing education regarding drought preparedness, and executing local adaptation initiatives.

5. Private Sector:

This includes Agribusiness and Financial Institutions (e.g. banks) from the private sector which are tasked by incentivizing them to invest in agricultural practices that are resilient to drought and to offer financial products that provide support to farmers under drought conditions.

4.2. Assignment of Responsibilities:

1. Policy Development:

The Ministries of Agriculture and Irrigation shall spearhead the formulation of a comprehensive drought management policy, integrating contributions from all relevant stakeholders, including NGOs and the private sector.

2. Coordination and Implementation:

The Higher Council for Environment and Natural Resources (HCENR) will be responsible for the coordination of the drought management plan's implementation, ensuring that all agencies and organizations collaborate cohesively.

3. Monitoring and Evaluation:

Research institutions will be entrusted with the ongoing monitoring of drought conditions and the assessment of the effectiveness of the strategies that have been implemented. They will deliver regular reports to the government and other stakeholders.

4. Community Engagement:

NGOs will play a facilitative role in community engagement initiatives, ensuring that local populations are well-informed and actively involved in drought preparedness and response activities.

5. Funding and Resource Mobilization:

The government will collaborate with the private sector to secure financial resources for drought management initiatives, whilst simultaneously seeking international assistance to augment resource availability.

Chapter Five

Drought Monitoring, Forecasting, and Early Warning

Drought monitoring, forecasting, and early warning systems are essential for effective drought management (Beguería et al. 2012). They help assess drought conditions, predict future occurrences, and provide timely information to stakeholders. These systems form the foundation of proactive drought policies and integrate various data sources, including precipitation, temperature, surface water supplies, soil moisture, and remotely sensed data, to identify climate and water supply trends (Wilhite and Svoboda 2000). Below are key aspects related to drought indices, current monitoring and forecasting, and drought information systems that can be adopted in managing drought in Sudan.

5.1. Drought Indices and Indicators:

- **Definition and Importance**:

Drought indices are quantitative measures that simplify complex climatic data to assess drought conditions. They provide historical references for planning and design applications and help communicate drought severity to diverse audiences. These indices serve as essential tools for decision-makers, allowing them to take appropriate actions to mitigate drought impacts (El-Ramady et al. 2014).

- **Types of Drought Indices**:

Drought indices are essential tools for monitoring and assessing drought conditions(Melsen et al. 2021; Zhang et al. 2022). Effective drought monitoring relies on the collection and analysis of diverse datasets to assess the onset, duration, and severity of drought conditions. Various drought indices have been developed to provide and monitor quantitative measures that help understand droughts' severity and impact.

Figure (1) below presents the correlation matrix, revealing significant relationships between various drought indices and environmental variables in Sudan. These insights are crucial for understanding how these environmental variables and drought indices

interact with each other. There is a very strong positive correlation between evapotranspiration (ET) and the Normalized Difference Vegetation Index (NDVI) (0.98), indicating that as evapotranspiration increases, NDVI also rises. Similarly, ET correlates positively with precipitation (0.87) and SPI_3 (0.90), suggesting higher precipitation and higher SPI_3 values are associated with increased ET. In contrast, there is a moderate negative correlation between ET and SPEI_3 (-0.53), indicating that higher ET tends to be associated with lower SPEI_3 values. NDVI also shows strong positive correlations with precipitation (0.81) and SPI_3 (0.93), while correlating negatively with SPEI_3 (-0.64). Precipitation has a strong positive correlation with SPI_3 (0.77) and a weak negative correlation with SPEI_3 (-0.09). Notably, SPI and SPEI indices have moderate negative correlations across different scales, such as SPI_3 and SPEI_3 (-0.61), SPI_6 and SPEI_6 (-0.64), SPI_9 and SPEI_9 (-0.61), and SPI_12 and SPEI_12 (-0.57), suggesting an inverse relationship between these indices. These insights are critical for understanding and managing drought conditions effectively.

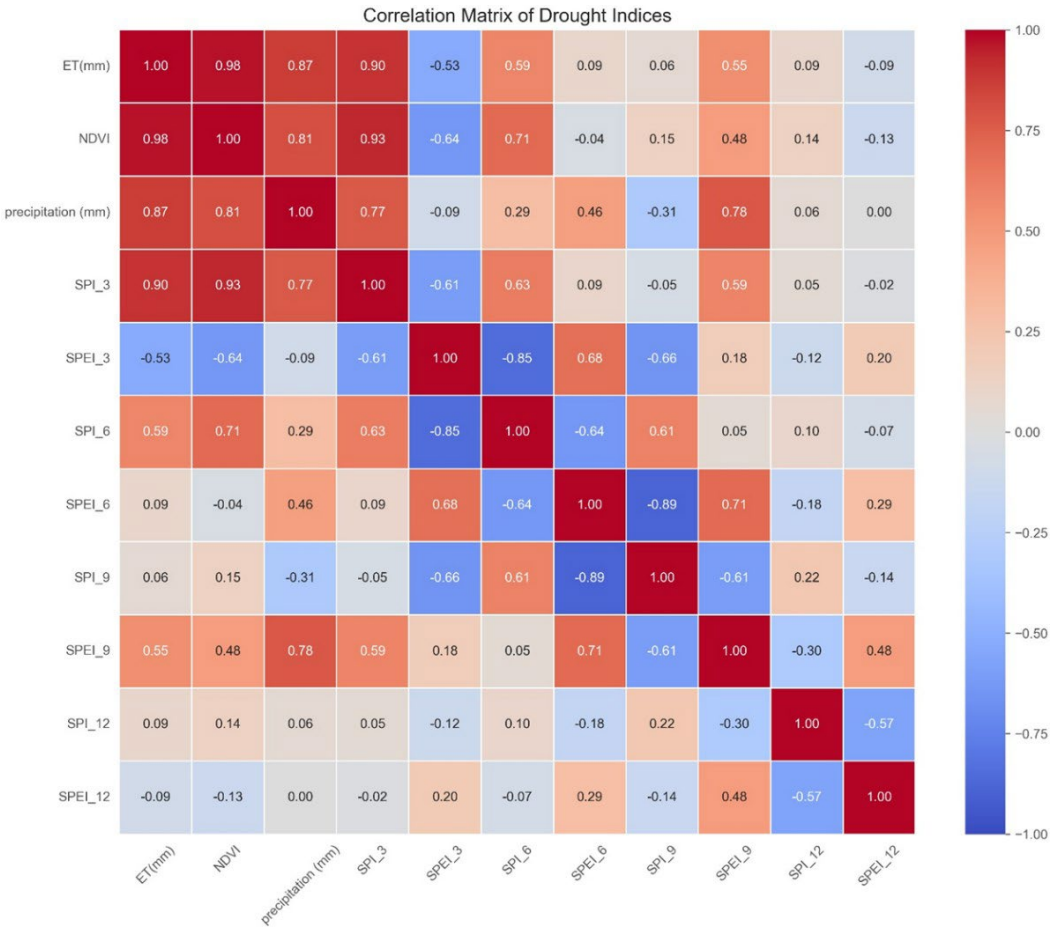

Figure (1) Pearson correlation matrix among different drought indices, where darker shades of red circles show a strong positive correlation, (darker shades of blue) show stronger negative correlations and Lighter shades indicate weaker correlations

Table (3) below provides examples of common drought indices focusing on their specific uses, way of development, and data sources.

