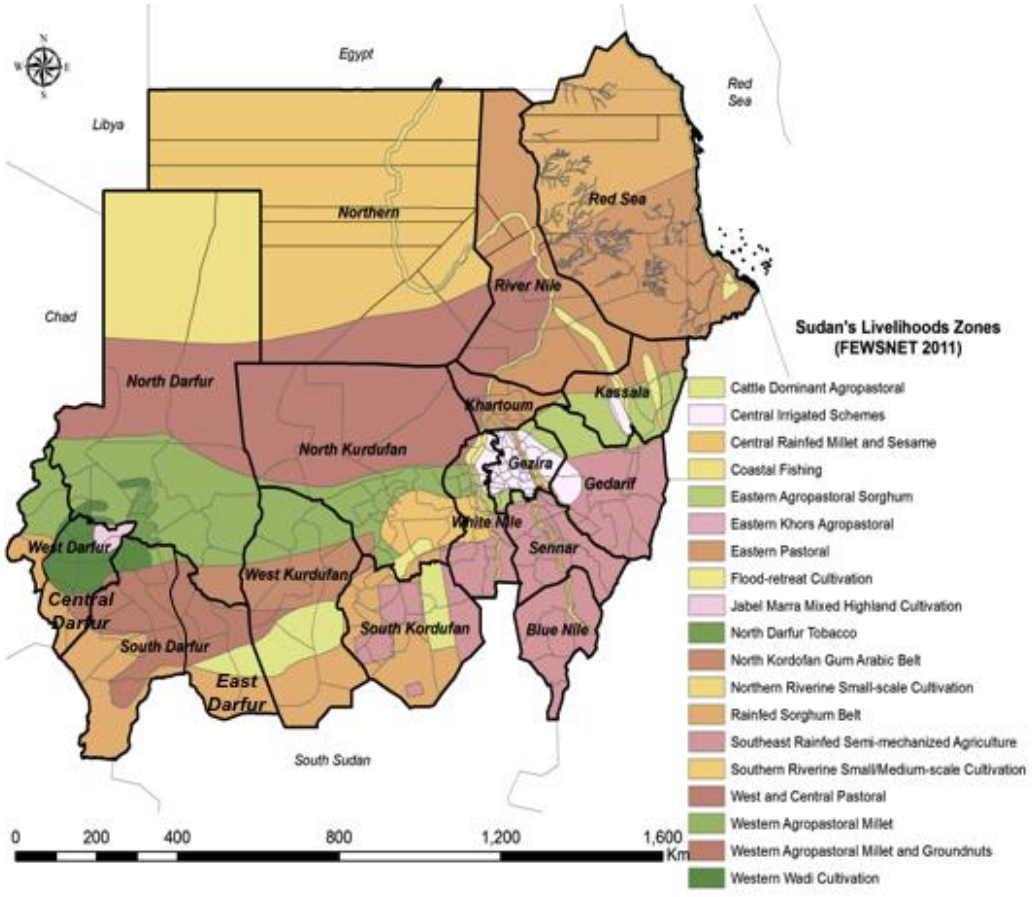
REPUBLIC OF THE SUDAN

Ministry of Environment & Physical Development

Higher Council for Environment and Natural Resources

National AdaptationPlan



May 2014

Minister's Foreword

Climate change poses significant challenges to Sudan. Climate Change is not merely an environmental issue that is defined by precipitation and temperature changes; it represents a serious sustainable development problem that affects everyone in our country, particularly those in rural communities who are the most vulnerable. Therefore, Sudan considers that effective and ongoing efforts to adapt to climate change a national priority.

As an active party of United Nations Framework Convention on Climate Change, Sudan has worked very closely with the international community on the issue of adaptation planning. This National Adaptation Planis both an example of this collaboration and a practical step forward in helping us assess the kinds of changes needed within our state and federal development planning processes to ensure effective and ongoing adaptation efforts throughout the country.

I am proud to note that agencies at the state and federal levels demonstrated a strong commitment to Sudan's National Adaptation Plan. From the initial preparation stages to the intensive stakeholder-driven vulnerability assessments to the identification of consensus adaptation priorities, the process has served as a model for effective action on perhaps Sudan's most serious development challenge.

We are well aware that this Plan requires substantial donor assistance resources for its implementation. We are looking forward for cooperation with Annex I Parties and international financial institutions to provide financing, support technology transfer, and strengthen institutional capacity. Taken together, this type of support will be critical in supporting Sudan ongoing efforts to adaptto climate change.

Hassan Abdel Gadir Hilal
Minister of Environment, Forestryand Physical Development
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Acknowledgments

Sudan's National Adaptation Plan is the product of a large member of institutions and the individuals. Although many have been contributed to the process of preparing this plan there are certain individuals and institutions deserve special recognition for their tangible inputs to this process.

His Excellency, Hassan Abdel Gadir Hilal, Minister of Environment, Forestry and Physical Planning has continuously supported all project activities and provided valuable leadership. Thanks are also extended to all the minsters at the State level for their support and commitment to the NAP process.

Deserving special recognition are the 18 state-level focal points and their technical committee members and all their institutions. Without them, the accomplishments of the project's activities would have been impossible. Special thanks go to the United Nation Environment Programme - Sudan office and to the Department for International Development of the UK for their vital financial and technical support. Thanks also go to the organization of the Protection of Environment of the Red Sea and Gulf and Aden for the data and technical input on the Red Sea coastal zone study.

Professional expertise of the national resource persons is gratefully acknowledged. We express pecial thanks to Dr. Salaheldin Yousif, Dr. Abdelhamid. Dirdiri. Nugud, Dr. Sumaya Ahmed Zakieldeen, Dr. Khitma Elawad, Dr. Asia Adlan, Dr. Salah Mohamed Taha, Mr. Hamdi Abbass Ibrahim, Dr. Amin Sanjaak, Dr. Abdel Rahman Elkidir, Dr. Mekki Abdel Latif Omar, Mr. Hatim Elobeid Ibrahim, Ms. Awatif Elnair, Dr. Abdalla Khyar Abdalla, Dr. Noureldin Ahmed Abdalla, Dr. Ahmed Mohamed Abdelkarim, Dr. Mohamed Elamin Hamza, Dr. Dirar Hassan Nasr, and Dr. Muamar Eltayeb .The contribution of each of these experts is highly appreciated.

We extend our gratitude and special thanks and recognition to our technical support partners, the Climate Change Research Group in Boston; in particular we want to thank and express are very special gratitude to Dr. William Dougherty and Dr. David Yates. Without their valuable technical support the success of the project would have been impossible.

We extend our gratitude to our colleagues and staff of HCENR and sister projects who participated fully in the implementation of this project. Finally deserving special recognition are project supporting staff, Ms. Manal Ahmed the Executive Secretary and Mr. El Gali Atwa the Accountant for their timely support.

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Preface

It is my great pleasure to present Sudan's National Adaptation Plan in response to the 2010 Cancun Agreement under the UNFCCC. The Plan responds to the overall objectives of the UNFCCC's National Adaptation Plan Guidelines forreducing vulnerability to the impacts of climate changethrough the building of local adaptive capacity and resilience and facilitating the integration of climate change adaptation into relevant new and existing policies, programmes and activities.

The Plan provides information on actions to reduce climate change vulnerability regarding water resources, agriculture and food security, public health, coastal zones, and rural communities in all the 18 states of Sudan. The range of adaptation options has been defined through systematic and bottom-up consultative processes at the state level. The process itself has been a significant achievement in raising awareness, building technical and institutional capacities, and integrating adaptation concerns into national development dialogues at all levels

On the behalf of the Government of Sudan, I would like to express my sincere appreciation and gratitude to the UNFCCC, the United Nations Environment Programme, and the Department for International Development of the UK for the financial and technical support, as well as to the Climate Change Research Group in Boston and all the state institutions and individuals contributed to the process and preparation of the plan.

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List of Acronyms & Abbreviations

AR4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BCSD	Bias Correction and Spatial Disaggregation method
bcm	Billion Cubic Meter
°C	degrees Celsius
CAF	Cancun Adaptation Framework
CCSM4	Community Climate System Model developed by the National Center for Atmospheric Research (USA)
CIARC	Consortium of International Agricultural Research Centers
CMIP-5	Climate Model Intercomparison Project-5 database
CO_2	carbon dioxide
CoP	Conference of Parties
CRiSTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods
DfID	Department for International Development (UK)
FF	financial flows
GCM	Global circulation model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas
GIS	Geographic Information Systems
GPS	Global Positioning System
HCENR	Higher Council for Environment and Natural Resources
IDP	internally Displaced Population
IF	investment flows
I&FF	investment and financial flows
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
LEG	Least Developed Countries Expert Group

mm	millimeters
MSW	municipal solid waste
NAP	National Adaptation Plan
NAPA	National Adaptation Plan of Action
O&M	operation and maintenance costs
PERSGA	Protection of Environment of the Red Sea and Gulf and Aden
RBSN	Regional Basic Synoptic Network
RCP	Representative Concentration Pathways
SMA	Sudan Meteorological Authority
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

There is a growing international consensus that even if stringent emission reduction measures are adopted, future climate change is inevitable. For Sudan[1], classified as least developed country by the United Nations General Assembly, this poses great challenges and risks to its people and economy. Alreadyburdened with recurrent droughts, food insecurity,water problems, malaria outbreaks and high poverty levels, Sudan's development efforts have struggled to succeed even withcurrent climatic change andvariability. The risks associated with long-term climate change will need to be carefully managed in order to ensure the survival and well-being of Sudanese communities.

As a result of the threat posed by climate change, the need for effective adaptation is increasingly becoming a recurring theme in long-term policy dialogues in Sudan. Much of the current momentum can be traced to the publication in July 2007 of Sudan's National Adaptation Programme of Action (NAPA). This document highlighted the acute vulnerability to current and future climate change impacts faced by poor Sudanese communities while identifying numerous high priority project-level interventions that address urgent and immediate adaptation needs. Several of these projects are already underway in several vulnerable regions of the country, and enjoy sustained community support.[2]

Building off these initial efforts, and in response to the Cancun Adaptation Framework (CAF) call for the development of National Adaptation Plans (NAP) in least developed countries, long-term policy dialogues in Sudan have shifted to a more programmatic approach in addressing adaptation to climate change. That is, the emphasis has turned from a project-level focus seeking to identify high priority adaptation interventions, to include alsoa programme-level focus that seeks to establish a framework or process by which to drive a sectoral andnational systematic approach to medium and long-term adaptation planning.

Therefore, the underlying motivation for the NAP process in Sudan is to provide a strategic plan as well as a platform for policy dialogue around adaptation to climate. Its goals are threefold. First it seeks to build capacity among Sudanese institutions in order to promote the development of climate change institutional arrangements for effective implementation of adaptation programmes and activities.Second, the Sudan NAP seeks to broaden the response to climate change to encompass institutional, economic, planning, and analytical dimensions of climate risk managementin order to facilitate the integration of climate change adaptation into new and existing policies, programs and activities, within all relevant sectors and at different levels. Third, it continues and enhances existing efforts to identify and prioritize potential adaptation initiatives at the regional level, as initially launched during the previous NAPA process.

The design and implementation of the NAP process in Sudan has relied heavily on guidance from the Least Developed Countries Expert Group (LEG). In keeping with the LEG's technical guidelines (LEG, 2012), the Sudan NAP has applied a flexible framework that is uniquely tailored to Sudan's unique circumstances and needs. In addition, the Sudan NAP process has sought to be anchored to a foundational set of principles, namely gender sensitivity, transparency, science-based, participatory, attentive to indigenous knowledge, and vulnerability-

[1] This National Adaptation Programme focuses on the Republic of Sudan, sometimes referred to as North Sudan, following the secession of South Sudan on 9 July 2011, which occurred with the consent of Sudan.

[2] 3430: Implementing NAPA Priority Interventions to Build Resilience in the Agriculture and Water Sectors to the Adverse Impacts of Climate Change in Sudan.

Table 1-1: Key elements, activities, and outputs of the Sudan NAP process (adapted from LEG, 2012)

Element	Activities	Key Outputs
Pre-NAP groundwork	• Initiate and launchthe NAP process in Sudan, covering all vulnerable regions and identifying key programmatic areas of focus	Report on NAP strategic plan, including programmatic areas of focus
	• Take stock of available information on climate change impacts, vulnerability and adaptation in order to assess gaps/needs for NAP process	15 scoping reports on state-level needs assessment
	• Establish and strengthen adaptation-related institutions in all the states through addressing capacity gaps and weaknesses for undertaking the NAP process	4 nationallevel capacity strengthening workshops
Preparing the NAP	• Analyzecurrent climate and future climate change scenarios	Report on downscaled climate change scenarios
	• Assess climate vulnerabilities and identify adaptation options at the sector, subnational, national and other appropriate levels	18 state-level reports on climate change vulnerability and adaptation options. 5 regional-level and 18 state-level consultation and awareness and capacity building workshops
	• Review and appraise adaptation options in the preparation of state-level adaptation reports	
Implementing the NAP	• Prioritize climate change adaptation in national and state levels planning	Implementation Strategy to operationalize, prioritizeintegrate andimplement activities identified in the Sudan NAP in development planning, undertaken as follow-up activity
	• Develop a long-term national adaptation implementation strategy	
	• Enhance technical and institutional capacity for planning and implementation of adaptation	
	• Promote coordination and synergy at the state and national level and with other multilateral environmental agreements	
Monitoring the NAP	• Review the NAP implementation process to assess progress, effectiveness and gaps • Conduct outreach on the NAP process and report on progress and effectiveness	Follow-up activity

focused. The result has been a process undertaken over the period from June 2011 to February 2014 and involving several elements, activities and key outputs, as summarized in Table 1-1.

The rest of this NAP document addresses the areas identified in Table 1-1. Section 2 provides country context relative to its geographic, demographic, economic circumstances. Section 3 provides an outline of the framework for the Sudan NAP process and focuses on the overall approach, major objectives, institutional aspects, and the stakeholder engagement process. In Section 4, the main pillars of the NAP vulnerability and assessment activities are described at both the regional and state levels. Section 5 provides a summary of enabling policy and analytical environments that were pursued in order to ensure continuity in ongoing vulnerability and adaptation assessment processes. Finally, Section 10 outlines the implementation strategy for the NAP.

2 Context

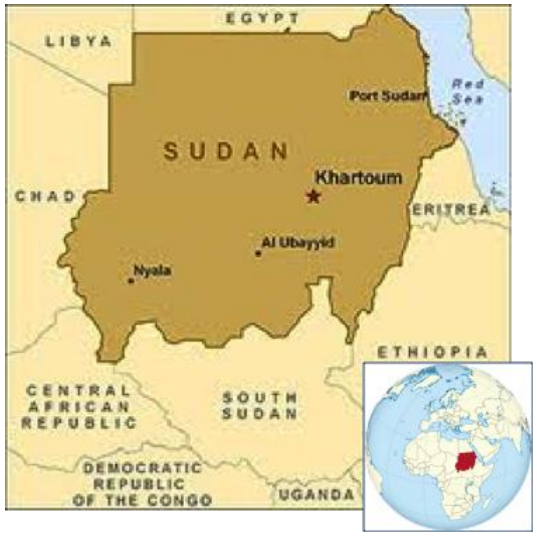
Figure 2-1 provides a map of Sudan. The overall territory encompasses an area of about 1.9 million km^2 and stretches over land between latitudes 10°N and 23° N and longitudes 21°45′E and 38°30′E. The territory borders South Sudan, six other African nations, and the Red Sea. The majority of the land is composed of vast arid plains interrupted by a few widely separated ranges

of hills and mountains. Water resources outside the Nile basin are limited, soil fertility is low, and drought is common. Compounded by a range of human pressures, these underlying conditions create a state of vulnerability in Sudan to climate impacts, and a troubling picture of the livelihood risks associated with current and future climate variability and change.

Sudan rainfal and land use profile is sumamrized in Box 2-1. The combined effects of the Intertropical Convergence Zone (ITCZ) and the country's topography dominate Sudan's climate. The result is wide spatial variation in rainfall.

Arable land constitutes about one third of the total area of the country, with about 21% of this land under cultivation. Over 40% of the total area of Sudan consists of pasture and rangelands. Since human communities, flora, and fauna have become adapted to subsist within these areas, climate change poses a major threat. Under changing climatic conditions, adverse changes in the distribution and productivity of Sudan's natural resources – its forests, soils, grasslands – are expected to have significant repercussions for millions of people.

Figure 2-1: Map of Sudan



Box 2-1: Sudan rainfall and land profile

Annual rainfall in the north ranges from close to zero near the Egyptian border, to about 200 mm around the capital Khartoum. Along the southern border, rainfall rarely exceeds 700 mm per year. The erratic nature of rain, and its concentration in short growing seasons, creates a vulnerable situation for rain-fed agricultural areas, the most prevalent type of agriculture in Sudan.

The country's land resources are dominated by arid and semi-arid ecosystems which constitute more than 80% of the area of the country. Low rainfall savannah make up the majority of other land types, with small montane vegetation areas taking up the remainder.

The Nile Basin traverses Sudan, from south to north. The Blue and White Nile converge just north of the capital, Khartoum. Sudan's current water resources, as well as its ability to harness them, are limited and prone to severe shortage. The Nile water basin contributes most of Sudan's available surface water. However, though the Nile transports over 93 billion cubic meters (bcm) of water per year on average, Sudan's share is only 20.5 bcm per year, in accordance with a 1959 water use treaty with Egypt. The water resource situation for remote areas is especially precarious, as flow from seasonal streams is limited in quantity and duration and varies in terms of turbidity.

Sudan is also burdened with low and economic development and serious environmental problems. In recent years, Sudan has made significant development strides, yet profound poverty and other challenges persist. Factors such as life expectancy, school enrollment, and GDP per capita combine to place Sudan in the low human development category of the UNDP Human Development Reporting system. Sudan's major environmental problems are deforestation, overgrazing, soil erosion, and desertification. In arid zones, historic vulnerability to drought has combined with anthropogenic pressures to create a situation of declining soil fertility and water resources, low agricultural productivity, and persistent food insecurity.

Traditional subsistence agriculture dominates the Sudanese economy, with over 70% of the population dependent upon crop production and/or livestock husbandry to support their livelihoods. Agriculture accounts for nearly half of GDP, and is responsible for the vast majority of employment. However, the sector is dominated by small-scale farmers who employ largely rain-fed and traditional practices – which renders Sudan highly vulnerable to climate variability

(as seen during past persistent drought), and to anticipated climate change. Its agro-ecological zones offer the potential to produce a range of crops, as well as livestock. Yet production is consistently quite low due to the vulnerability of rain-fed agriculture to rainfall variability and prolonged drought.

The direct dependence of Sudanese communities on the natural environment for survival has contributed to competition and conflict over scare natural resources. Indeed, most of the past conflicts have been resource-based in nature, often between pastoralists and farmers. The prospect of climate change increases the urgency to find creative ways of bringing communities together in a spirit of adaptation, to share finite resources and encourage a collective responsibility towards sustainable management of local resources, in a way that will encourage investment in supportive, civil processes.

Sudan has made notable strides in addressing the risks posed by climate change to its communities, natural resources, and economy. Sudan's Initial National Communication identified agriculture, water and health as the highest priority sectors where urgent and immediate adaptation action is needed to confront increasing climatic variability and climate change. The National Adaptation Programme of Action (NAPA), submitted to the UNFCCC in July 2007, identified 32 urgent adaptation initiatives in these sectors to reduce the increasing vulnerability of the rural communities to current and future climatic risks.Some of the highest priority adaptation-focused interventions are currently being implemented to enhance food security through building adaptive management capacities of the rural population, particularly of rainfed farming and pastoral communities.

The long-term solution to the vulnerability of Sudanese communities, natural resources and economic sectors to climate change is effective mainstreaming of adaptation strategies into the national planning process. This is directly related to the just-completed NAP initiative in Sudan, which has begun the process whose ultimate aim is the integration of climate risks into all national development planning processes.Financial resources and international support will be vital to a successful implementation of the adaptation programme described in the remainder of this document. Such support will help build the capacities of state-level, local andcivil society organizations as crucial partners in building resiliency to the impacts of climate change.

3 Framework

The underlying vision for Sudan's NAP is to contribute to climate change-resilient communities, businesses, and productive systems across the country in the future. This requires a clear and actionable framework for adaptive, flexible and decisive action to reduce climate change risks in partnerships ranging from state governments to international donors; from the household sector to the private sector; and from one end of the national institutional spectrum to the other. It involves efforts to encourage businesses to undertake wide-ranging adaptation investments that can link successful operations with risk reduction practices and emergency management arrangements. Finally, it involves the introduction of new land use arrangements, decentralized management systems, and legislative initiatives that seek to reduce exposure to gathering risks from climate change.

3.1 Approach

In short, Sudan's National Adaptation Plan is intended as a proactive approach to reduce vulnerability by integrating information about emerging climate change risks into current development planning systems and arrangements. Such a strategy is urgently needed because the adverse climate change impacts are already being experienced to such a degree that achieving

sustainable development goals related to poverty reduction and good governance will become progressively more difficult. The underlying goal for developing Sudan's National Adaptation Plan is to contribute to sustainable development and poverty reduction by reducing the long-term impacts of climate change.

Risk management was the core framework by which climate change adaptation has been addressed in the Sudan NAP. The NAP development process has been designed to be a holistic, multi-hazard strategy that integrates the range of climate change risks within an action framework that focuses on climate impact prevention, preparedness, and response. While addressing each of these elements will help to build resilience, the emphasis of Sudan's NAP is on prevention and preparedness programmes and measures. That is, the NAP emphasize resilience-building through reliance on proactive, anticipatory actions to reduce climate risks across different time scales, making use of legislative developments/options to promote institutional coordination, as well as mid-course corrections in the light of emerging information.

Enhancing capacity for undertaking State-level adaptation planning was the core focus of the Sudan NAP. That is, the establishment and strengthening of state-level NAP institutions was understood to be an important pathway towards fulfilling the requirements of Cancun Adaptation Framework of the UNFCCC as the Cancun Agreement requires developing countries to strengthen institutional capacities and enabling environments for adaptation, including for climate-resilient development and vulnerability reduction. The emphasis on State-level institutions was also consistent with the overall national objective to improve federal-state coordination on the implementation of general policies, strategies, plans and activities promoting environmental protection and sustainable development.

3.2 Objectives

The approach to Sudan's NAP process was closely linked to the overarching objectives set forth in the Durban decision at COP-17. That is, the primary objective of Sudan's NAP is to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience among state- and national-level institutions. A secondary, though equally important objective, is to promote the integration of climate change adaptation perspectives into existing and new policies, programmes and activities.

Both of these key objectives have been pursued relative to the divergent development planning processes and priority sectoral vulnerablities at the state level in Sudan. That is, both the planning processes of Sudan's state-level institutions as well as the country's broader developmental policies have been addressed in the NAP development process with a view toward facilitating eventual integration into a coherent adaptation plan that is state-specific.

On the one hand, the NAP process has emerged as a central basis for proposing needed action by the government in reshaping its current programmes and protocols to ensure that adaptation is well-integrated into everyday planning and operations and is not viewed as an activity limited to the HCENR or some particular governmental department.

On the other hand, the NAP process has been shaped to promote the integration of climate risk management across all affected ministries in order to address the wider Sudanese sustainable development challenges posed by climate change. Achieving these objectives has involved a wide range of stakeholders to collect, integrate, and respond to a wide range of pertinent information from affected ministries/institutions and the private sector in the formulation of actionable risk reduction strategies.

3.3 Institutions

At the national institutional level, Sudan's Higher Council for Environment and Natural Resources (HCENR) was the focal point for the development of the NAP. With a mandate that spans both coordination and institutional implementation activities, the HCENR has served as the lead national agency in meeting the challenge of climate change in the near- and long-term. The HCENR is also is the lead agency charged with the formulation of medium- to long-term actions that not only mitigate the impacts of climate change related disasters such as drought, flash flooding, vector-borne disease outbreaks, but also reduce the vulnerability of communities most exposed to natural phenomena.

At the state institutional level, one of the main areas of interest was the establishment of adaptation-focused planning institutions in each of Sudan's 18 states. In each of the states, a focal point and inter-agency technical team of experts from related government, research, academia and civil society organization, have been established. The capacity of these units has been strengthened through targeted training sessions; learning-by-doing programmes; and the establishment of networks to exchange knowledge and experience. Moreover, these units were tasked during the NAP process with data collection, vulnerability assessment, adaptation strategy formulation,policy review, institutional appraisal, and the identification/prioritization of specific adaptation initiatives. They participated throughout the entire consultation process and took part in numerous organized workshops held throughout the country (see Table 1-1).

Ultimately, Sudan's NAP aims for disaster resilient communities, individuals and organizations where risks are defined and understood, effective response plans to anticipate and respond to the needs of the most vulnerable, and actions that are well coordinated across spatial (local & regional), institutional (inter-ministry as well as intra-ministry), and temporal (both near-termand long-term) scales.

3.4 Process

The NAP development processin Sudan began in June 2011. The overall process included a number of interlinked synergistic activities as illustrated in Figure 3-1 and summarized in the bullets below.

Figure 3-1: Sudan NAP development process

- *International support:*When they became available in December of 2012, the LEG technical guidelines proved to be a helpful source in consolidating and reporting core outcomes, as did UNEP regarding financial assistance.
- *Capacity building:* Multi-level training and consultation workshops were implemented, at local, state,regional and national levels in support of training on thematic areas identified during an initial needs assessment process.
- *Stakeholders:* The NAP process was designed as a highly inclusive and participatory process with extensive engagement throughout the states.
- *Assessment:* This involved a set of strategic explorationsinto the vulnerability of key livelihoods and economic sectors to climate change in Sudan, together with the systematic

identification by state-level teams of priority adaptation needs. These assessmentsrepresent the core of NAP outputs.

- *Systems:* This involved putting in place systems for future vulnerability and adaptation assessments. The focus was on the development of regional climate scenarios, enhancement of systems observation networks, training in methods and tools for vulnerability hotspot mapping and climate proofing, and the analysis of adaptation financial flows.
- *Coordination:*This involved a team at the HCENR to oversee the implementation of the various activities associated with NAP development in collaboration with designated institutions in all the states of Sudan.
- *Synthesis:* This involved a compilation of the conclusions reached by the various assessment teamsin all the statesinto an actionable programme and projectsfor addressing climate change at the state and national levels.

At the operational level, the Sudan NAP process involved extensive coordination between the HCENR and State-level institutions. Administrative units focusing on adaptation planning were first developed within appropriate State-level institutions, typically state environmental agencies (Ministry or Council) or state agricultural ministries. Subsequently, focal points and technical teams were appointed for each state-level unit, primarily by the state-level ministers, which indicated the support and commitment of state government to NAP project activities. During NAP activities, these state-level teams were responsible, in coordination with the HCENR, for data collection, vulnerability assessment, stakeholder consultations, and the prioritization of adaptation strategies and measures. The work of the state-level teamsis the basis for the core elements of this NAP document.

4 Vulnerablity,Impacts & Adaptation Programmes and Activities

This chapter provides an overview of the vulnerability of key sectors and communities in Sudan, while providing a targeted set of priority adaptation strategies and measures. The chapter is premised on the perspective that the long-term solution to the vulnerability of Sudanese communities, natural resources and economic sectors to climate change is effective mainstreaming of adaptation strategies into the national planning process. The sections below describe both the process used in undertaking state-level vulnerability and adaptation assessments, as well as the key results of those assessments. The findings below illuminate Sudan's plan to integrate climate risks into all national and state development planning processes.Financial resources and international support will be vital to a successful implementation of the adaptation programme described, including the building of capacities of state-level, local andcivil society organizations as crucial partners in building resiliency to the impacts of climate change.

4.1 Introduction

The capacity to conduct vulnerability and adaptation assessments of agriculture, water and health at the state level is important for Sudan as a natural progression of the work undertaken in the NAPA process. The results of such assessments can help identify regions of the country where action is urgently needed. At the time the NAP process was undertaken, no vulnerability and adaptation assessment had yet been undertaken at this level of spatial detail in Sudan, although the experience and skills were readily available numerous individuals who had been involved in the previous NAPA effort. For this reason, pre-NAP groundwork activities identified state-level assessments for the priority vulnerable sectors as an essential input to the NAP process.

4.1.1 Objectives

The main objectives of each state-level vulnerability assessment were to a) characterize vulnerability to climate change in the agriculture, water, and health sectors; and b) identify urgently needed adaptation strategies. The assessments were carried out by state-based project teams in each of the 5 regions and 18 states shown in Table 4-1. Upon completion of the state-level assessments, a synthesis report was prepared to document observed patterns, issues, and recommendations (Zakieldeen, 2013). The synthesis of information covered the key climatic factors affecting the three priority vulnerable sectors, the adverse impacts and vulnerabilities, non-climatic factors, as well as the range of urgent adaptation activities to be integrated into the NAP itself.