Type of Index	Objective	Sources of Data and Way of Development	Website/Link
Vegetation Condition Index (VCI)	Monitors vegetation health based on reflective data.	Developed from satellite reflective data to assess vegetation health.	NOAA's STAR (Noureldeen, Mao et al. 2020)
Temperature Condition Index (TCI)	Assesses temperature-related stress on vegetation.	Utilizes thermal satellite data to determine temperature impacts on vegetation.	NASA MODIS (Burka, Biazin et al. 2024)

Soil Moisture Indices (e.g., SSI)	It uses microwave data to evaluate soil moisture levels, focusing on agricultural drought.	Derived from microwave remotely sensed data to monitor soil moisture levels.	ESA SMOS (Javed, Bhattarai et al. 2024)
Normalized Difference Drought Index (NDDI)	Detects drought conditions by analyzing vegetation health and moisture levels, combining ET, PET, and NDVI.	Based on satellite data, integrates ET, PET, and NDVI for soil moisture insights.	USGS Earth Explorer (Nguyen, Dao et al. 2024)
Vegetation Drought Index (VDI)	Assesses vegetation health in response to drought conditions, useful for monitoring agricultural droughts.	Derived from satellite data to evaluate vegetation's response to drought.	Landsat Program (Omidvar, Nabavizadeh et al. 2024)
Standardized Precipitation Index (SPI)	Quantifies precipitation deficits over various time scales to estimate drought occurrence likelihood.	Uses historical precipitation data for analysis over varied temporal scales.	NOAA NCEI (Noureldeen, Mao et al. 2020)
Drought Severity Index (DSI)	Detects and monitors global drought events, providing a comprehensive severity assessment.	Developed using MODIS data to assess and monitor the severity of drought events globally.	MODIS Global (Lenczuk, Ndehedehe et al. 2024)
Microwave Integrated Drought Index (MIDI)	Evaluates agricultural drought conditions using soil moisture data from microwave sensors.	Integrates microwave remotely sensed soil moisture data to assess drought conditions.	Copernicus (Kaushik, Pandey et al. 2024)

5.2. Current Monitoring and Forecasting:

- **Drought Monitoring Systems**:

Effective drought monitoring systems are crucial for early detection and proactive response. They include timely data acquisition, data synthesis and analysis, and efficient dissemination networks (e.g., radio, TV, web, and media …etc.). Key data sources include weather stations, stream gauges, and soil moisture sensors. These systems integrate multiple data sources to provide a comprehensive view of drought conditions, enabling early warning and informed decision-making (Beguería et al. 2012).

Remote sensing technologies, such as MODIS and Landsat, play an increasingly important role in drought monitoring, offering wide spatial coverage and frequent temporal updates (Farahmand et al. 2015). The Vegetation Condition Index (VCI) derived from remote sensing data provides valuable insights into drought conditions in Sudan. The mean annual VCI from 2000 to 2024 in Figure 2 (a) shows significant temporal variations, indicating fluctuations in vegetation health over time. This time series helps identify years of better and worse vegetation conditions, likely corresponding to changes in rainfall patterns and drought events. Additionally, the spatial distribution of VCI across Sudan reveals areas more prone to drought (Figure 2 (b)), with variations in vegetation health visible across different regions. This spatial representation aligns with the drought risk areas identified in the assessment, particularly highlighting vulnerabilities in the northern, eastern, and central regions of Sudan.

- **Forecasting Techniques**:

Current forecasting methods utilize historical data and predictive models to anticipate drought conditions. This includes operational assessments using indices like the Drought Severity Index (DSI) and satellite data for real-time monitoring. Other widely used indices include the Standardized Precipitation Index (SPI), the Palmer Drought Severity Index (PDSI), and the Vegetation Condition Index (VCI). Advanced technologies such as machine learning and artificial intelligence are also being employed to improve forecasting accuracy. These techniques are enhancing the lead time and reliability of drought predictions, allowing for more effective preparedness and response strategies (Hao et al., 2018). Additionally, integrating seasonal climate forecasts with hydrological models improves long-term drought outlooks (Yuan et al., 2013).