Table 4-1: Regions & states where NAP assessment activities were conducted

No.	Name	No.	Name
1	Darfur States	1	North Darfur
		2	West Darfur
		3	South Darfur
		4	Central Darfur
		5	East Darfur
2	Kordofan States	6	North Kordofan
		7	South Kordofan
		8	West Kordofan
3	Eastern States	9	Kassala
		10	Al Gedaref
		11	Red sea
4	Nile States	12	River Nile
		13	North
		14	Khartoum
5	Central States	15	Gezera
		16	Sennar
		17	Blue Nile
		18	White Nile

4.1.2 Process

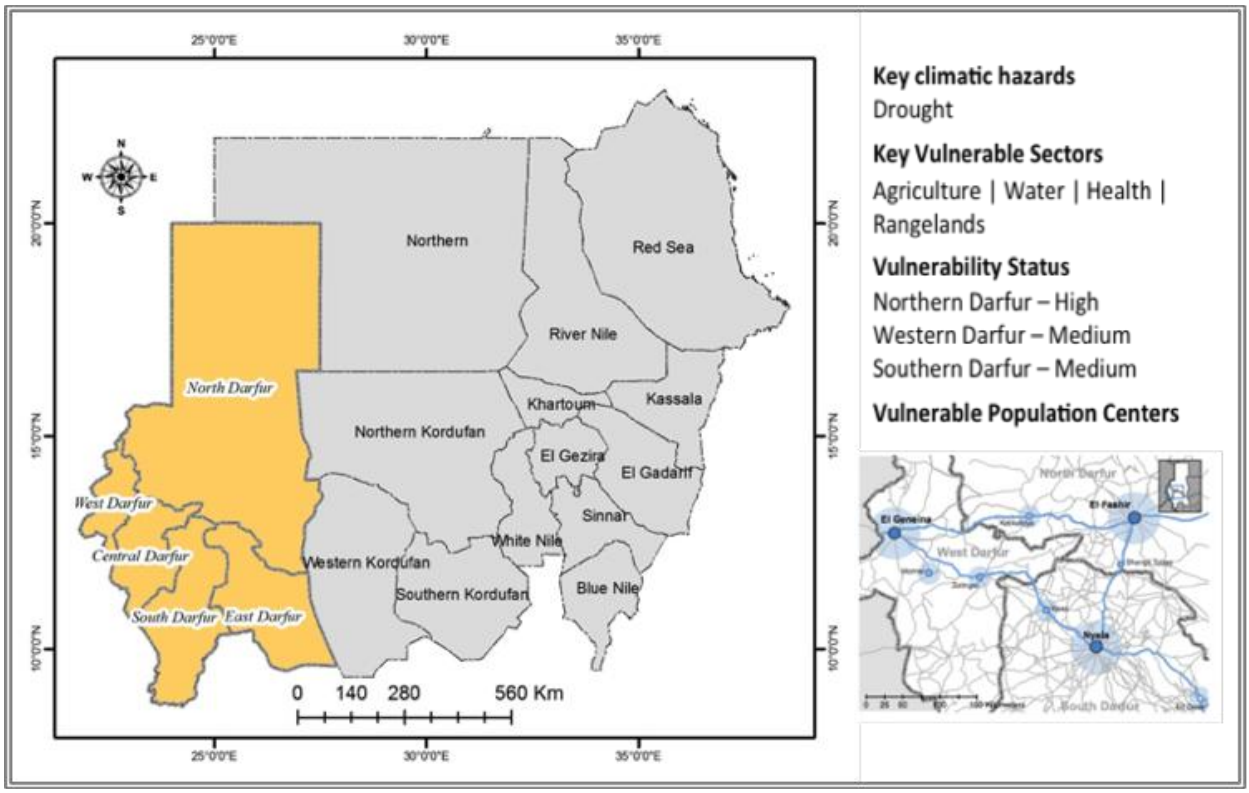
The approach for conducting sector- and state-based vulnerability and adaptation assessments consisted of four stages, as described in the bullets below.

- *Capacity strengthening:* Prior to any assessment activities, training programmes were developed and implemented to equip sector- and state-based team with knowledge, methods and tools needed to undertake the assessments;
- *Vulnerability assessment:* The vulnerability assessments were based on observation and available literature. Both climatic and non-climatic factors were considered in assessing the vulnerability of key sectors (i.e., agriculture, water resources, public health, coastal zones) at the state level. Upon completion of the assessment, a national workshop was convened to review and discuss the vulnerability assessment reports, as well as to build awareness through sharing lessons learned.
- *Priority adaptation needs:* The adaptation assessment focused on the identifications by the same state-level teams of priority adaptation needs. This was carried out through a consultative process with key stakeholders. Upon completion of the assessment, a national workshop was convened to review and discuss the adaptation assessment reports, as well as to build awareness through sharing lessons learned.
- *Public awareness:* Upon completion of all the sector- and state-based vulnerability and adaptation assessment, regional workshops were held to share results and build awareness among the general public, as well as discuss issues to implement recommendations into state-level development policies and plans. Upon completion of the regional workshops, a final round of state-level workshops was organized to enhance public awareness. Finally, national workshop was convened to outline final recommendations for Sudan's national adaptation plan.

4.2 Darfur States

The Darfur States are located in the western part of Sudan, as shown by the highlighted borders in Figure 4-1, together with some key results of the overall vulnerability assessment. It covers an area of nearly 500 thousand square kilometers and has a population of about 8 million

Figure 4-1: Map of the Darfur States and overall climatic vulnerability characteristics



characterized by subsistence livelihoods. Darfur is comprised of five major States: North Darfur is characterized by a semi desert climate; West and Central Darfur are low rainfall savannah zones; and the remaining South and East Darfur are high rainfall savanna zones.

While rainfall has always shown high variability in the Darfur States, recent years have seen this pattern intensify. For example, in North Darfur, 20 of the 25 driest years on record have occurred since 1972, threatening agricultural and livestock production, particularly in North Darfur (North Darfur State NAP Committee 2013). Across the northern and western areas of the region, 40% of harvests currently fail on average; by 2050, it is expected that 70% of harvests are likely to fail on average. Only the high rainfall savannas of the southern area are less vulnerable to drought.

Without appropriate planning, future climate change is expected to have serious impacts on Darfur's economy and population. For example, shifting rainfall patterns and high demand are rapidly depleting groundwater levels. Monitoring systems at groundwater sites and wells show a risk of acute groundwater depletion.

Hence, adaptation planning is crucial across the Darfur States to achieve food and water security in the face of poverty and climate change. Given the diversity of ecological zones within the Darfur States, each state face a different set of vulnerabilities and requires a tailored suite of adaptation plans, as described in the paragraphs below.

4.2.1 North Darfur

With a semi-desert climate, North Darfur state is prone to drought, low rainfall and has a geological system that is unfavorable for groundwater storage. Vulnerability studies undertaken as part of Sudan's INC and NAPA processes confirm that increasing temperatures and decreasing rainfall will bring about not only a southward shift in agro-climatic zones but also

reduced groundwater recharge rates. Box 4-1 provides some essential climatic and vulnerability information for North Darfur state.

Under certain scenarios, rainfall is expected to decline by 9 mm/year. As Figure 4-2[2] shows, North Darfur is already experiencing a downward trend in rainfall, effecting its limited sorghum and millet production, while Table 4-2 shows the sensitivity of crop production to climate trends, with sorghum and millet production ranging from negligible in the dry years of 2009 and 2011 to upwards of 46 and 80 million tonnes during the wet year of 2010. Climate projections suggest that crop failure due to inadequate or highly variable rainfall could reach as high as 70% by 2050 in North Darfur (North Darfur State NAP Committee 2013).

Box 4-1: North Darfur conditions

Baseline Climate (1971-2000) - El Fashir
Average annual max temperature: 35 °C
Average annual min temperature: 18 °C
Average annual rainfall: 195 mm/yr

Vulnerable Areas: 8 Localities with varying degree of vulnerability

Vulnerable Locations:
Water
El Fasher| Komoi | Malhah

Agriculture & Rangelands:
Mileet | Almalha | Umkadada | Um Baro, Karnoy | Alteena

Forests
AlMalha | Al Komah | Um Kaddadh | Elfashir, Maleet

Erratic rainfall and drought have lead to a series of maladaptive coping strategies. For example, livestock overgrazing, aggressive agriculture and deforestation is degrading land quality. Maladaptation practices stem from lack of awareness of best practices (i.e. crop rotation) and poor agricultural policy, which ties land ownership to frequency of use. Compounding this problem is weak management of water resources. Water tables have fallen rapidly in some areas – including by 10 meters around El Fasher since 2007, with eight IDP communities vulnerable to acute groundwater depletion (UNEP, 2007).

Figure 4-2: Annual rainfall pattern in El Fasher, North Darfur, mm per year (source: UNEP, 2010)

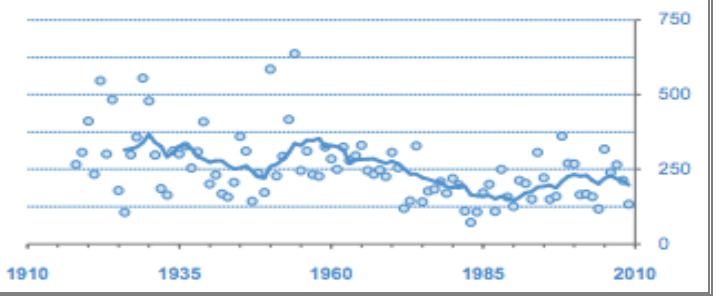


Table 4-2: Crop production in North Darfur, thousands tonnes (source: UNEP, 2010)

	Crop production	
Year	Sorghum	Millet
2009	4	19
2010	46	80
2011	7	24

Major categories of adaptation initiatives in agriculture and water are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Agriculture*. Major adaptation measures should include changing policy to discourage mal-cultivation practices and introducing improved crop varieties, shelterbelts, crop rotation and water harvesting and irrigation technologies.
- *Water*. Major adaptation measures should focus on conducting studies to improve water management around the most vulnerable areas. More wells and boreholes should be dug in areas that are safe from pollution and more efficient irrigation systems should be introduced. These activities should be undertaken throughout Northern Darfur.

4.2.2 West Darfur

West Darfur falls into a low rainfall savannah zone, an ecosystem rich in seasonal valleys and tributaries that can sustain forests, rangelands, and agriculture. There is large variation within

the state, with areas in the south receiving nearly 500 mm of rain per year and areas in the north receiving less than half of that amount (West Darfur State NAP Committee 2013). The Paleozoic sandstones provide groundwater resources that have sustained the area during dry years. Box 4-2 provides some essential climatic and vulnerability information for the region.

Approximately 80% of the state's economy is based on agriculture and livestock production. Farmers produce a diverse set of cash crops that include cereal crops, oil crops (groundnuts, sesame), legumes, vegetables, and horticultural crops (mango, citruses etc.).

West Darfur has a history of chronic food insecurity. A household health survey conducted in 2006 found that it is the most food insecure region in Sudan with greater than 40% of the population unable to obtain a health daily diet (see Figure 4-3). While additional modeling needs to bar carried out to predict changes in temperature, rainfall and evapotranspiration rates for West Darfur, the current expectation is that food insecurity will deepen in West Darfur absent effective adaptation. The region will experience increasing temperatures, increasing rainfall variability, and higher drought frequencies. Combined, these effects will adversely impact crop yield, lead to further deterioration of rangelands, and further deplete groundwater resources.

Box 4-2: West Darfur conditions

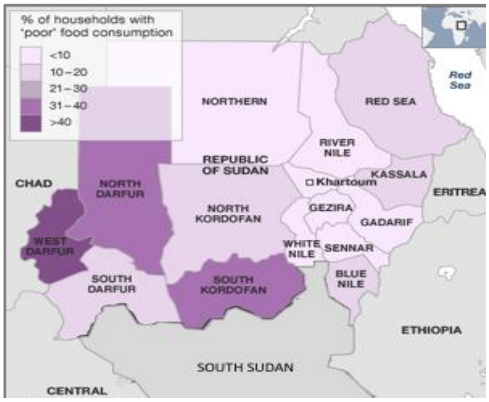
Baseline Climate (1971-2000) - El Genena
Average annual max temperature: 34 °C
Average annual min temperature: 18 °C
Average annual rainfall: 400 mm/yr

Vulnerable Locations – Agriculture:
Gargar | Karty | Habila Kanakry | Sarba | Aesh Barah | Morny | Kirainik

Vulnerable Locations- Water:
Karty | Sarba | Aesh Barah | Morny | Kirainik | Gargar | Habila Kanakry |Kulbus | Masteri

Vulnerable Locations- Health:
Ateya | Karty | Sarba | Aesh Barah | Morny, Kirainik | Gargar | Habila Kanakry

Figure 4-3: Food insecurity in West Darfur



Climatic stress is exacerbated by the absence of a rational land use policy, which has led to a host of maladaptive strategies. For example, the livestock population far exceeds the carrying capacity of many rangelands and persistent deforestation is accelerating land deterioration (West Darfur State NAP Committee 2013). At the same time, farmers who are unaware of best practices are utilizing low quality crop varieties that are not suitable for changing climatic conditions. Adaptation in West Darfur should address these trends and focus on both climate and non-climate stressors on its agricultural, water, and public sectors. Major categories of adaptation initiatives in agriculture, water and public health are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Agriculture*. Research around new drought resistant and early maturing varieties could help farmers adapt to shifting climate conditions.
- *Water*. Improved water harvesting techniques, provision of agricultural inputs to local farmers, afforestation, and building capacity are urgently needed. Moreover, additional studies are needed to assess existing groundwater reserves. These would inform the much needed implementation of new water projects (wells and dams) as well as the rehabilitation of existing water sources.
- *Public health*. Climate change could accelerate the spread of malaria, yellow fever and cholera. Although the provision of basic health services and health education among locals

will be a necessary element to adaptation, more studies are needed to understand the link between rising temperatures, water stress and the spread of these diseases, particularly in the context of Western Darfur.

4.2.3 *South Darfur*

South Darfur falls into the high rainfall savannah zone. The region is endowed with extensive fertile land, including a flood plain, which supports a mix of traditional cultivation, mechanized farming, pastoralism and forestry. Rainfed agriculture provides both cash and subsistence crops, and because the Southwest receives heavy rains twice a year it has two harvests. Good rangeland covers much of the region, with rangelands further north providing refuge to migrating tribes during the rainy season (*Makharif*). Box 4-3 provides some essential climatic and vulnerability information for the region.

Box 4-3: South Darfur conditions

Baseline Climate (1971-2000) - Nyala
Average annual max temperature: 35 °C
Average annual min temperature: 21 °C
Average annual rainfall: 367 mm/yr

Vulnerable Locations
Agriculture
Kass | Nyala | Bilail | Mershing | Al Malem, Nittaiga | Alsalam

Water
Mershing | Kass | Nyala | Bilail | Al Malem, Nittaiga | Alsalam

Animal Resources
Nyala | Bilail | Al Malem | Mershing | Nittaiga | Kass | Alsalam.