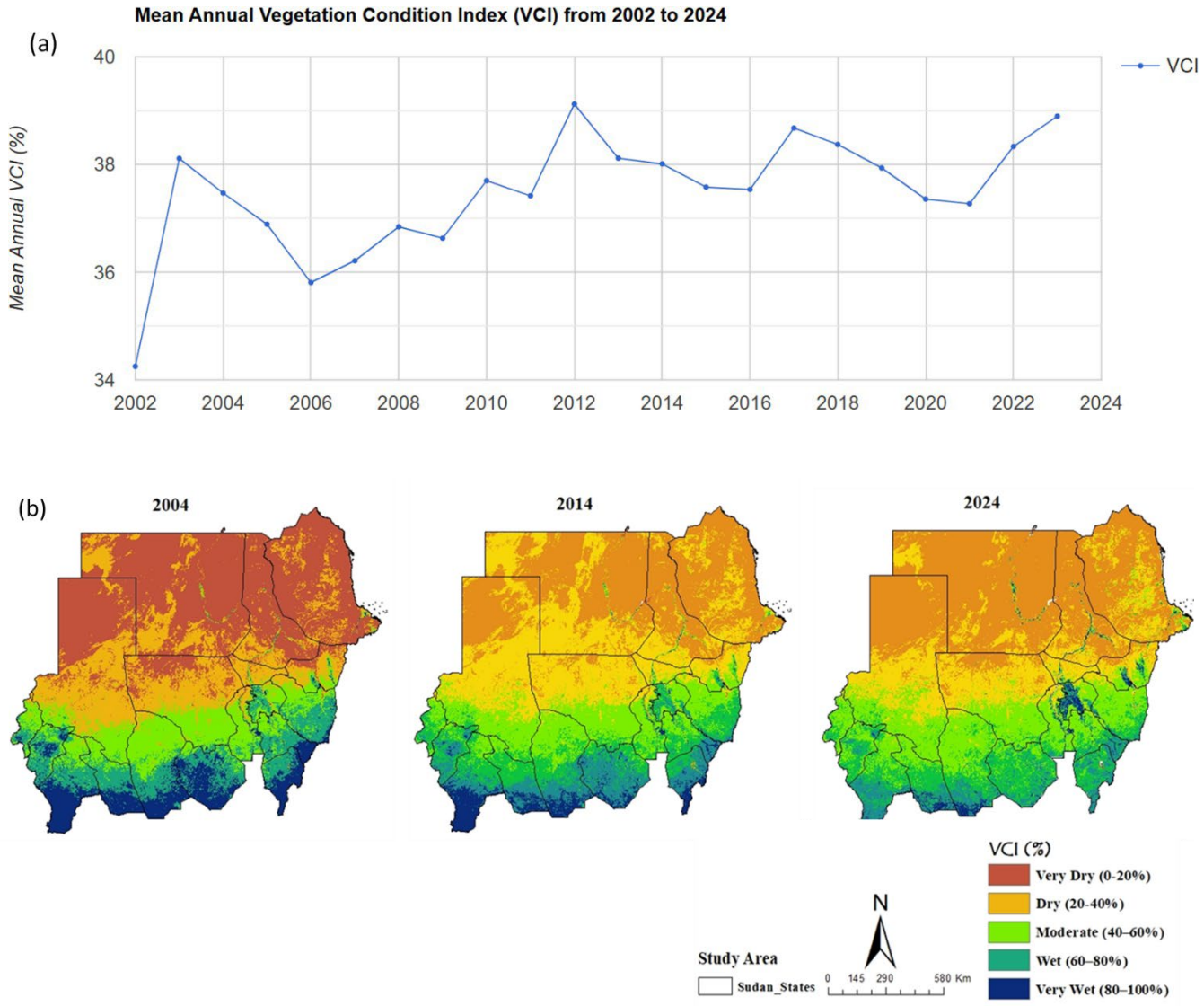

Figure 2: Vegetation Condition Index (VCI) in Sudan: (a) Mean Annual VCI (2004-2024) and (b) Spatio-temporal distribution of VCI for 2004, 2014, and 2024

The assessment and prediction of drought conditions in Sudan using the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) have provided valuable insights into the region's climatic patterns and future risks. The historical analysis of SPI and SPEI, spanning the years 2000 to 2023 Figure 3, highlighted significant periods of drought, with the longest recorded drought duration lasting 6 months.

The historical data and advanced forecasting models like ARIMA and TBATS provide a comprehensive understanding of drought dynamics and future risks. The forecasts indicate an increased risk of drought incidents in the coming years, with the SPI and SPEI projections for 2025 and 2027 showing a higher likelihood of drought conditions compared to the historical average. These findings underscore the importance of preparedness and adaptive strategies. Policymakers and stakeholders in Sudan are encouraged to implement measures such as improved water management practices, the development of drought-resistant crops, and investment in infrastructure to mitigate the impacts of future droughts. Continuous monitoring and accurate forecasting are essential for building resilience and ensuring sustainable water resource management in Sudan.

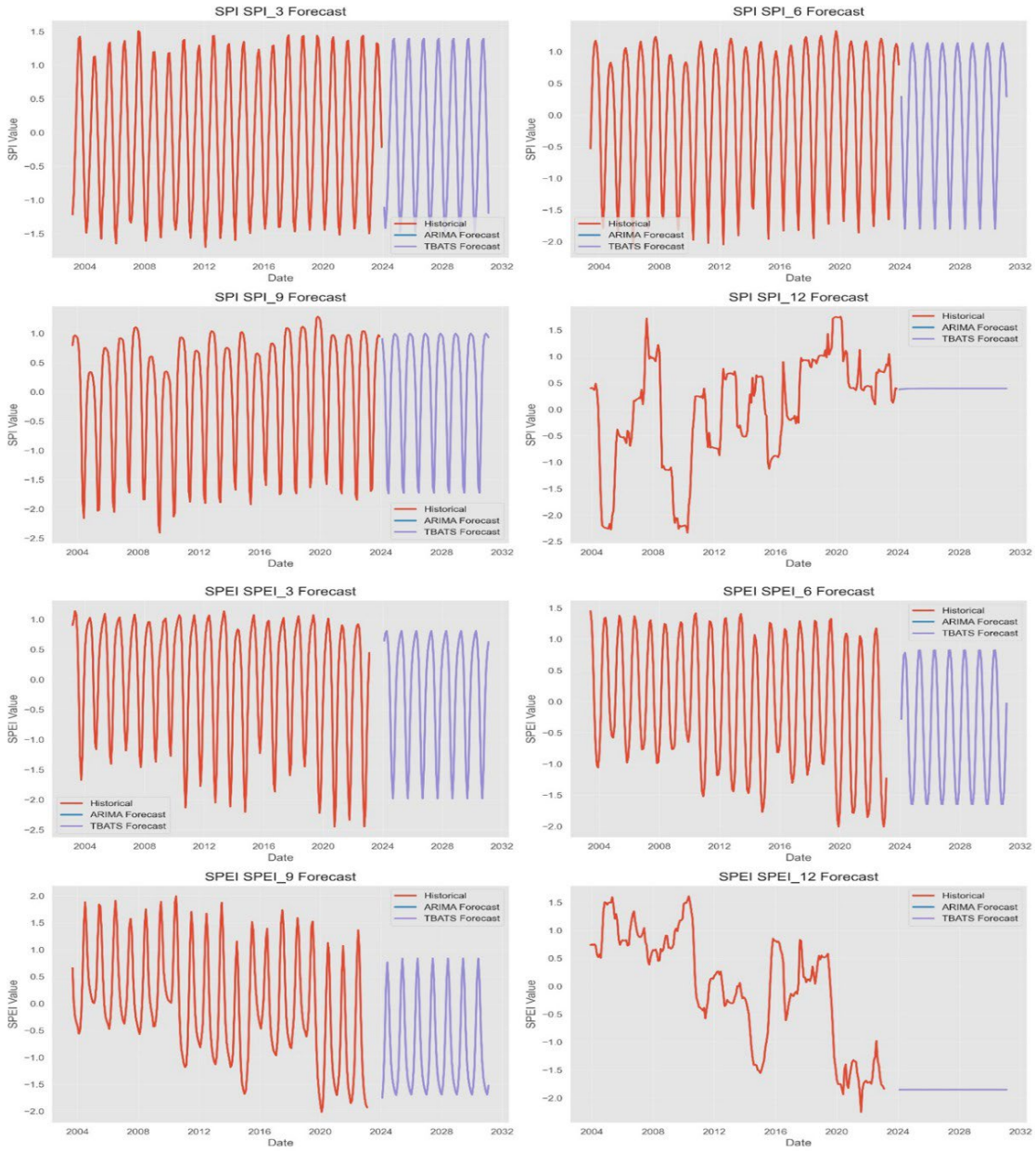

Figure 3: The historical analysis of SPI and SPEI for Sudan, spanning the years 2000 to 2023

5.3. Drought Information System:

- **Components of a Drought Information System**:

A comprehensive drought information system integrates monitoring, forecasting, and communication tools. Key components include:

- **Monitoring and Forecasting**: Continuous assessment of climatic conditions and predictions of drought occurrence.
- **Decision-Making Tools**: Providing actionable information to policymakers and stakeholders for effective drought management.
- **Education and Awareness**: Raising public awareness about drought risks and preparedness measures.

- **Role in Drought Management**:

The drought information system serves as a foundation for implementing drought management strategies, enhancing preparedness, and facilitating timely responses to mitigate impacts. Drought monitoring, forecasting, and early warning systems are vital for managing drought risks effectively. By utilizing various drought indices, current monitoring techniques, and a robust information system, stakeholders can enhance their preparedness and response strategies, ultimately reducing the adverse effects of drought on communities and ecosystems. Moreover, these systems incorporate tools for impact assessment, allowing for the evaluation of potential impacts of drought on different sectors, such as agriculture, water resources, and the economy (Wilhite et al., 2014). They also support long-term planning by integrating climate change projections to develop adaptation strategies and manage water resources sustainably (Mishra & Singh, 2011). Additionally, establishing trigger mechanisms within these systems helps set clear thresholds for different levels of drought severity, which can automatically initiate specific response actions when necessary (Steinemann et al., 2015). This version integrates your points into a cohesive narrative about the role of drought information systems in management strategies.

Chapter Six

Drought Risk and Vulnerability

6.1. Drought Risk and Vulnerability Assessment and Mapping

In this study, the assessment of drought risk and vulnerability in Sudan has been grounded on a comprehensive framework that considers both natural and human-made factors. This includes evaluating the interrelationship between climate change, demographic growth, and socio-economic conditions exacerbating drought vulnerability. We primarily utilized remote sensing and Geographic Information Systems (GIS) technologies to conduct a systematic and standardized assessment to identify and evaluate the various factors contributing to drought risk in Sudan. This includes identifying and analyzing key vulnerability indicators such as meteorological data, agricultural productivity statistics, vegetation changes, and socio-economic indicators. These indicators will help prioritize areas that require immediate attention and intervention (figure 4).

6.2. Drought Risk Areas (Distribution):

As the main finding for our assessment, we created a detailed map that illustrates drought-risk areas and highlights regions most susceptible to drought conditions and, therefore, forms potential areas for ongoing and future drought risk reduction and adaptation interventions.

The drought risk map of Sudan (Figure 4) provides a comprehensive visualization of the spatial distribution of drought risk across the country. The map employs a color gradient to represent varying levels of drought risk, with darker shades indicating higher-risk areas and lighter shades representing lower-risk regions. This spatial representation is based on the integration of the Vegetation Condition Index (VCI), Temperature Condition Index (TCI), and precipitation data, offering a multi-faceted approach to drought risk assessment.

The map delineates areas of high, medium, and low drought risk. High-risk areas, predominantly concentrated in the northern and eastern parts of Sudan, are

characterized by darker shades. These regions likely correspond to areas with significant precipitation shortfalls, higher temperature stress, and poor vegetation health as indicated by the VCI, TCI, and precipitation analysis. The gradient of risk visible on the map reflects the complex interplay of these factors across Sudan's diverse landscape.

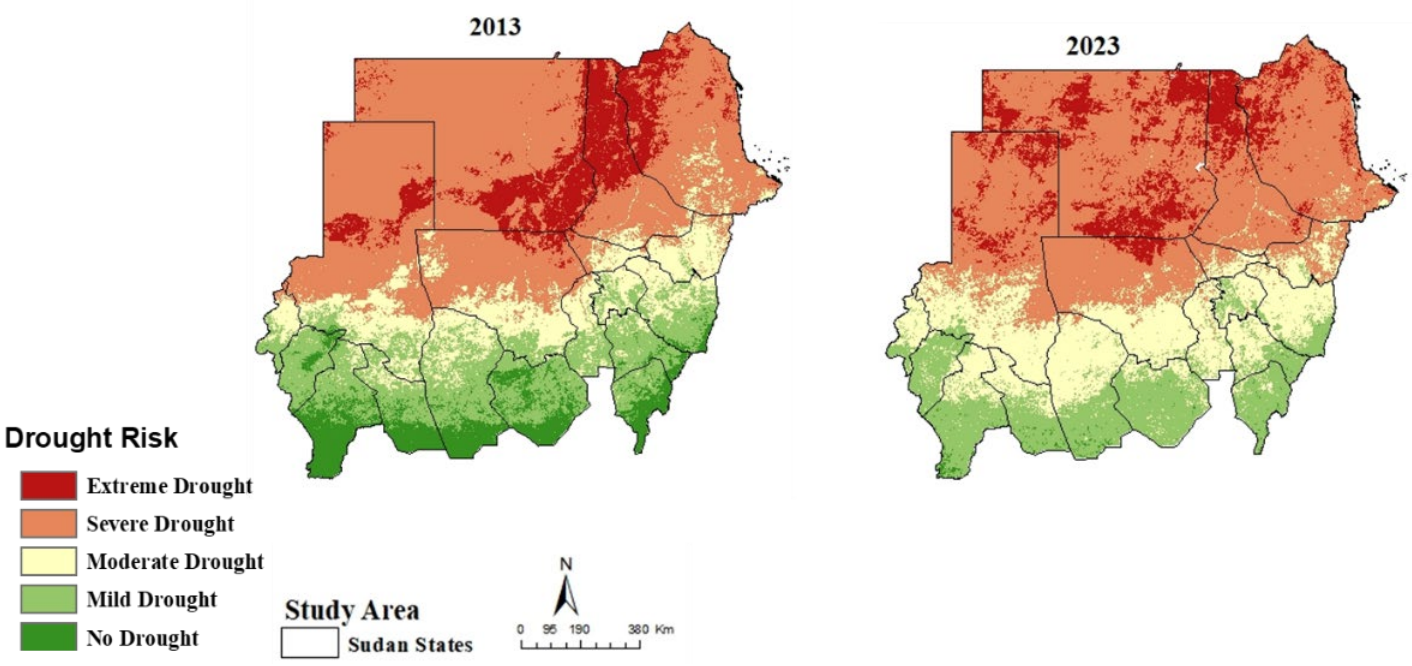

Figure 4: The drought risk map of Sudan based on the integration of the Vegetation Condition Index (VCI), Temperature Condition Index (TCI), and precipitation data for 2013 and 2023.

- **Identification and Mapping of Drought Risk Areas (Distribution):**

Identifying high-risk regions in Sudan is crucial for effective drought management. Based on the findings of the drought-risk assessment, we classified Sudan into three drought-risk regions which are high, medium, and low-risk as indicated in Figure 4. Hence, high-risk areas are characterized by significant precipitation shortfalls, erratic rainfall patterns, and high levels of socioeconomic vulnerability. For instance, regions in Sudan that experience precipitation deficits, and late and unevenly distributed rainfall are particularly considered vulnerable and classified as high-risk areas. According to

Sudan's National Drought Plan of 2018, the area considered drought-prone is estimated at 690,000 square kilometers, producing 90% of the cultivated food crops, and hosting 70% of livestock. It is a source of 85% of firewood. In the following, we provide potential High-Risk Areas in Sudan:

1) **Northern and Eastern Regions**:

Drought-risk areas in Sudan are primarily concentrated in the northern regions, which are largely desert, transitioning to semi-desert and savannah areas in the south. This region includes the Northern, River Nile, Khartoum, Kassala, and Red Sea states, which are classified as high-risk areas because low and erratic rainfall patterns characterize them. Moreover, agricultural activities in this region heavily depend on consistent rainfall, and most of their population depends on rain-fed agriculture.

2) **Western Sudan**:

Regions such as Darfur may also be at high risk due to historical patterns of drought and conflict, which exacerbate vulnerability. The combination of socio-economic challenges and climatic variability makes these areas particularly susceptible to drought impacts.