Health
Kass | Nyala | Bilail | Mershing | Al Malem | Nittaiga | Alsalam | Rehaid | Al Birdi

South Darfur has a less extreme climate than other areas of Darfur, the region will still face more erratic rainfall and more frequent dry spells. Contour maps between isohyets in 1946-1955 and 1976-1985 show that 400 mm of rain have shifted southward of Nyala and maximum rainfall in the Marrah Mountains has decreased from 900 mm to 600 mm per year. This has lead to a reduction in seasonal stream levels and a decline in crop yield. Should these trends continue, South Darfur will likely experience a 40% harvest failure rate by 2050 (South Darfur State NAP Committee 2013).

Animal production is also threatened. Shifting climates may hasten the disappearance of palatable rangeland species (*Beghail, Abu asabea*) and appearance of other invasive species, with overgrazing adding further stress. Migrants from the North as well as refugees from neighboring countries are adding additional stress to rangelands.

As a starting point, it will be important for adaptation planning in South Darfur to address underlying factors than contribute to vulnerability to climate change. These include current conditions of poor land management, overgrazing, deforestation and community displacement. Major categories of adaptation initiatives in agriculture, water and rangelands are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Agriculture*. Adaptation plans for agriculture include the use of improved varieties for field and horticultural crops, improved water harvesting and spreading technologies, improved crop storage, the establishment of community forests and nurseries, alternative energy sources, and the adoption of legislation to improve communities' adaptation to climate change. This will require awareness-raising among policy makers and government institutions.
- *Rangelands*. Adaptation measures for rangelands should start with the mapping and monitoring of rangelands, to evaluate their current condition. Other measures could include rehabilitating livestock markets while also encouraging farmers to replace cattle with smaller livestock, which would be better suited to drought. Regular surveillance of animal diseases through improved monitoring would limit the spread of disease among livestock populations while rehabilitating *hafirs* and dams would improve water access.

- *Water*. Adaptation in the water sector should include the establishment of rain gauge stations to monitor and provide hydrological information. This should coincide with the maintenance of existing reservoirs and rehabilitation of the water basin infrastructure to increase water storage capacity.

4.2.4 *Central Darfur*

Box 4-4: Central Darfur conditions

Baseline Climate (1971-2000)- Zalingei
Average annual max temperature: 34 °C
Average annual min temperature: 14 °C
Average annual rainfall: 568 mm/yr

Vulnerable Locations - Rangelands,
Garsila,Mukjar,Golo Abata,Rokoro,Sullu

Vulnerable Locations:
Agriculture
Shawa | Abta | Rongatas
Water
Nertati | Abta | Shawa.
Health:
Mukjar | Bandasi | Um Khair | Um dokhan

Central Darfur falls into the low rainfall savannah zone. The region is characterized by diverse climate and soils, including volcanic soils in Jebel Marra (a mountainous area) sandy, clay and alluvial soils in the different valleys traverse the state towards the west to Chad and Central African Republic. Most economic activities are focused on agriculture and pastoralism. About 80% of the state's population is comprised on farmers and pastoralists. Communities are suffering from recurrent droughts, increasing temperature and rainfall variability, which together with high poverty rates have led to a growing misuse of resources as evidenced by overgrazing and denuding of forests. Box 4-4 provides some essential climatic and vulnerability information for the state.

Central Darfur faces a number of hazards associated with climate change. These include higher maximum temperatures, increased drought frequency; decline in annual rainfall; and increasedrainfall variability. Communities throughout the state have experienced all of these hazards over recent decades. As in other Darfur states, the only coping strategy available to poor households is a deepening exploitationof limited land, water and animal resources. This has in turn led to reductions in soil fertility;loss of total forested area;reduced forest productivity; declining crop productivity; decreasedgroundwater levels and seasonal streamflow, and increased outbreaks of diseases such as malaria, typhoid and yellow fever.

It will be important for adaptation planning in Central Darfur to address underlying socioeconomic factors than contribute to vulnerability to climate change. Major categories of adaptation initiatives in rangelands water and health are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Rangelands*. Adaptation measures for rangelands should include building awareness in local communities regarding sustainable natural resource management; enforcement of existing legislation; introduction of legislative reforms to better ensure protection of the natural resource base; launching of special programs targeting pastoralists for improving livestock genetic stock and productivity; and improved extension programmesfocused on agroforestry, rangeland management and pastoral systems.
- *Water*. Adaptation in the water sector should include capacity building on water harvesting techniques and the introduction of best practices regardingsustainable cropping systems.
- *Health*. Adaptation in the health sector should include rural public health awareness programmesregarding measures to protect against community diseases and vectors, particularly among children.

4.2.5 *East Darfur*

East Darfur falls into several climatic zones; semi-arid in the northern areas; low rainfall savannah in the central areas; and high rainfall savannah in the southern areas. Economic

activity is dominated by pastoralism and agriculture, with about 90% of the population being pastoralists and farmers. Key agricultural products include gum arabic, groundnuts,Millet (known locally as *Dokhn*), sorghum, Hibiscus (known locally as*Kerkrade*) and other crops. Large numbers of cattle, camel, and sheep are found throughout the state, one of the state prominent characteristics relative to the rest of Sudan. Current trends of changing climatic conditions - notably decreasing annual rainfall and increasing variability - have taken increasingly burdensome tolls on the livelihoods of local communities.Box 4-5 provides some essential climatic and vulnerability information for the state.

Box 4-5: East Darfur conditions

Baseline Climate (1971-2000) - Al Deain[3]
Average annual max temperature: 34 °C
Average annual min temperature: 21 °C
Average annual rainfall: 468 mm/yr
Northern areas: 250 mm
Southern areas: 700 mm

Vulnerable Locations:
Agriculture and Rangelands
El Ferdous | Silaia'a | North Deain | Um dai | Yassin | Um Labania | Sheiria
Water
Deain-Gallabi | Khazzan Gadeed,
Health
Sheiria | Khazzan Gadeed | Abu Gabra | Abo Matarig | Adeela

East Darfur faces a number of impacts associated with climate change, particularly related to water. Reduced or highly variable rainfall levels have led to serious degradation of rangelands. This has resulted in a lack of regeneration or rangelands and in some cases, the disappearance of certain grasses and herbs. Nomads who rely on these resources have been forced to cope by means of several unsatisfactory options for feeding their livestock herds, namely accessing forests for lower quality treeleaves; grazing on agricultural lands of settlers; or moving across the border to South Sudan. Moreover, East Darfur hasbecome the home for significant numbers of displaced people from other states of the region, all suffering from reduced rainfall in their places of origin. This has amplified the consequences of climatic change for the state and further exacerbated environmental degradation and socio-economic disruptions.

It will be important for adaptation planning in Central Darfur to address underlying socioeconomic factors than contribute to vulnerability to climate change. Major categories of adaptation initiatives in water, agriculture, natural resources, and health are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Water*. Adaptation in the water sector should include new geophysical studies to better understand groundwater resources, drilling of new water wells, rehabilitation of old wells, introduction of new water harvesting methods in north, construct earth dams in the south.
- *Agriculture*. Adaptation in the water sector should include efforts to sustainably increase soil fertility through use of organic fertilizer, strengthen agricultural extension; more efficiently exploit surface and groundwater; and introduce drought-resistant seed varieties.
- *Natural resources*. Adaptation in the natural resource sector should include efforts to increase the proportion of perennial plants and forest farming; develop environmental extension programmes; improve the physical properties of the soil to increase its ability to retain moisture through the installation of windbreaks, agroforestry techniques, dedicated cultivation belts, and protected community forests.

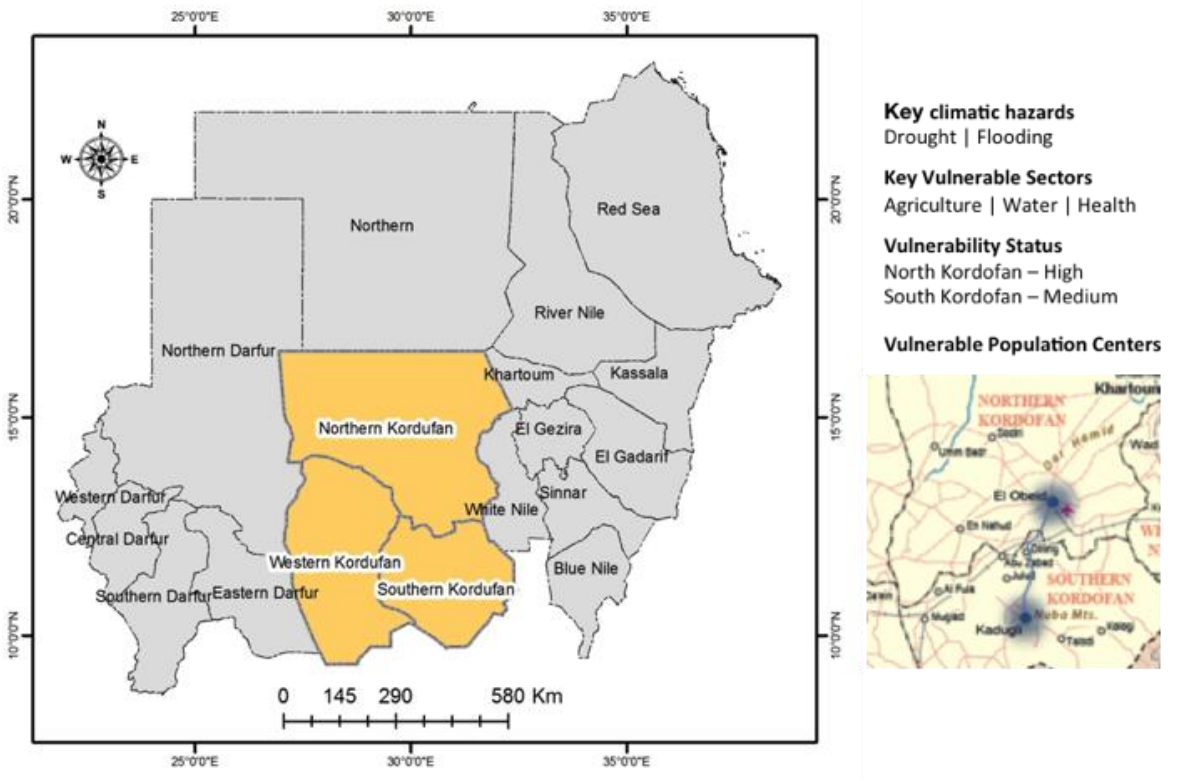
[3] The average annual maximum and minimum temperature values of Al Deain area in East Darfur State for the baseline climate (1971-2000) have been estimated based on experts judgment because of lack of good quality observational data.

- *Health*. Adaptation in the health sector should include capacity building among rural health personnel, rural public health awareness programmes, installation of rural health centers, and increased access to standard vaccines.

4.3 Kordofan States

The Kordofan States are located in the south-central part of Sudan, as shown by the highlighted borders in Figure 4-4, together with some key results of the overall vulnerability assessment. It covers an area of nearly 380 thousand square kilometers and has a population of about 5.4 million people. The economy is dominated by agriculture, with gum arabic, groundnuts, cotton, and millet the major crops. Kordofan consists of three states: North Kordofan, which falls into a semi-desert zone and West and South Kordofan States, a high rainfall savannah area.

Figure 4-4: Map of the Kordofan States and overall climatic vulnerability characteristics



A number of climate change scenarios are available for Kordofan states. Climate scenarios for 2030 and 2060 in Sudan's INC project a decrease in average precipitation and an increase in average temperatures, with pronounced changes expected for Northern Kordofan (INC 2003). Alam et al (2012) confirmed these findings in modeling future climate change scenarios through 2080 in 5 locations in the Kordofan States, with the exception that rainfall and evapotranspiration rates may decrease in some localities. The major sectors impacted by climate change are agriculture, water and health, in both Northern and Southern Kordofan. That said, Northern Kordofan is considered more vulnerable due to a climate that is already prone to low rainfall and extreme temperatures.

4.3.1 Northern Kordofan

Northern Kordofan state is located in the central western part of Sudan on the northern edge of the savanna belt. The state's climate is characterized by low rainfall, sparse vegetation and

extreme temperatures, which reach as high as 49 degrees C in the summer and as low as 1.5 degrees C in the winter (North Kordofan State NAP Committee 2013). Box 4-6 provides some essential climatic and vulnerability information for Northern Kordofan state.

Although unable to support heavy agriculture, Northern Kordofan's climate allows for small scale farming, which produces a mix of livestock and cash crops, such as watermelon seeds, hibiscus, gum Arabic and peanuts. Roughly 79% of the state's population depends on agriculture for their livelihoods, with agricultural production in Northern Kordofan contributing about 30% to the country's overall non-oil exports (North Kordofan State NAP Committee 2013).

Within the sector, crop production comprises 53% of agricultural output, livestock 38%, and forestry and fisheries a combined 9%. Industry and service sectors are also developing slowly. However, this development is concentrated in urban centers leaving a large portion of the state's 3 million people living below the poverty line.

Box 4-6: Northern Kordofan conditions

Baseline climate (1971-2000) - El Obeid
Average annual max temperature: 35 °C
Average annual min temperature: 20 °C
Average annual rainfall: 330 mm/yr

Vulnerable Locations:
Agriculture (rainfall variability)
Sudari | Gabret Esheikh | Bara | Western Bara | Umm-Dumm

Agriculture (Flood prone lowlands)
Elnehud | Elkhway |Abuzabd

Agriculture (Drought)
Sudari | Gabret Esheikh |West Bara | northern Rahad | Sheikan | Eial Bakheit

Animal resources
Salem Doud | Tanah | Eyal Bakheit | Umm Sedir | Elburgah | Jebel | Hamdelah | Faragalah

Water resources
Salem Doud | Tanah | Jebel | Hamdelah | Faragalah | Eyal Bakheit | Umm Sedir | Elburgah

Public health
Salem Doud | Tanah | Jebel | Hamdalah | Faragalah | Eyal Bakheit | Umm Sedir | Elburgah

A harsh climate and an agriculture dependent economy make Northern Kordofan one of Sudan's most vulnerable states. Since the 1960s, recurring drought has caused widespread desertification. Should drought and rainfall variability intensify, this could threaten the state's already limited agricultural sector and increase food insecurity. Major categories of adaptation initiatives in agriculture, water and public health are described in the bullets below. Additional specific measures are identified in Section 6 and Annex A.

- *Agriculture*. Adaptation plans for agriculture include the introduction of improved crop varieties, shelter belts, crop rotation, efficient irrigation, and the establishment of early warning systems. In addition, strengthening the sector's poor infrastructure and expanding use of arable land may help compensate for declining crop yields. The initial study of state level vulnerability provided a long list of vulnerable localities in North Kordofan. To identify high impact adaptation measures, more information is planned to be obtained for these sites and their role in Northern Kordofan’s economy.
- *Water*. Adaptation in the water sector should include improved water management as well as improved livestock and agricultural techniques. Geo-physiological studies are needed to determine ideals sites for digging wells, trainings would enable water committees to adopt better management practices, and rehabilitating or constructing new boreholes, *hafirs* and water pipes would help alleviate water scarcity as well as new wells in Um Gawaseer and studies to identify water harvesting opportunities in Wadi Abu Dom.
- *Public health.*The potential appearance of new skin diseases, such as *Jarab*, will require additional basic health services.

4.3.2 *Southern Kordofan*

Southern Kordofan state is located in the heart of Sudan and is composed of two climates. The northern part of the state is a semi-dry low rainfall savannah while the south is a semi-humid high rainfall savannah. Over 85% of the state's population lives in rural areas and depends on a mix of traditional and mechanized agriculture. Fertile soil and predictable rainfall means the state has high agricultural potential yet large swaths of arable land and forests go unused due to poor water infrastructure. The existing water infrastructure - *hafirs* and boreholes -remain insufficient to meet even current demands.Box 4-7 provides some essential climatic and vulnerability information for Southern Kordofan state.

Box 4-7: Southern Kordofan conditions

Baseline climate (1971-2000) - Kadogli
Average annual max temperature: 35 °C
Average annual min temperature: 21 °C
Average annual rainfall: 667 mm/yr
Northern areas: 350 mm
Southern areas: 750 mm

Vulnerable Locations:
Agriculture (Drought)
Julud | Dalang | Abu Zabad | Al Fula | Rashad | Kadugli Abasia | Wakra | Algooz | Alreef Alshargy

Water
Dalang | Algooz | Alreef Alshargy | Habeela | Dalami | Kawaik | Kadugli Alguz

Rangelands
El gitta | Al garbi | Abugibaiha | Kadugli

Health
Southern areas, rural areas, Western and Eastern side of the state

A recent study of two sites in Southern Kordofan - Rashad and Kadugli - recorded significantly higher baseline rainfall. While both sites averaged around 27 °C, Rashad received on average 654 mm of rainfall per year from 1970-1990 while Kadugli received 598 mm per year over the same time frame (South Kordofan State NAP Committee 2013). A high climate change scenario predicted large gains in temperatures (nearly 5°C) and large losses in rainfall (53 mm and 26 mm, respectively). A low climate change scenario predicted a 2.5 °C increase in temperatures and negligible changes in rainfall.

Because of its wetter climate, Southern Kordofan state is less vulnerable to drought conditions than its northern counterpart. However, the adverse impacts of climate change may be experienced indirectly via forced migration. That is, as agricultural regions in other parts of Sudan become less productive, states further south may see an influx of climate refugees.

At present, Southern Kordofan lacks to infrastructure to accommodate rapid population growth. Having been at the center of a long running civil conflict with the south, the state is characterized by widespread poverty, lack of basic services, poor infrastructure and continued land disputes.

Climate change adaptation in Southern Kordofan should focus developing institutional and infrastructure capacity to accommodate a potential influx of climate refugees. Despite the area's high potential for agriculture, poor infrastructure, maladaptive policies and insufficient policy implementation have caused serious land degradation. For example, poor policy implementation allowed mechanized farming to expand without leaving the shelterbelts required by the Forest Act. Major categories of adaptation initiatives are described in the bullets below. Additional specific adaptation measures are provided in Chapter6 and Annex A.

- *Agriculture*. Adaptation measures would include strengthening institutional capacity to create and implement land policy that encourages effective agriculture. This would include a revision of property right laws and the development of new land dispute mechanisms.
- *Water*. At the same time, building out the state's water infrastructure to meet not only current but future demand would increase resilience against water scarcity.

4.3.3 Western Kordofan

Western Kordofan is located in the southwest corner of Kordofan State. The northern part of the state is classified as semi-desert; the southern part of the state is classified as high rainfall woodland savannah. The area is almost flat with sandy soils covering about 60% of the state.Transhumance dominates socioeconomic activities. Box 4-8 provides some essential climatic and vulnerability information for Western Kordofan state.

Nomadic tribes dominate the population and economy of Western Kordofan. Inhabitants are mainly Baggara tribes, who are mainly cattle breeders and Hamar tribes, who are mainly camel and goat breeders.Most of the population is found where water and other services are available.

Box 4-8: Western Kordofan conditions

Baseline climate (1971-2000) - Alnehud
Average annual max temperature: 35 °C
Average annual min temperature: 20 °C
Average annual rainfall: 352 mm/yr

Vulnerable Locations

Agriculture
Baba Nousa | Muglad | El Nohood | Gebaish

Natural resources (Rangelands)
Baba Nousa | South Muglad | El Nohood | Elodia | Fula|El Khowi

Water
Dalling | Habeela | Dalami | Kawiak | Kadugli | Elgoz | El Garbiya

Health
All of the above communities

Western Kordofanis confronting several climate change impacts. In the agricultural sector, higher temperature and increased rainfall variability has led to crop failure, increased pest incidence, and out-migration by farmers. For natural resources, climatic hazards have resulted in overgrazing of rangelands and the loss of forested areas. For pastoralists, lower humidity levels and higher temperatures has led to grassland degradation and animal diseases. For the water sector, there have been diminished levels of healthy drinking water due to lower rainfall. Finally, communities have experienced a higher incidence of certain climate-related epidemics.

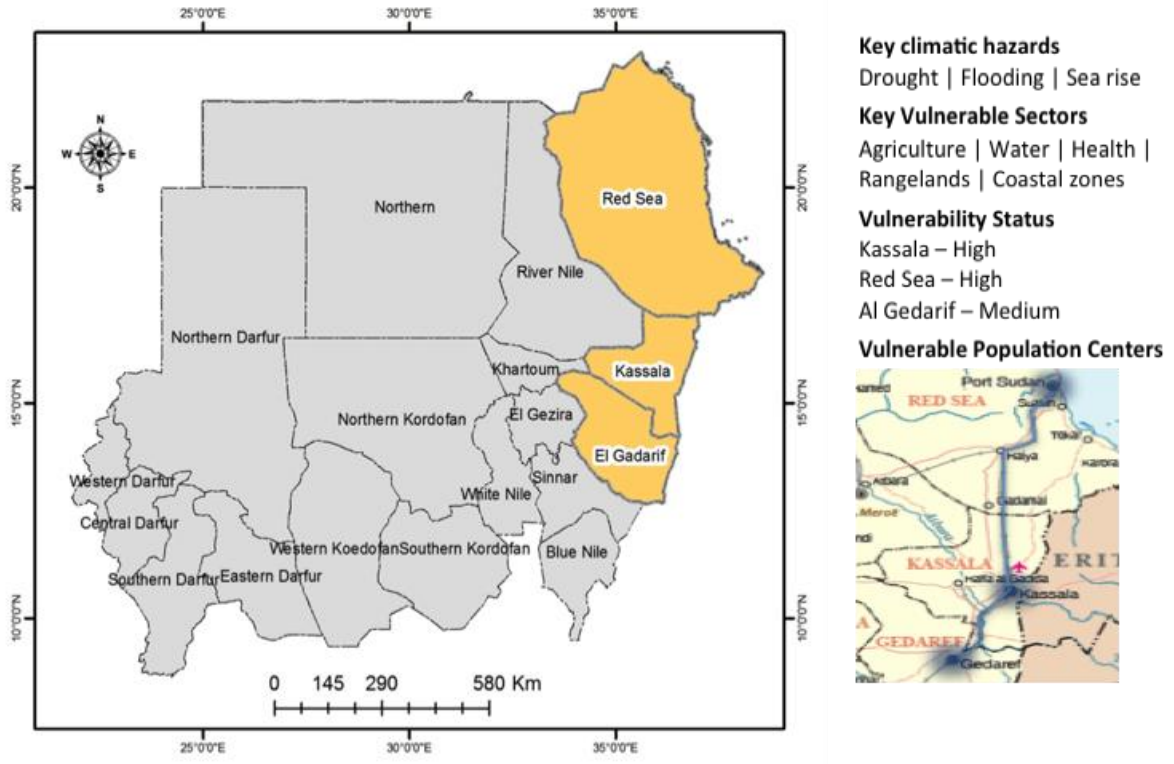
It will be important for adaptation planning in Western Kordofan to address underlying socioeconomic factors than contribute to vulnerability to climate change, namely poverty levels among nomadic tribes and their lack of household income diversification. Major categories of adaptation initiatives in rangelands and agriculture are described in the bullets below. Additional specific measures in these and other sectors are identified in Chapter 6 and Annex A.

- *Rangelands*. Adaptation in the rangeland sector should focus on a wide range of reclamation activities that are effective in mitigating dune encroachment. It should also seek to increase the use of remote sensing technology to collect information about the negative effects of climate change on pastoral lands.
- *Agriculture*. Adaptation in the agriculture sector should focus on research related to soil and crop varieties that can be grown in the state under worsening climatic conditions.

4.4 Eastern States

The Eastern States are located in the northeast part of Sudan, as shown by the highlighted borders in Figure 4-5, together with some key results of the overall vulnerability assessment. It covers an area of nearly 325 thousand square kilometers and has a population of about 3.1 million people. In inland areas, the economy is characterized by a mix of traditional and mechanized rainfed agriculture, as well as pump irrigated agriculture and livestock. Along the coast, economic activity is centered in Port Sudan where Sudan's main harbor is located. The Eastern States consists of three states in three separate ecological zones. In the North, the Red Sea state falls into the desert zone; the centrally located Kassala state is in the semi desert zone; and Al Gedarif stateis a low rainfall savannah ecological zone.

Figure 4-5: Map of the Eastern States and overall climatic vulnerability characteristics



Similar to other areas in Sudan, these states are experiencing increased rainfall variability, decreased average rainfall, and increased temperatures. However, given the region's ecological variety these changes are projected to be unevenly distributed across the three states. Of these states, Kassala is considered the highly vulnerable due to high rainfall variability and increasing temperatures while the Red Sea state is considered to be highly vulnerable due to sea level rise and the adverse of impacts of sea surface temperature changes on marine biodiversity.

4.4.1 Kassala

Kassala state extends across a semi desert zone as well as a low rainfall savannah zone in the south. Its population of 1.7 million is growing at an average 2.5% per year, with most inhabitants living in Kassala town and other semi-urban centers. The economy is dominated by agricultural activities. As a result, water and agriculture, and to a lesser extent health, were identified as the primary sectors of concern during the vulnerability assessment. Box 4-9 provides some essential climatic and vulnerability information for Kassala state.

Box 4-9: Kassala state conditions

Baseline climate (1971-2000) - Kassala
Average annual max temperature: 37 °C
Average annual min temperature: 22 °C
Average annual rainfall: 247 mm/yr

Vulnerable Locations:
Agriculture (Drought)
Aroma | Khashm Algirba | North Delta
Water (Flooding)
Aroma | Khasim Algirba | Tarkook | Hamashkorib
Health
Aroma | Hamashkorib

Given its location in the semi-arid north, Kassala is extremely vulnerable to climate change. Over the past decade temperatures have increased and rainfall has decreased. In particular, the range in annual rainfall has dropped to between 67 and 425 mm/year over the past decade, well below baseline rainfall conditions (Kassala State NAP Committee 2013).

High rainfall in certain parts of the state means Kassala is coping with frequent seasonal flooding from the Gash and Atbara rivers in the western part of the state. Historically, floods have occurred every 6-7 years over the 1970-200 period. In recent decades, flooding frequency has increased to about every 4-5 years. Moreover, in semi-desert zones, drought frequency has also been increasing, with two major droughts occurring in 2008 and 2011. In the future, this intensifying cycle of floods and drought is projected to continue and intensify, with Kassala's already vulnerable rural population - 85% of which are living below the poverty line and relying on subsistence agriculture - most at risk. Major categories of adaptation initiatives are described in the bullets below. Additional specific adaptation measures are identified in Chapter 6 and Annex A.

- *Agriculture/rangelands*. On the policy side, capacity building and training programs may improve management and enforcement. For example, greater institutional capacity could help water committees enforce important regulations, such as requirement to cultivate 5% of irrigated schemes with trees to limit flooding. These efforts would coincide with a comprehensive rangeland rehabilitation program that could include: water harvesting programs, reseeding rangelands with favorable species, and rehabilitating available *hafirs* in rural areas to enable remote grazing. Policy makers could also introduce the concept of community forest and mesquite management by reseeding indigenous species like sider, Seyal and Tundb.
- *Water*. Water scarcity would be alleviated by drilling more wells, improving water harvesting techniques, and eradicating invasive mesquite trees from water source areas. An awareness-raising program would help farmers adopt more efficient and modern irrigation system. In particular, the rehabilitation of four *hafirs* in the rural Aroma locality (Kilinda, Garadaieb, Gug Elfil, and Elaraish) could provide the additional water needed to enable grazing on remote/rural pastures.
- *Public health*. Increasing temperatures threaten to accelerate and extend the spread dengue fever and malaria, which are already prevalent in Kassala. This can be offset first by more entomological surveys, proper solid waste disposal and construction of communal latrines in agricultural villages. Water treatment plans for agricultural villages would prevent villagers from drinking non-potable water from irrigating canals.

4.4.2 Gedarif

Gedarif state is the southernmost state in the Eastern State and receives enough rain to sustain a healthy agricultural sector. In the south, there are approximately 8,400 square kilometers of rain-fed agriculture with mechanized rain-fed agriculture along the Atbara, Sitat and Rahad rivers. Although animal production represents the bulk of agricultural production for the state, Gedarif is also the main producer of grains in Sudan, contributing 50% of the country's sorghum and millet production. Box 4-10 provides some essential climatic and vulnerability information for Gedarif state.

Box 4-10: Gedarif state conditions

Baseline climate (1971-2000)-Gedarif
Average annual max temperature: 37 °C
Average annual min temperature: 21 °C
Average annual rainfall: 613 mm/yr

Vulnerable Locations:
Agriculture (Drought)
Qala | Nahal

Forestry (Drought)
Doka | Rawashda Forest | Wadkabou Forest

Increasing rainfall variability, rising temperatures, and decreasing average rainfall are already affecting Gedarif's agricultural economy, 90% of which is rain-fed. Crop data analysis indicates that frequent droughts and increasing rainfall variability have led to a decrease in sorghum

productivity between 1981 and 2008, with a 20% reduction in annual rainfall reducing sorghum production by up to 25%. This has serious implications for local food security. Forests have also been a major part of Gedarif's economy. Although once one of the major producers of gum Arabic, Gedarif state has lost significant vegetation cover over the past few decades, severely reducing it's ability to produce gum Arabic (Gedarif State NAP Committee 2013).Major categories of adaptation initiatives are described in the bullets below. Additional specific adaptation measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Proposed adaptation measures for agriculture include introducing practices that reflect the ecological zones. In the northern part of the state, adaptation measures focus on land set-asides for grazing and animal production only. In the semi-arid southern part of the state, adaptation measures focus on the introduction of animals into agricultural rotations, and the cultivation of sorghum alongside other crops meant for animal production. Across both part of the state, improved plant and animal breeds should be introduced, early warning systems should be put in place, as well as capacity building and awareness raising programs developed.
- *Forests*. The forest sector can be improved by implementing legislation, planting trees inside reserved forests, and cultivating courses of seasonal streams with trees and annuals to prevent soil deterioration.