3) **Central Sudan**:

The central regions (i.e. Kordofan and White Nile states), where pastoralism and agriculture are prevalent, may face high risks due to their reliance on rain-fed systems. Variability in rainfall can lead to significant agricultural shortfalls in this high-risk area where precipitation deficits were noted.

- **Factors Contributing to High-Risk Classification**

  A. **Shortfalls**:

Areas with significant precipitation shortfalls, particularly those exceeding 50%, are likely candidates for high-risk classification. This mirrors findings from many other countries in Africa such as Ethiopia, Kenya, and Botswana, where certain districts there faced severe rainfall deficits.

B. **Vegetation degradation**:

Vegetation degradation in Sudan's drylands, driven by overgrazing, deforestation, and unsustainable farming, leads to higher drought risk by reducing vegetation essential for soil moisture retention and erosion prevention. This results in lower water availability for plants and livestock, diminishing agricultural productivity and resilience. Degradation disrupts ecological processes, impairs soil fertility, and decreases biodiversity, weakening ecosystem resilience. Changes in microclimates from reduced vegetation exacerbate drought conditions and disrupt water cycles, leading to prolonged dry spells. Consequently, agricultural communities face increased vulnerability, with heightened water shortages and economic challenges during droughts.

C. **Socio-Economic Vulnerability**:

Regions with high poverty levels, limited access to water resources, and reliance on subsistence farming are more vulnerable to drought. The distribution of drought-risk areas significantly impacts communities' livelihoods, particularly in rural settings where agriculture is the main source of income. Vulnerable communities in these areas face severe food shortages and health issues during prolonged drought periods. This socio-economic context is critical in determining the overall risk level.

6.3. Most Vulnerable Sectors to Drought in Sudan:

- **Agriculture**: The agricultural sector is the most vulnerable to drought in Sudan. Drought significantly impacts crop yields, leading to food shortages. For instance, according to SNDP (2018), the 2015 rainy season saw a 25% drop in staple food production compared to the five-year average, highlighting the sector's susceptibility to changing weather patterns and insufficient rainfall.
- **Livestock**: Livestock production is also highly vulnerable to drought conditions. Drought leads to reduced pasture availability and water scarcity, which can result in decreased livestock health and productivity. This is particularly critical in pastoral communities that rely on livestock for their livelihoods.
- **Water Resources**: Water resources are under severe threat from drought, especially in regions where water availability is already limited. The Nile water

basin, which is crucial for Sudan's water supply, faces challenges due to competing demands and climate variability. Drought exacerbates these challenges, leading to increased competition for water among agricultural, domestic, and industrial users.

- **Food Security**: Food security is directly affected by drought, as it leads to reduced agricultural output and increased prices for food commodities. The combination of lower production and higher prices can push vulnerable populations into food insecurity, particularly in rural areas where dependence on agriculture is high.
- **Rural Communities**: Rural communities, which often rely on subsistence farming and livestock rearing, are particularly vulnerable to the impacts of drought. The loss of crops and livestock can lead to economic instability and increased poverty levels, making it difficult for these communities to recover from drought events.

6.4. Impact of the Ongoing Armed War on Drought Vulnerability in Sudan:

Generally, instability and conflicts increase vulnerability to drought through the disruption of agricultural activities, displacement of populations, degradation of natural resources, increased competition for resources, and weakening of governance structures. These factors collectively hinder the ability of communities to adapt to and recover from drought conditions. In the following, we list the most potential consequences of the ongoing armed war on drought vulnerability in Sudan:

- **Disruption of Agricultural Activities**:

Ongoing conflicts in Sudan can severely disrupt agricultural activities, which are crucial for food security. When disputes arise, farmers may be forced to abandon their fields, leading to reduced crop production. This abandonment exacerbates vulnerability to drought, as communities become less resilient to food shortages during dry periods.

- **Displacement of Populations**:

Conflicts often result in the displacement of populations, forcing people to leave their homes and agricultural lands. Displaced individuals may settle in areas that are less suitable for farming or may lack access to essential resources like water. This displacement increases their vulnerability to drought, as they may not have the means

to adapt to new environmental conditions.

- **Degradation of Natural Resources**:

The ongoing conflicts can lead to the degradation of natural resources, including land and water. Armed conflicts often result in unsustainable practices, such as overgrazing and deforestation, which diminish the land's ability to recover from drought. The degradation of these resources makes communities more susceptible to the impacts of drought.

- **Increased Competition for Resources**:

Conflicts can heighten competition for scarce resources, such as water and arable land. As drought conditions worsen, the struggle for these resources can lead to further tensions and violence among communities. This competition can undermine cooperative efforts to manage resources sustainably, increasing overall vulnerability to drought.

- **Weakening of Governance and Institutions**:

Ongoing conflicts can weaken governance structures and institutions responsible for managing drought risk and response. When governments are preoccupied with conflict, they may neglect essential services such as agricultural support, disaster preparedness, and infrastructure development. This lack of support can leave communities ill-equipped to handle the challenges posed by drought.

Chapter Seven

Drought Communication and Response Action

Drought Communication and Response Action are crucial for effective drought management, as they ensure the timely dissemination of accurate information, enabling proactive decision-making and preparation. Coordinated response efforts among agencies improve resource allocation and execution efficiency, while public education on drought risks fosters community resilience through sustainable practices like water conservation. Moreover, these actions facilitate valuable feedback loops, allowing strategies to adapt and remain effective over time. This chapter introduces the Drought Communication Protocol, a strategic framework for orchestrating a nationwide response to drought.

7.1. Drought Communication Protocol:

1. Objectives of the Drought Communication Protocol

1. Enhance Stakeholder Engagement:

The protocol seeks to actively engage all pertinent stakeholders, encompassing governmental bodies, non-governmental organizations, and local communities, within the drought communication framework. This approach guarantees that all parties are adequately informed and can participate meaningfully in drought management initiatives.

2. Facilitate Effective Information Flow:

Establishing unequivocal communication channels to guarantee that information pertaining to drought conditions, forecasts, and corresponding response actions is disseminated proficiently among stakeholders. This necessitates the delineation of roles and responsibilities for each entity involved in the communication framework.

2. Key Components of the Drought Communication Protocol

1. Internal Communication Plan:

Formulate a robust internal communication strategy that delineates how information will traverse within the organization and extend to external stakeholders. This strategy should encompass regular updates concerning drought conditions and corresponding response measures, and appointing designated communication officers tasked with the dissemination of information.

2. Public Awareness Campaigns:

Launch initiatives to raise public awareness about the risks of drought and preparedness measures. This should include utilizing various media outlets to share information on drought forecasts and recommended actions for communities. Additionally, work with local leaders and organizations to spread awareness at the community level.

3. Monitoring and Feedback Mechanisms:

Develop systems to assess communication efforts' effectiveness and gather stakeholder feedback. This could involve conducting surveys and organizing community meetings to evaluate how well the information is understood and its impact. Moreover, adapt communication strategies based on feedback to improve clarity and reach.

3. Response Actions During Drought Events

- Timely Alerts and Warnings:

Ensure that timely alerts about drought conditions are effectively communicated to all stakeholders. This involves partnering with the Sudan Meteorological Authority (SMA) to deliver accurate weather forecasts and drought warnings. Furthermore, create a rapid response team to act swiftly upon receiving alerts and to coordinate prompt response measures.