4.4.3 Red Sea

The Red Sea state is distinguished from other states in the Eastern region as the only state with a coastline. The state covers about 219 thousand square kilometers state and has the highest poverty rate in Sudan. The Red Sea state has a750-kilometer coastline characterized by numerous islands, the majority of which have no fresh water or vegetation. TheState's climate is characterized by high rainfall variability, low rainfall, and extreme temperatures. The marine environment is characterized by high salinity and high evaporation rates. Box 4-11 provides some essential climatic and vulnerability information for Red Sea state.

Box 4-11: Red Sea state conditions

Baseline climate (1971-2000)-PortSudan
Average annual max temperature: 33 °C
Average annual min temperature: 24 °C
Average annual rainfall: 84 mm/yr

Baseline marine environment
Sea surface temperature: 26.2°C to 30.5°C
Salinity: 38% to 41%
Average tidal range: 0.55 meters

Vulnerable Locations:
Agricultureand Rangelands (Drought)
Qala | Nahal | Khor Aldeaib | Khor Arab | Wadi Amor | Adobna | Ageeg | Hoshairy | Arbaat | Arkweet | *Dordaib* | *Toker* | *Olaib* | *Iram*

Coastal zones (Coral reefs)
Dungonab Bay | Suakin harbor

Coastal zones (Sea level rise)
Port Sudan

Coastal zones (Mangroves)
Mersa Sheikh Ibrahim | Kilo Tammaria

Coastal zones (Seagrass beds)
Entire coastline between shore and fringing reefs

Water
Arbaat | *Saloom* | *Sinkat* | *Gabait* | *Dolbeyay* | *Agetay* | *Iteria*

Health
Haya, Dordaib, Toker, Coatal area of Port Sudan and Sawaken

For inland areas, the hilly topography at the Basement Complex formation of base rock makes surface run-off the only reliable source of fresh water in the Red Sea state. The Basement Complex's combination of rocks, compact soils, steep slope, and pattern of rainfall and poor vegetation cover, all contribute to high rates of run-off in the region that is difficult to predict or control. On the whole, the region relies on dams, water treatment, hafiers and wells from both ground and surface water for their water supplies. Over the last decade, the water table has reduced an average of 5 to 10 meters, with declining well productivity (Red Sea State NAP Committee 2013).

For coastal areas, the Red Sea supports varied and

diverse coastal and marine habitats, including coral reefs, mangroves, and seagrass beds. A large number of species of birds and fish are supported by these ecosystems, many of which are not found anywhere else in the world. These resources also provide food and income for the communities living along the Red Sea coast. The most significant implications of climate change affecting these coastal zones are the increase in sea surface temperature and sea level rise. Rising sea levels threaten to inundate wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of coastal lagoons and groundwater.

An overarching concern across inland and coastal areas is water scarcity. Since the drought in the 1980s, the state has been in a constant condition of food insecurity and has relied on external assistance, particularly in rural areas. The lack of ready access to water threatens the state's main livelihoods, which are agriculture and livestock raising. About 102 thousand square kilometers are classified as natural grazing area, supporting about 1.8 million heads of livestock (Red Sea State NAP Committee 2013). At present, there is a gap between production and demand in key crop groups. At the same time, overgrazing is rapidly deteriorating rangeland, in particular placing the Baja agro-pastoralist group in jeopardy.Major categories of adaptation initiatives in agriculture, water and coastal zones are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Adaptation measures in this sector focus on the provision of improved drought-resistant seeds, introducing water-harvesting techniques, constructing four enclosures for reseeding study purposes, and rehabilitant 21 square kilometers of pasture.
- *Water*. Adaptation measures for water include establishing desalination stations along the Red Sea, constructing subsurface dams and improving water harvesting techniques.
- *Coastal zones.* Adaptation measures in this sector include mangrove restoration and conservation; the development of program for marine-related research; monitoring, education, and awareness-raising; introduction of policies to promote integrated coastal zone management; and support for mangrove-dependent communities to reduce mangrove destruction.

4.5 Nile States

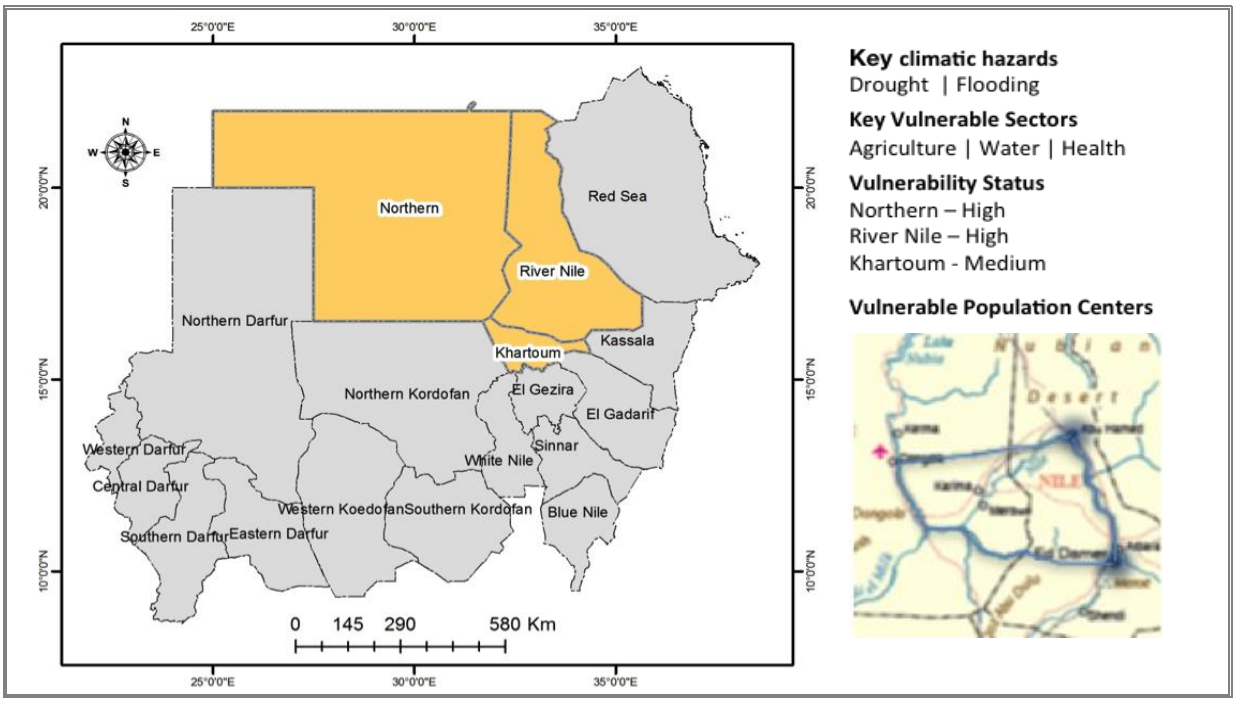
The Nile States consist of Khartoum, River Nile and the Northern state, as shown by the highlighted borders in Figure 4-6, which also includes some key results of the overall vulnerability assessment. Both states are characterized by an arid climate with low rainfall, extreme temperatures, sparse vegetation, and increasingly erratic weather patterns. The region covers an area of nearly 471 thousand square kilometers and has a population of about 7.2 million people.

4.5.1 River Nile State

The River Nile state straddles both desert and semi-desert zones. It contains the River Nile, the River Atbra and a number of seasonal streams that support wheat production. Agriculture is the dominant economic activity with irrigated cultivation concentrated around the River Nile and the River Atbra banks and delta area. Flood irrigation is concentrated mainly around the River Atbra while rainfed agriculture is practiced in other parts of the state remote from seasonal streams. Box 4-12 provides some essential climatic and vulnerability information for the state.

From 1994 - 2005, significant increases in winter temperatures were recorded at the beginning and end of the growing season, shortening the growing season, reducing the productivity of winter crops (River Nile State NAP Committee 2013). Given that arable land is highly

Figure 4-6: Map of the Nile States and overall climatic vulnerability characteristics



constrained, production decreases because of rising temperatures have led to greater food shortages. At the same time, high wind speeds and shifting sand dunes affect cultivated lands by sometimes blocking irrigation channels.

Farmers in the lower River Atbara area are most vulnerable to these conditions. At the same time, annual flow rates of the River Atbara have been decreasing, leading to lower crop and animal productivity.

Increasing temperatures, floods and drought exacerbate persistent health threats. Endemic diseases in River Nile state include waterborne diseases due to shortage of water as well as poor water quality. The incidence of disease is highly seasonal and usually occurs at the start of the wet season. Waterborne diseases make up 80% of the reported diseases. These include malaria, Giardiasis, Cholera, Dysentery, and parasitic infection like schistosomiasis (River Nile State NAP Committee 2013). High frequencies of tuberculosis were reported in rural areas in the north and lower Atbara.

Box 4-12: River Nile state conditions

Baseline climate (1971-2000)-Gedarif
Average annual max temperature: 31 °C
Average annual min temperature: 14 °C
Average annual rainfall: 57 mm/yr

Vulnerable Locations
Agriculture (Drought)
Lower River Atbara area
Water (Scarcity)
Berber | Abuhamad
Health (Water borne diseases)
Berber | Abuhamad
Health (Tuberculosis)
Northern areas | Lower River Atbara area

Animal husbandry represents the other major livelihood system in the River Nile state. However, rangeland productivity has been rapidly deteriorating, due to a variety of factors including increasing temperatures, recurrent drought, rising wind speeds, and over-grazing. The most vulnerable areas are north of Atbara. Hence, major categories of adaptation initiatives in agriculture, water and public health are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Adaptation measures in this sector focus on the introduction of shelterbelts, agro-forestry cultivation techniques, new drought-resistant seeds and the introduction of new cash crops with emphasis on fruits, and non-timber forest trees and shrubs.

- *Rangelands*. Adaptation measures in this sector focus on the improvement of vegetation cover of key rangelands, research on rehabilitation of degraded lands using indigenous and introduced species, and livestock restocking.
- *Water*. Adaptation measures encompass improved water harvesting techniques, construction of canals inside the River bed to enhance and lead water to irrigation pumps intakes, provision of small scale pumping units for irrigation to reduce the negative impacts of water recession, well drilling in rural areas, and construction of water dams for controlling river bank erosion.
- *Public health.* Adaptation measures in this sector focus on vaccination campaigns and awareness-raising program on key preventable diseases such as schistosomiasis.

4.5.2 Northern State

Located in the heart of the desert zone, the Northern state is characterized by low rainfall, extreme temperatures, and sparse vegetation. The local economy depends upon both irrigated and rainfed agriculture. Box 4-13 provides some essential climatic and vulnerability information for the Northern state.

Box 4-13: Northern state conditions

Baseline climate (1971-2000)-Dongla
Average annual max temperature: 37 °C
Average annual min temperature: 19 °C
Average annual rainfall: 11 mm/yr

Vulnerable Locations
Agriculture
Marawi , Adabah,Elgaba
Water (Scarcity)
Umm Gawaseer |Wadi Abu Dom | Wadi Elmugdam | Wadi Elmalik | Alesalami | Nori | Dungla
Health (Skin diseases)
Umm Gawaseer

Rising temperatures, decreasing rainfall, fluctuations in the River Nile, and increased wind speeds have combined to result in a mix of drought and flooding with adverse effects on crop yields, rangelands, animal production, and river bank erosion (Northern State NAP Committee 2013). Shifting climates have also hastened the arrival of new plant diseases, such as the date palm disease in the Elgab area, and new skin diseases, such as Jarab, which are not historically common in the state. While irrigated agriculture is vulnerable at all localities, hotpots for rainfed agriculture include forests and rangelands in Marawi and Adabah localities. Major adaptation initiatives in agriculture, water and public health are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Adaptation measures include the adoption of improved varieties, crop rotation, and sprinkler irrigation. In addition, shelter belts, studies of bank erosion, and the rehabilitation of Umm Gawaseer project for settlement of migrating people are all recommended.
- *Water*. Adaptation measures include the construction of new wells in Umm Gawaseer and other settled areas, underground storage of water, and conducting studies in Wadi Abu Dom for water harvesting and conducting socio-economic studies, digging boreholes for drinking purposes in low land areas.
- *Health.* Adaptation measures focus on providing health services to the Umm Gawaseer area could alleviate health risks from the spread of new skin diseases as well as the lack of potable water.

4.5.3 Khartoum

Khartoum, the capital of Sudan, is located in the tropical zone around the River Nile. During the rainy season, from July to September, Khartoum receives between 110 and 200 mm of rainfall

on average, with the remainder of the year being fairly dry. Dust storms are regular occurrences and river fluctuations threaten riverbank erosion and flooding (Khartoum State NAP Committee 2013). Box 4-14 provides some essential climatic and vulnerability information for Khartoum state.

Box 4-14: Khartoum state conditions

Baseline climate (1971-2000)-Khartoum
Average annual max temperature: 37 °C
Average annual min temperature: 23 °C
Average annual rainfall: 121 mm/yr

Vulnerable Locations:
Water
East Nile locality (Wad Abu Salih villages) | western part of Um Badda locality | Dar assalam | Mayo and Jebl Awliya locality | for other rural areas (ground water)

Agriculture, rangeland and food security
East Nile locality (Wadi Abu Sodod | Wadi Burtah) | Bahari locality (Wadi Alafaya) | Karari locality (Wadi Abyad), large cooperative agricultural schemes in Khartoum state | Jebl Awliya and Umdurman localities

Health
East Nile and Bahari | Jebl Awliya | Kararianд Umdurman localities

Rapid urban growth combined with rising temperatures, rainfall variability, and river fluctuations have placed serious pressure on Khartoum's resources. Although studies are needed to assess existing and future climate change, if Khartoum follows the country-wide trend of an increasingly dry climate, then this will threaten crop yields, rangelands, and natural forests in the area. Major adaptation initiatives in agriculture, water, public health, and urban areas are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture*. Major adaptation activities include the cultivation of early maturing crop varieties, research activities on drought-resistant seed varieties, and awareness-raising among farmers.
- *Water*. Major initiatives are focused on capacity strengthening, the adoption of water saving irrigation techniques, integrated water planning, awareness-raising among farmers about climate change.
- *Public health.* Major adaptation activities include ensuring adequate treatment supplies for vector-borne diseases and improving health awareness among rural communities.
- *Urban areas.* Major initiatives are focused on the development of a comprehensive strategy for mitigation of health impacts in urban areas, transportation planning, and community participation in addressing urban environmental issues.

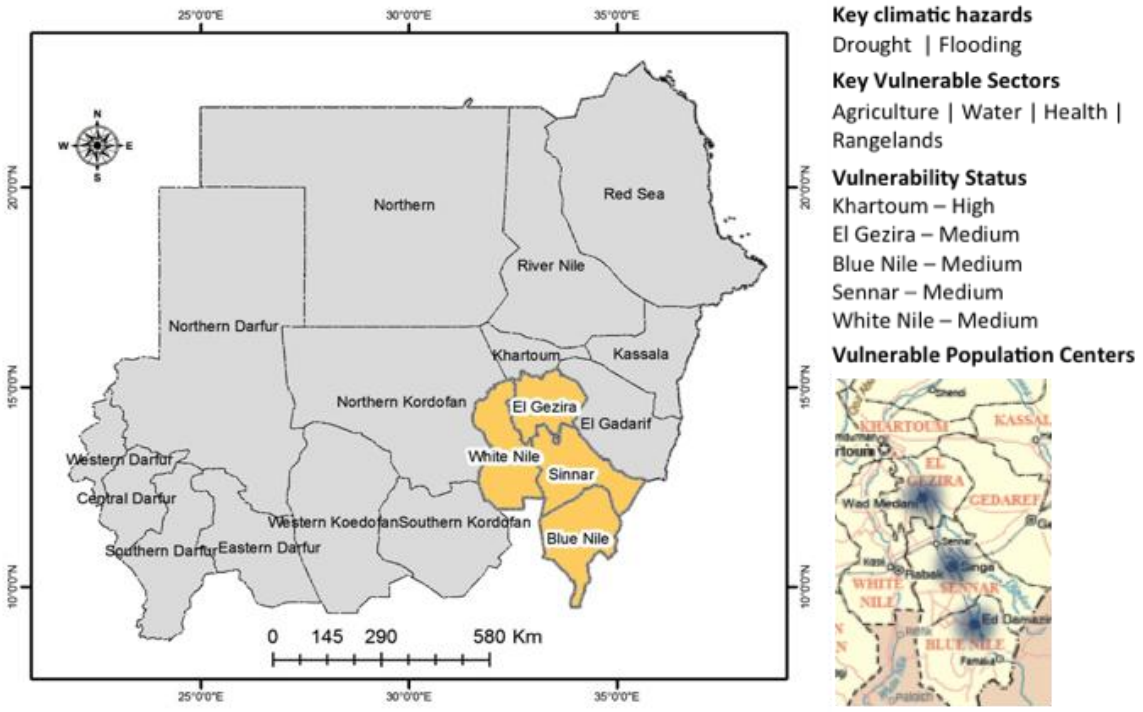
4.6 CentralStates

There are four states within the central region of Sudan - Al Gezira, Blue Nile, White Nile and Sennar. The location of these states is shown on Figure 4-7, which also includes some key results of the overall vulnerability assessment. While Sennar and the White Nile States are low rainfall savannahs, the Blue Nile is a high rainfall savannah, and Khartoum and Al Gezira are in the semi-desert zone. Given the diversity of climates, climate change vulnerability and adaptation options needs to be addressed at a state specific level.

4.6.1 Al Gezira State

Gezira State covers an area of approximately 26 thousand square kilometers and belongs to an arid climatic zone where rainfall and evapotranspiration yield a negative annual water balance (Al Gezira State NAP Committee 2013). The annual rainfall is variable and ranges between 420 mm in the south and 250 mm in the north. However, the current evapotranspiration rate is very high (2300 mm per annum) and the current ratio of evapotranspiration to maximum evapotranspiration is predicted to increase by 11%. Box 4-15 provides some essential climatic and vulnerability information for Al Gezira state.

Figure 4-7: Map of the Central States and overall climatic vulnerability characteristics



Rainfall, the Nile River and groundwater are the main water resources of the state. Thus, the state water resources are vulnerable because of high variability associated with rainfall and Nile flow, let alone the transboundary nature of the Nile river and groundwater; noting that most of the state livelihood generations are highly water- and climate-dependent. It is also important to note that rainfall and groundwater dominate (80%) the state's domestic water supply.

Given the high evaporation rate, irrigation is essential for sustaining the state's agricultural activities. Al Gezira has one of the largest irrigation scheme in the world – about 12.6 thousand square kilometers – with groundwater providing about 80% of the state's domestic water supply (Al Gezira State NAP Committee 2013).

There are two main freshwater sources: Nubian Formation (confined aquifer): Crosses AlGezira State and is least affected by the climate change and variability due to its confined nature and hydraulic conditions where its water is non-renewable and of meteoric origin. The Gezira Formation (unconfined aquifer): The bulk of drinking water is extracted from this aquifer amounting to 80% of the water resources of Gezira State. It covers most of the State except the Eastern Gezira and Southern Managil. Water extraction methods and technologies range from water table Hand Pumps, Hand-dug Mataras for animal and vegetables farming to deep motorized wells and Compact Units filtering surface water from Haffirs and irrigation canals.

The formation receives its recharge partly from the Blue Nile to a distance of 1 to 4 km and rainfall infiltration and percolation in two distinct sub-aquifers within the formation. As such, it is likely to be impacts by climatic change. Two types of forests

Box 4-15: El Gezira State Conditions

Baseline climate (1971-2000)-Wad Medani
Average annual max temperature: 37 °C
Average annual min temperature: 20 °C
Average annual rainfall: 283 mm/yr

Vulnerable Locations:
Agriculture
Gezira Scheme |western parts of Managil area |Abu Guta area |eastern Gezira

Water
Eastern Gezira (Butana) |Managil Ridge |Abu Guta areas

Health
EntireState

exist, Nile forests and natural forests. The total area of reserved forest 407.000 feddans, where about 70% is the actually existed in the ground. The natural vegetation is 7.7% of the total area of the State.

Going forward, climate variability is expected to pose a real climatic hazard, threatening the water sector, rainfed and irrigate agriculture, forest and rangelands. Major adaptation initiatives are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture*. Adaptation measures focus on not only improved policy, planning and predictive studies, but also adopting technologies that are climate change resistant, such as alley cropping, developing stress varieties ad modern irrigation systems. Agroforestry may also protect field and horticultural crops. Aggressive agriculture and monocropping are rapidly depleting soil nutrient, exacerbating the effects of climate change. These should be mitigated through multiple cropping systems, fallow systems and planting trees to act as shelter belts.
- *Water*. Establish borehole irrigation, rainfall and water catchment basis to enhance communal water storage systems and to supplement rainfed agriculture. Improve already poor designs for water storage. Plant trees around water storages, raising awareness and capacity building.

4.6.2 *Blue Nile State*

Located in the southeastern part of Sudan, the Blue Nile state is a high rainfall savannah that receives between 700 and 975 mm of rainfall per year. This climate supports a large agricultural sector that includes forestry and a mix of crops, such as sorghum, corn, cotton, groundnuts, sunflower, Guar, gum Arabic and legumes. Box 4-16 provides some essential climatic and vulnerability information for the Blue Nile state.

Over the last decade, rainfall has decreased to 450 - 500 mm per year (Blue Nile State NAP Committee 2013). At the same time, the area has seen an increase in flood and drought cycle as well as an increase in temperatures and wind speed. In particular, our vulnerability assessment identifies the Damazeen, Roseries and Atadamoun localities as particularly vulnerable to climate impacts.

Box 4-16: Blue Nile state conditions

Baseline climate (1971-2000)-Al Demazin
Average annual max temperature: 36 °C
Average annual min temperature: 21 °C
Average annual rainfall: 697 mm/yr

Vulnerable Locations:
Agriculture
Ban Gadid |Desa |Sero |Haroon and Shamar |Azaza |Gary |Gadala |Tayba Billab |Hamda |Bados and Dewa |Agadi Roro |Gerawa |Garabeen |Golly |Boot |Kurmouk | Gissan |Bao

Water
Ban Gadid |Haroon |Azaza |Tayba Billab |Bados |Dewa |Abo Garin and Tadamon Villages

Health
Abu Garin |Sabil |Ban Gadid |Desa |Sero| Haroon |Azaza |Hamda |Bados and Dewa |Agadi Roro |Gerawa |Boot |Umdrafa |Galgani |Fadima |Musfa |Moreek |Wad Abook |Balang |Abigo and Akeeli

Climate change threatens the state's agricultural based economy, putting food security at risk.Major adaptation initiatives are described in the bullets below. The Gissan, Bao and Kurmouk localities are very vulnerable with regards to health and waters. These areas are subject to frequent flooding, which threatens infrastructure and hasten the spread of water born diseases, such as malaria. Major adaptation initiatives are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture and rangelands*. Major adaptation activities include the establishment of modern meteorological stations to better track climate shifts, rehabilitating rangelands, use of improved animal breeds, and the establishment of pilot rangeland farms. More specifically

there should be new research on developing crop varieties that can adapt to new conditions and tests to determine future behavior of pests under new climates.

- *Water*. Major adaptation activities include the extension of water infrastructure, construction of contingency water storage facilities, and improving community awareness regarding water conservation
- *Public health*.Major adaptation activities include improving rural health services and capacity building around early detection of malnutrition in rural communities.

4.6.3 Sennar State

Sennar is a low rainfall savannah in the southeastern part of Sudan. The state has a diverse ecosystem that includes the Dinder National Park as well as rivers, khors and a semi alluvial plain. The state economy depends on a mix of rainfed and irrigated agriculture, forestry, grazing and fishing. The total area of rainfed agriculture is estimated at 23 thousand square kilometers (or 57% of total state land area). Box 4-17 provides some essential climatic and vulnerability information for the Blue Nile state.

Box 4-17: Sennar state conditions

Baseline climate (1971-2000)-Sennar
Average annual max temperature: 37 °C
Average annual min temperature: 20 °C
Average annual rainfall: 427 mm/yr

Vulnerable Locations
Agriculture
Sinnar Locality |East Sinnar |Abu Hogar |Dinder |Souki |Dali & Mazmoum |Singa
Water
Dali & Muzmoom |Dinder |Singa |Alsooki
Health
Dali & Muzmoum |Dinder |Alsooki

The state is vulnerable to rainfall variability, rising temperatures, increasing wind speeds and an intensifying cycle of floods and drought. This has and will lead to a lower crop yields and quality as well as the deterioration of rangeland and vegetation cover. At present the most vulnerable localities for agricultural production are: Fanguga, Jabel Mwia, Jabel Sagadi, Doba, Goz Abourwaf, Elbagia, UmmRahaba, Albardanah Awra, Awd Masri, and Hwbua. Major adaptation initiatives are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Major adaptation activities include the protection of arable land through windbreaks, demonstration projects for drought-resistant seeds, and climate change information awareness campaigns in rural areas.
- *Forests and rangelands.* Major adaptation activities include rangeland and tribal migration route rehabilitation projects, improvement in livestock rotation schedules, and an enhanced regulatory regime for forest protection.
- *Water*. Major adaptation activities include the extension of water infrastructure, construction of contingency water storage facilities, implementation of water harvesting techniques, and improving community awareness regarding water conservation
- *Public health*.Major adaptation activities include improving rural health services and ensuring access to safe drinking water.

4.6.4 White Nile State

White Nile state has three different ecological zones ranging from sub-humid to semi-arid. Average annual rainfall rangesfrom 300 mm in the north to more than 600 mm in the south. Total land area is nearly 40 thousand square kilometers with a population of more than 1.7 million, of which almost 70% earn a living based on traditional rainfed agriculture and livestock. Animal resources (sheep, goals, cattle) are nearly 8 million head. Box 4-18 provides some essential climatic and vulnerability information for the White Nile state.

As one of Sudan's most vulnerable regions, the White Nile State is severely impacted by the climate change induced droughts and floods. Most notably, increasing temperatures, decreasing trends of annual precipitation as well as increased variability, are causing a gradual shift of climate end ecological zones from north to south. That is, formerly semiarid ecological zones, such as the majority of the White Nile State, are gradually moving southward as the climate becomes increasingly hotter, thus taking on characteristics similar to the arid zones currently found further north.

Box 4-18: White Nile state conditions

Baseline climate (1971-2000)- Kosti
Average annual max temperature: 37 °C
Average annual min temperature: 22 °C
Average annual rainfall: 348 mm/yr
Northern areas: 300 mm/yr
Southern areas: 600 mm/yr

Vulnerable Locations
Um Rimmta | Al Dwaim | Kosti | Tandelti | Alsalam | Algabalain

This situation has adversely impacted water availability and agricultural potential, through increased frequency of droughts, dust storms and heat waves. There is also an increasing frequency of extreme flooding events caused by an increase in intensity of rainfall both during the rainy season and in rainstorms (flash flooding). These climate trends and risks are exacerbated by a number of non-climate issues such as: decreased vegetation cover due to overgrazing and deforestation, and inefficient management of water resources – thus further increasing trends of ecological zone shift and desertification.

Almost all localities in the western side of White Nile River were found to be among the most vulnerable to droughts and other impacts of climate change. These impacts have already been manifested in declining crop productivity, loss of grazing resources and rangeland valuable species, land degradation, increased frequency of diseases crops, livestock and population, loss of livelihoods and human migration in search for jobs and alternative livelihoods. While climate impacts are severe across the state, the communities on the western bank of the White Nile River are particularly vulnerable due to several factors. These include: low general awareness of climate change;lack of knowledge about water harvesting;lack of access to improved seeds and other agriculture inputs;presence of overgrazing and severe deforestation;high poverty levels and lack of alternative livelihood systems; lack of technology and know-how for better agricultural practices; and high frequency of rangeland fires.

Major adaptation initiatives are described in the bullets below. Additional specific measures are identified in Chapter 6 and Annex A.

- *Agriculture.* Major adaptation activities include thedissemination of improved seeds (drought resistant and early maturing); promotion of vegetable production to improve nutrition; and the introduction of dairy processing skills.
- *Water*. Major adaptation activities include the introduction of water harvesting techniques, building of micro dams in some water valleys to improve water supply in vulnerable areas, and the construction of water wells and with solar pumps in water stressed areas for both human and animal use.
- *Forestry*.Major adaptation activities includeplanting of 10% of the area of the agricultural land with forest trees; establishment of shelterbelts and promotion of social forestry; and enforcement of natural resources legislation.
- *Rangelands.* Major adaptation activities includerehabilitation of rangelands; and establishment of grazing enclosures and improved grazing management.
- *Other*. Several other adaptation measures have been identified to reduce underlying socioeconomic vulnerability. These include promotion of fish farming as another source of income and food security; provision of energy conservation and renewable energy

technologies; and biogas for domestic energy and lightning and also for production of fertilizer.