- Coordination of Response Efforts:

Facilitate the coordination of efforts among diverse agencies and organizations engaged in drought response activities. This should include regular meetings to deliberate on prevailing drought conditions and collaborative response strategies.

Sharing resources and information to augment the overall efficacy of the response initiatives.

4. **Post-Drought Evaluation:**

After a drought event, conduct evaluations to assess the effectiveness of the communication and response measures. This process should involve: Analyzing the outcomes of the response initiatives and identifying areas necessitating improvement. Documenting lessons learned to inform future drought communication strategies.

Chapter Eight

Drought Mitigation and Preparedness Strategies and Activities

8.1. Overview of Drought Mitigation Strategies:

Drought mitigation strategies are imperative for diminishing the adverse effects of droughts on communities, agricultural systems, and ecological environments. The subsequent strategy and activities are indispensable for proficient drought preparedness and responsive measures.

8.2. Key Strategies for Drought Mitigation:

1. Early Preparedness and Resilience Building:

Emphasize the enhancement of the resilience of natural resources, particularly in arid and semi-arid territories, which represent a substantial fraction of Sudan's geographical landscape. This necessitates the conservation of the environment and the mitigation of losses about livelihood assets and natural resources.

2. Contingency Crop Planning:

Formulate contingency strategies for crop management in reaction to atypical meteorological conditions. This encompasses the selection of drought-resistant crop varieties and the planning of appropriate cropping systems to safeguard food security during periods of drought.

3. Soil and Water Management:

Execute agronomic methodologies aimed at conserving soil moisture, such as mulching and timely weed management. Furthermore, optimizing irrigation techniques and managing agricultural inputs to align with climatic conditions are crucial for sustaining soil health and moisture retention.

4. Disaster Risk Reduction (DRR):

Disaster Risk Reduction (DRR) refers to the systematic approach to identifying, assessing, and reducing the risks of disaster (e.g. drought). It aims to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevent) or to limit (mitigate and prepare for) the adverse impacts of hazards, within the broad context of sustainable development. Therefore, incorporating DRR into all sectoral strategies as part of the Drought Management Plan is crucial to mitigate vulnerabilities and associated drought risks.

8.3. Activities to Enhance Drought Preparedness:

1- Capacity Building and Training:

Facilitate training programs for stakeholders, encompassing local communities, non-governmental organizations, and governmental agencies, to enhance their comprehension of drought risks and response methodologies. This capacity enhancement is vital for effective drought management.

2- Monitoring and Evaluation:

Develop monitoring frameworks to assess drought conditions and appraise the efficacy of mitigation strategies. This entails collecting data regarding water resources, crop health, and community preparedness levels.

3- Public Awareness Campaigns:

Initiate campaigns aimed at educating the populace concerning drought risks and preparedness strategies. Engaging local leaders and leveraging diverse media platforms can facilitate the dissemination of critical information to susceptible communities.

4- Collaboration and Coordination:

Encourage collaboration among various technical institutions and agencies engaged in drought-related issues. A synchronized approach ensures the effective sharing of resources and the alignment of all stakeholders in their endeavors to foster drought resilience.

Chapter Nine

Public Awareness, Research, and Education

9.1. Awareness Raising:

Awareness raising for drought management is essential for enhancing the preparedness and resilience of communities, governments, and organizations. Here are some suggested types of awareness-raising activities relevant to drought management in Sudan:

1) Community Workshops and Seminars: Conduct workshops and seminars in local communities to educate people about the causes and impacts of drought and how climate change exacerbates these conditions. These sessions can also introduce practical measures to conserve water and manage resources effectively.
2) Media Campaigns: Utilize radio, television, and social media platforms to disseminate information about drought conditions, water conservation techniques, and the importance of sustainable resource management. Creative content such as dramas, skits, and music incorporating local traditions can engage a wider audience.
3) School Programs and Competitions: Implement school-based programs that teach students about the importance of water conservation and environmental stewardship. Organize competitions, such as poster-making or essay writing, to encourage students to think creatively about solutions to drought.
4) Public Information Centers: Establish centers where citizens can access resources and information about drought, including forecasts, risk assessments, and mitigation techniques. These centers can serve as hubs for community learning and engagement.
5) Collaborative Campaigns with NGOs: Partner with non-governmental organizations to expand the reach of awareness campaigns, drawing on their expertise and established networks to engage communities effectively.

9.2. Research and Education:

Research and education activities are crucial for enhancing drought management by increasing understanding and improving responses to drought conditions. Below is Table (4) summarizing research and education activities suggested for drought management efforts in Sudan, with examples for each type of activity but here are some typical activities within these areas:

1. *Interdisciplinary Research Initiatives*: Promote research that combines disciplines such as climatology, agronomy, and social sciences to develop comprehensive strategies for drought prediction, assessment, and management tailored to Sudan's unique environment.
2. *Climate Change and Drought Curricula*: Develop curricula for higher education institutions focusing on climate science, impact assessments, and sustainable agriculture and water management practices. This will prepare the next generation of scientists and policymakers.
3. *Field Studies and Pilot Projects*: Conduct field studies and pilot projects in vulnerable areas to test new drought-resistant crops and water management technologies. These studies can provide valuable data and insights for scaling successful solutions.
4. *Data Collection and Analysis*: Enhance data collection efforts on rainfall patterns, soil moisture levels, and water usage to create robust datasets that inform drought modeling and prediction efforts.
5. *Capacity Building Workshops for Researchers and Educators*: Organize workshops and training sessions for researchers and educators to equip them with advanced methodologies and tools for studying and teaching about drought and climate change.

Table (4): provides a concise overview of different research and education activities tailored to enhance drought management in Sudan, along with concrete examples.

Type of Activity	Examples
Proposed Research Activities	
Climate and Meteorological Studies	• Analyzing historical data to identify drought patterns. • Developing models to predict future drought scenarios.
Soil and Hydrology Research	• Monitoring soil moisture using remote sensing technologies. • Assessing groundwater availability during droughts.
Ecological and Environmental Studies	• Conducting impact assessments on biodiversity loss due to drought. • Researching ecosystem restoration methods.
Agricultural Research	• Developing drought-resistant crop varieties. • Innovating water-efficient irrigation techniques.
Socio-Economic Studies	• Identifying communities vulnerable to drought impacts. • Evaluating existing drought management policies.
Proposed Education Activities	
Curriculum Development	• Integrating drought topics into school programs. • Offering workshops on water conservation.
Public Awareness and Outreach	• Conducting community education sessions on drought preparedness. • Launching media campaigns for awareness.
Professional Training and Capacity Building	• Training farmers on drought-resilient practices. • Developing certification programs in water management.
Collaborative Networks and Exchanges	• Building research partnerships between institutions. • Organizing conferences to share best practices.
Use of Technology in Education	• Creating e-learning courses on drought management. • Utilizing virtual simulations for educational purposes.

Chapter Ten

Resource Mobilization and Partnerships

The successful implementation of the Drought Management Plan in Sudan requires identifying funding sources that can be anticipated to cover these proposed initiatives, which are listed throughout this plan. Here are the key funding sources these identified and suggested for potential resource mobilization and partnerships:

10.1. Domestic Funding:

- ***Government Budget Allocations**:* National and local governments (e.g. Ministries of Agriculture, Irrigation, …etc.) can allocate specific budget lines for drought management activities, ensuring that resources are available for implementation.
- ***Public-Private Partnerships**:* Engaging the private sector (e.g. companies and banks) can provide additional financial resources and expertise for drought management initiatives.

10.2. International Funding:

- ***Bilateral and Multilateral Development Partners**:* Countries and organizations that provide financial assistance to developing nations can be crucial. This includes entities like the World Bank, the African Development Bank, the Islamic Development Bank, and regional development agencies.
- ***Climate Change Funds**:* Accessing funds specifically designated for climate change adaptation and mitigation, such as the Green Climate Fund (GCF), Global Environment Facility (GEF), Adaptation Fund (AF) …etc., can support drought management efforts.

10.3. Non-Governmental Organizations (NGOs) and Foundations:

- ***Grants from NGOs**:* Various NGOs and philanthropic foundations may offer grants for projects aimed at improving resilience to climate change and drought.

- ***Collaborative Projects****:* Partnering with NGOs can also open additional funding avenues through joint projects.

10.4. Research and Development Grants:

- ***Academic Institutions****:* Funding from research grants in universities and research institutions aimed at studying drought impacts and developing innovative solutions can be leveraged to support the plan's implementation.
- ***International Research Collaborations***: Engaging in international research initiatives can provide access to additional funding sources.

10.5. Community Contributions:

- ***Local Community Funding***: Encouraging local communities to contribute resources or labor can enhance the sustainability of drought management initiatives.

10.6. Private Sector Investments:

- ***Corporate Social Responsibility (CSR)****:* Companies may invest in drought management initiatives as part of their CSR strategies, providing financial and technical support.

In summary, these anticipated funding sources are critical for ensuring that the activities outlined in the Drought Management Plan can be effectively implemented and sustained over time. Adequate financial resources will enable the plan to effectively address the challenges posed by drought and climate change.

Chapter Eleven

Report Conclusions and Recommendations

11.1. Notable Conclusions:

The proposed Drought Management Plan for Sudan outlines several critical conclusions to address the challenges posed by climate change and drought. Here are the key points derived from the proposed plan:

- **Sustainable Strategies**: The plan proposes strategies and activities designed to tackle the historical and anticipated challenges of drought in Sudan sustainably, enhancing the resilience of the economy and its citizens against increasing drought occurrences due to climate change.
- **Framework for Future Actions**: It establishes a framework for future strategies and actions that aim to mitigate the adverse effects of climate change-induced droughts. This includes raising awareness among the local population about the impending challenges and demonstrating the government's commitment to collaborate with the community and development partners for a sustainable future.
- **Urgency of Action**: The document emphasizes that if no action is taken to reduce or minimize the expected impacts of drought, the costs to society and the economy will be substantial. This highlights the urgency of implementing the proposed strategies.
- **Vulnerable Sectors Identification**: The plan identifies sectors most vulnerable to the impacts of climate change-induced drought and proposes interventions to mitigate these impacts while promoting climate-resilient production systems.
- **Need for Financial Resources**: The plan stresses the need for substantial additional financial resources to implement the activities outlined in it. Funding is required from both domestic and international sources, and partnerships must be

established to integrate climate and drought management into various programs and projects.

- **Research and Development**: The plan calls for new and additional resources to support research and development efforts and strengthen academic institutions capable of predicting drought incidence and duration.
- **Monitoring and Evaluation**: The overarching objectives of the Monitoring and Evaluation (M&E) System will focus on tracking Sudan's transition to a low-carbon and climate-resilient economy, ensuring that the strategies are effective and adaptive to changing conditions.

11.2. Recommendations for the Drought Management Plan of Sudan:

1. Strengthening Governance Links:

To enhance coordination among national, regional, and local governance, establish Inter-Agency Collaboration Committees with representation from all levels. These committees should meet regularly and work under formal Memoranda of Understanding to align goals and strategies. Additionally, develop a centralized digital platform for efficient information sharing, hosting real-time data and updates to improve transparency and cooperation. Provide training to ensure effective use of the system. Lastly, organize regular workshops and forums to facilitate feedback and collaborative discussions among stakeholders, aligning policies with practical realities and fostering collective responsibility.

2. Community Involvement and the Adoption of Gender-responsive Strategies:

Integrating community involvement and gender-responsive strategies into Sudan's Drought Management Plan (DMP) is crucial for effective and sustainable outcomes. Participatory planning should involve local communities in designing, implementing, and monitoring plans, ensuring all voices, particularly those of marginalized groups, are heard. Incorporating traditional knowledge enriches strategies, fostering ownership and relevance. Capacity building, including workshops and community-based monitoring, enhances preparedness. Developing local early warning systems ensures timely, culturally appropriate information dissemination. Gender-sensitive assessments tailor interventions to different impacts on men, women, and children. Promoting inclusive

participation secures equal decision-making roles and leadership opportunities for women. Targeted support programs and economic empowerment initiatives reduce burdens faced by women, especially during droughts, by improving access to resources, markets, and training. Protection measures against gender-based violence and access to health services, including reproductive health, are essential. Collecting sex-disaggregated data informs decisions, while awareness campaigns address gender-specific challenges, promoting equitable solutions.

3. **Launching Pilot Initiatives:**

To enhance Sudan's drought management, a Pilot Initiative could introduce various community-based programs. Community-led water Harvesting Projects can improve water access through small-scale infrastructures like rainwater tanks managed by locals. Participatory Rangeland Management would involve community groups in sustainable grazing practices and rehabilitation of degraded lands using indigenous knowledge. Agroforestry and Home Garden Initiatives could enhance food security by integrating tree cultivation with crops and encouraging household gardens to diversify income and improve soil quality. Village-Level Early Warning Systems would enable communities to monitor and react to climate changes quickly. Conducting trials for Drought-Resilient Crops should involve local farmers in selecting and testing varieties suited to local climates. Establishing Community Water Governance Committees can enhance local management and planning for water resources, while Educational Workshops can empower communities with drought mitigation techniques, emphasizing water conservation and sustainable agriculture. These initiatives aim to build resilience and provide scalable solutions for broader implementation.

4. **Focusing efforts on the focal areas e.g. Al Salam locality:**

Considering focused and localized drought actions within the national plan will be useful, especially with limited resources and intervention of other socioeconomic factors related to impacted communities. As such we encourage focusing drought management actions on some identified focal areas e.g. Al Salam locality in the White Nile state where community-centered solutions are vital in addressing these challenges, leveraging traditional water conservation techniques and indigenous practices for managing livestock and crops during droughts. Moreover, this approach allows for tailored adaptation actions such as implementing small-scale water storage systems like water

jars and sand dams, promoting drought-resistant crops suited to local soil, and establishing livestock fodder storage and supplementary feeding programs are crucial for enhancing resilience and securing livelihoods in Al Salam locality. Replicating this experience in different locations must have a greater impact. More examples of localized drought planning can be found in the Drought Emergency Response Plan (DERP) for the Al Salam locality in the White Nile state is produced simultaneously with this report.

5. Monitoring, Reporting, and Verification (MRV):

Monitoring, Reporting, and Verification (MRV) are crucial components of the proposed drought management plan of Sudan, as they ensure accountability, transparency, and effectiveness in managing drought risks. Through systematic monitoring, the plan can track progress and measure the impact of various interventions, enabling timely adjustments and resource optimization. Reporting provides a structured mechanism for communicating findings to stakeholders, facilitating informed decision-making, and fostering collaboration across government agencies, NGOs, and communities. Verification adds an essential layer of integrity, ensuring data accuracy and credibility, which is vital for policy formulation and international cooperation. Consequently, a robust MRV framework enhances the plan's ability to adapt to changing conditions, improves resilience, and supports sustainable development goals in the face of increasing climate challenges. Below is Table (5) which provides a suggested MRV plan for the implementation of Sudan's Drought Management Plan.

Table (5): organizes the Monitoring, Reporting, and Verification (MRV) components of the drought management plan, highlighting key activities within each component and providing examples.

Item	Examples
Monitoring Component	
Establish Indicators	1) % of agricultural land with drought-resistant practices. 2) Number of operational early warning systems. 3) Reduction in household water usage.
Data Collection Methods	1) Satellite imagery for vegetation monitoring. 2) IoT devices for soil moisture tracking. 3) Household surveys for water availability.

Frequency of Monitoring	1) Monthly climate data collection. 2) Quarterly assessment of reservoir levels. 3) Annual community awareness surveys.
Responsibility and Coordination	1) Agricultural Extension Services for crop resilience. 2) University partnerships for climate analysis. 3) NGO collaboration in data collection.
Verification Component	
Independent Review	1) Local university audits. 2) Evaluations by international consultants. 3) Reviews by a technical advisory panel.
Site Visits and Field Verification	1) Conduct spot checks of water infrastructure projects. 2) Perform field visits to agriculture regions. 3) Carry out inspections of drought-impacted areas.
Stakeholder Involvement	1) Engage farmer associations in verification activities. 2) Facilitate NGO-led community verification workshops. 3) Involve local government officials in verification observations.
Adaptive Management	1) Update water allocation plans based on verification outcomes. 2) Adjust training programs in response to verification feedback. 3) Modify early warning protocol using verified local data.
Reporting Component	
Regular Reporting Schedule	1) Quarterly reports to government agencies. 2) Annual reports for international partners. 3) Monthly progress summaries for internal use.
Report Format and Content	1) Include visual aids such as graphs and maps in reports. 2) Feature case studies of successful community interventions. 3) Append detailed challenges and solutions in a report appendix.
Stakeholder Communication	1) Host webinars with stakeholders to discuss findings. 2) Distribute email newsletters containing report highlights. 3) Provide public access to reports on a web portal for transparency.
Feedback Mechanism	1) Offer online feedback forms for stakeholder input. 2) Conduct focus groups with stakeholders to gather insights. 3) Organize public meetings to collect community input on reports.

6. Future Updates and Revisions:

The Drought Management Plan for Sudan necessitates regular updates and revisions every 3-5 years to remain effective amid evolving environmental and socio-economic conditions. As climate change continues to modify weather patterns, increasing both the frequency and severity of droughts, it is essential for the plan to integrate the latest scientific research, technological innovations, and best practices in drought mitigation and response. These periodic reviews enable the assessment of achievements against set objectives, facilitate the identification of emerging challenges, and allow for the reallocation of resources to the most critical areas. Additionally, continuous stakeholder engagement ensures the plan is responsive to the dynamic needs of local communities and harmonized with national and international climate policies. Implementing this structured update process significantly enhances resilience, ensures sustainable resource management, and protects vulnerable populations from the adverse impacts of drought.

7. The Action Plan (DAP):

This proposed action plan is a detailed outline of the specific steps required to achieve Sudan's drought management plan objectives. It serves as a roadmap for implementing suggested strategies, ensuring coordinated efforts toward mitigating and combating drought impacts in Sudan, and building community resilience. Table (6), provides a structured overview of the key components of the Action Plan, detailing what needs to be done (action), who is responsible (entities), when (timeline), needed resources, and means of verification to ensure effective drought management in Sudan.

Table (6): provides an organized overview of the action plan with proposed actions, responsibilities, timeline, necessary resources, and verification means to ensure effective implementation and follow-up of the Drought Management Plan in Sudan

No.	Action Item	Objective	Responsible Entities	Timeline	Resources Needed	Means of Verification
1	Objective Setting	Establish specific, measurable objectives for reducing drought impact.	National Drought Management Committee	Month 1	Research data, expert consultants, meeting resources	Approval of objectives document
2	Stakeholder Identification and Engagement	Foster collaboration and ensure active participation from all relevant stakeholders.	Government Agencies, NGOs, Community Leaders	Months 1-2	Communication tools, logistics for meetings, stakeholder lists	Stakeholder engagement reports, attendance records
3	Risk Assessment and Data Collection	Identify vulnerable areas and improve data gathering on drought conditions.	Meteorological Authority, Water Management Bodies	Months 2-4	Data analytics software, technical experts, monitoring equipment	Risk assessment reports, updated data sets

No.	Action Item	Objective	Responsible Entities	Timeline	Resources Needed	Means of Verification
4	Capacity Building and Training	Enhance skills and knowledge for drought resilience in local leaders and communities.	Agricultural Extension Services, Educational Institutions	Months 3-6	Training materials, workshop funding, expert trainers	Training completion certificates, feedback forms
5	Infrastructure and Resource Management	Develop and improve infrastructure for water storage and efficient distribution.	Ministry of Water, Agriculture Agencies	Months 4-8	Construction materials, financial investment, engineering expertise	Infrastructure project completion reports, site visits
6	Policy and Institutional Framework	Update and strengthen policies and institutions related to drought management.	Legal Affairs, Policy Makers	Months 4-6	Policy analysis resources, legal consultants, policy draft documents	Revised policy documents, and implementation plans
7	Response and Recovery Planning	Establish protocols for immediate response and long-term recovery from drought.	Emergency Services, Relief Agencies	Months 6-12	Emergency response equipment, recovery funds, protocol templates	Approved response protocols, drill reports

No.	Action Item	Objective	Responsible Entities	Timeline	Resources Needed	Means of Verification
8	Monitoring, Evaluation, and Adaptation	Implement systems for regular assessment and adaptation of drought management strategies.	Monitoring and Evaluation Unit	Ongoing; Quarterly	M&E tools, data collection resources, expert analysts	Evaluation reports, adaptation plans
9	Funding and Resource Allocation	Identify and allocate resources effectively to support drought management initiatives.	Finance Ministry, Development Partners	Months 1-4 (review quarterly)	Financial resources, budget planning tools, partnership agreements	Funding allocation reports, financial audits
10	Communication and Public Awareness	Increase public awareness about drought risks and promote effective communication strategies.	Communications Office, Media Outlets	Months 2-5	Media campaign funds, education materials, communication channels	Media coverage reports, public awareness surveys

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