5 Enabling Environments

This chapter provides an overview of additional activities that were undertaken as part of the NAP process. As described in the previous section, the major focus of Sudan's NAP was to develop a better understanding of adaptation challenges at the regional and state level. Nevertheless, there was also an emphasis on the identification and implementation of new programmes and activities that could strengthen technical capacity to undertake future climate change assessments.

This chapter is premised on the perspective that effective mainstreaming of adaptation strategies into Sudan's state and national planning processes requires building upon a science-based approach that can effectively address issues of priority vulnerabilities, adaptation financing costs/benefits, and ways to integrate climate resiliency into development project design. The sections below describe both the process used in undertaking these efforts, as well as the key results of those assessments. The discussion below illustrates Sudan's progress in the development of programmtic activities that can foster a science-based integration of climate risks into all national and state development planning processes.

5.1 Introduction

Adaptation to climate change needs to be strongly rooted in the overall Sudanese development context. For example, climate-change related impacts on rangelands can lead to a potential deepening of resource-based conflicts among pastoral, transhumant and farmer communities - adaptation interventions will need to take this dynamic into account to promote equitable, advocacy-based interventions that incorporate new technology, better practices and conflict resolution strategies. Also, more frequent droughts increase food insecurity differently among rural communities that can only be effectively addressed through the kinds of state-specific adaptation interventions that are developed relative to specific state circumstances.

Creating an enabling environment that accounts for regional and state-level differences in Sudan is largely a challenge related to strengthening local capacity in the use of specialized methods and tools. During the NAP process, a specific set of training programmes was pursued that focused on regional climate modeling, vulnerability hotspot mapping, climate proofing, and adaptation financing. Building local technical capacity around these areas will help support adaptation decision-making at the federal level through line ministries, as well as atstate and communitylevels.

5.1.1 Objectives

The main objectives of each enabling environment activity were to a) implement a capacity building programme in suitable methods and tools; and b) develop initial assessments based on the training received. Activities were carried out in the context of national training workshops convened over the course of the NAP process.

5.1.2 Process

The approach for undertakingenabling environment activities focused on fivekey areas, as briefly summarized in the bullets below. The subsections that follow summarize the activities and outputs for each activity.

- *Regional climate modeling:* This activity sought to strengthen nationalcapacity to develop regional climate projections that could be subsequently used in the assessment of the impacts of climate change on key sectors and systems in Sudan.
- *Research and systematic observation:*This activity sought to develop a programme to enhance national monitoring programs and research capacity to detect biological, physical and chemical responses due to direct and indirect effects of climate change.
- *Vulnerability hotspot mapping:* This activity sought to strengthen national capacity to develop a national "hotspot" mapping framework that can contribute to the integration of climate change adaptation activities into national planning protocols, through the development of maps and other visual aids.
- *Climate proofing:* This activity sought to mainstream climate change adaptation at both the project and programmatic levels through the development of a screening tool and its application in Sudan to develop a more robust national adaptation policy.
- *Adaptation financing:*This activity sought to strengthen national capacity to quantify investment strategies for addressing adaptation to climate change across different sectors and economic activities, which could serve as inputs to adaptation planning and future negotiating positions.

5.2 Regional climate scenario development

The development of regional climate scenarios was driven by the understanding within the NAP planning process that climate change vulnerability and adaptation assessments should include comprehensive, up-to-date evaluation of the potential effects of climate change on many sectors of Sudan's economic and ecological systems. Assessments should explore how to best utilize the latest climate science to select from available climate projections; introduce the selected climate projections into models (water, agriculture, hot-spot, economic, etc.); and provide guidance on how to incorporate assessment results into long-range planning.

The capacity to develop regional climate scenarios is important for Sudan because vulnerability assessments should include comprehensive, up-to-date evaluation of the potential regional effects of climate change in the mid- to long-term. At the time the NAP process was undertaken, no regional climatic scenarios were available, only outputs from global circulation models (GCMs). The resolution of such is typically on the order of hundreds of kilometers rather than the much finer resolution desired for detailed vulnerability assessments. For this reason, pre-NAP groundwork activities identified the development of regional climate projections as an essential input to the development of a better understanding of the vulnerability ofkey economic sectors and ecological systems in Sudan, and by extension the range in adaptation strategies to reduce local vulnerability.

5.2.1 Objectives

The NAP process launched an effort to explore, develop and make accessible, data and methods that can be used to develop practical climate change scenarios for use in future climate impact analysis. Three objectives underline the regional climate scenario assessment, as summarized in the bullets below. A technical report was produced that provides a detailed description of regional climatic change through 2100 (Abdelkharim, et al, 2013). The results of this report are synthesized in the paragraphs that follow.

- *Build technical capacity:* This involved establishing a collaborative relationship between Sudanese meteorologists and international experts, as well as the convening of on-site and remote capacity strengthening programme.
- *Assemble data:* This involved the acquisition and organization of Sudan-specific observed data and climatic projection outputs from numerous global circulation models;
- *Develop future regional climatic projections:* This involved a series of steps to explore the correlation between global outputs and historical regional climate, conduct statistical downscaling, and produce graphical outputs for temperature and precipitation up through the year 2100; and
- *Address uncertainty:* This involved characterizing the multiple contributors to uncertainty, including future climate drivers such as greenhouse gas emissions, choice of climate models, and choice of downscaling method.

5.2.2 Key activities

This assessment activityexplored, developed and made accessible, data and methods that can be used to develop credible, defensible, and practical regional climate change scenarios for use in future impact and adaptation analysis in Sudan. This has involved a number of key activities, as outlined in thebullets below.

- *Acquire* existing climate change projections at scales commensurate with the evaluation of effects at the water basin level, and the subsequent evaluation and selection of those projections most appropriate for regions throughout and beyond Sudan based on records of observed and reconstructed climate variability;
- *Contextualize*future climate within the historical record where instrumental data is available, and if available, use paleo climate data to develop a more comprehensive representation of the full range of natural variability; and
- *Emphasize* the multiple contributors to uncertainty, including future climate drivers such as greenhouse gas emissions, choice of climate models, choice of downscaling methods including dynamical models as well as statistical downscaling approaches, and choice of hydrologic, agricultural and economic modeling methods and approaches.

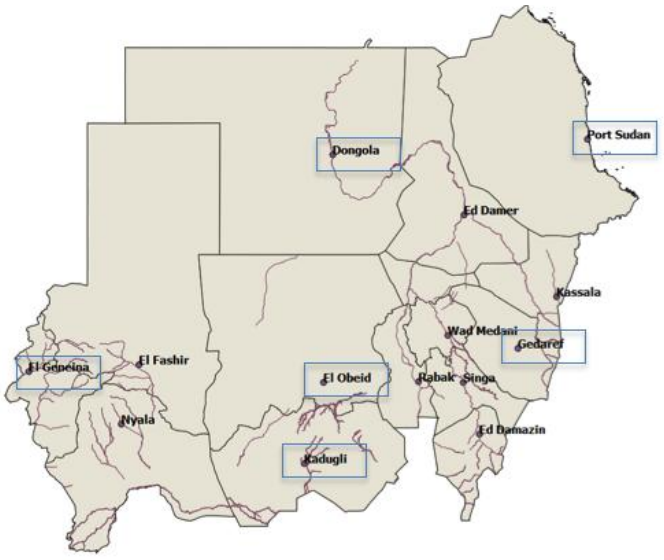
Within the NAP process, this involved research to develop a set of regional climate scenarios on projected temperature and precipitation changes in Sudan that can subsequently be integrated into planning protocols (e.g., redefine the 100-year storm event based on climate change). Training activities have also been undertaken to strengthen national capacity to undertake regional climatic modeling.

5.2.3 Approachand results

The overall approach to developing regional climatic scenarios consisted of several major steps. These included defining current climate trends in Sudan; obtaining the most recent GCM outputs; applying statistical downscaling techniques to define future climate at a finer spatial resolution, and producing a series of maps and charts. Each of these steps is briefly summarized below.

For current climate in Sudan, six stations were selected to summarize precipitation and temperature characteristics over Sudan for the period 1961 through 2010. These stations are well distributed across Sudan and are identified on Figure 5-1 as enclosed in blue boxes. These stations represent the diverse climate in Sudan's ecological zones, from the dry desert of the North to the sub-tropical regime of the south. The observed record suggest a fairly strong warming trend, with only Kadugli station near the border with South Sudan suggesting a slight negative or cooling trend over the historic period. Monthly average precipitation and total annual precipitation show strong seasonality, north-south gradient, and inter-annual variability and no long-term trend.

Figure 5-1: Location of meteorological stations used for developing regional climate projections



The most recent GCM outputs were obtained from the upcoming IPCC Assessment Report-5 (AR5) model runs. Specifically, this involved obtaining the Climate Model Intercomparison Project-5 database (CMIP-5), a framework for coordinated climate change experiment comparisonwhere coupled atmosphere-ocean general circulation models allow the simulated climate to adjust to changes in climate forcing, such as increasing atmospheric carbon dioxide. CMIP-5 data was collected for 22 GCMs (see Table 5-1) for a region including Sudan. The availability of GCM outputs made it possible to examine global and regional climate predictions across dozens of GCMs and multiple realizations from each of those models.

The specific region for which CMIP-5 data was collected is shown in Figure 5-2. The region encompasses all of Sudan, portions of Ethiopia including the whole of the Blue Nile River Basin; as well as the Equatorial Lakes region, including the headwaters of the White Nile River Basin. The region extends just north of the border with Egypt.

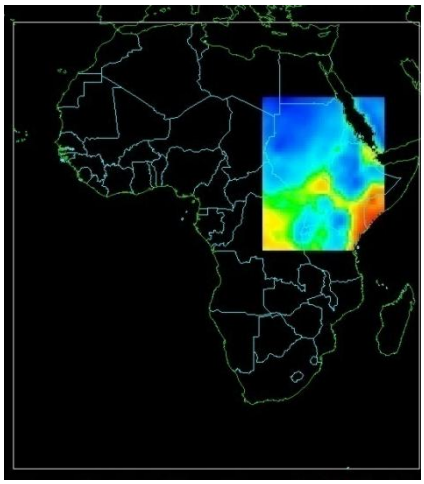
Representative Concentration Pathways (RCPs) were used to develop regional climatic scenarios. Unlike the IPCC's Fourth Assessment Report (AR4) where emissions scenarios were used *(*e.g., A1B, A2, B1), RCPs were used in AR5 and the accompanying CMIP-5 datasets. RCPs are four greenhouse gas concentration (not emissions) trajectories of four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs are RCP2.6, RCP4.5, RCP6, and RCP8.5. Each is named after a possible range of radiative forcing values in the year 2100 (2.6, 4.5, 6.0, and 8.5 W/m^2, respectively).

For future climate, statistical downscaling was used to take the CMIP-5regional data for the four RCPs and produce local scale climatic data at a 12-km spatial resolution. CMIP-5 data were downscaled using the Bias Correction and Spatial Disaggregation method (BCSD). This method was used to develop a monthly, gridded time series of CMIP-5 data for the period 1950 to 2100 for the entire region. The BCSD technique resamples a month of historical weather at a time, and was used to generate monthly 50 km grids of precipitation and minimum and maximum temperature over Sudan and portions of Ethiopia to encompass the source water of the Blue Nile River Basin.

Table 5-1: GCMs that were used in the assessment of regional climatic scenarios for Sudan

No.	GCM Name	Institution
1	ACCESS	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia), and BOM (Bureau of Meteorology, Australia)
2	BCC-CSM1	Beijing Climate Center, China Meteorological Administration
3	BNU-ESM	College of Global Change and Earth System Science, Beijing Normal University
4	CanESM2	Canadian Centre for Climate Modelling and Analysis
5	CCSM4	National Center for Atmospheric Research (USA)
6 7	CESM1-BGC CESM1-CAM5	National Science Foundation, Department of Energy, National Center for Atmospheric Research
8	CMCC-CM	Centro Euro-Mediterraneo per I Cambiamenti Climatici
9	CNRM-CM5	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique
10	CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence
11	EC-EARTH	EC-EARTH consortium
12	FGOALS-g2	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; and CESS, Tsinghua University
13	FIO-ESM	The First Institute of Oceanography, SOA, China
14 15 16	GFDL-CM3 GFDL-ESM2G GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory (National Oceanic and Atmospheric Administration (NOAA)/Office of Oceanic and Atmospheric Research) (USA)
17	GISS-E2-R	NASA Goddard Institute for Space Studies
18	HadCM3/GEM2	Meteorology Office Hadley Centre
19	IPSL-CM5A-LR	Institut Pierre-Simon Laplace
20	MIROC4h/5/E	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
21	MPI-ESM-LR/MR	Max Planck Institute for Meteorology (MPI-M)
22	NorESM1-ME/M	Norwegian Climate Centre

Figure 5-2: Area of focus for regional climatic projections



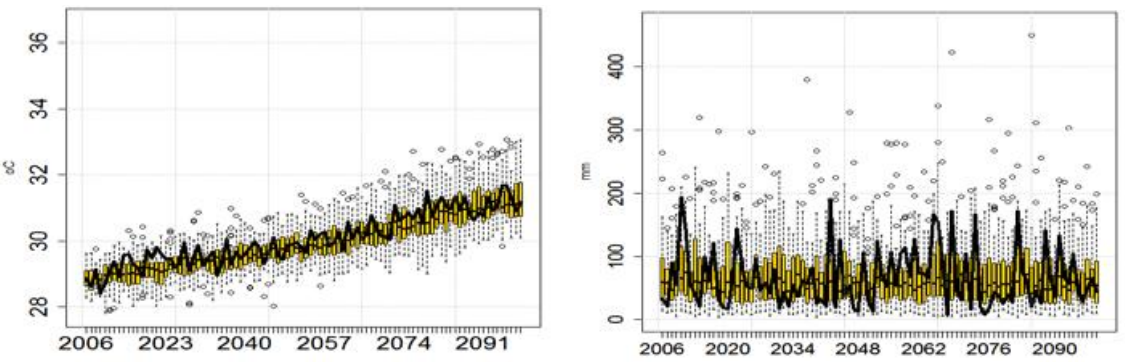
The final step in the regional scenario process was the development of a set of maps and charts that illustrate how climate change would unfold in Sudan. For each of the six stationsand 4 RCPs, the full dataset of downscaled projections from all 21 GCMs have been developed and plotted for annual average temperature and annual total precipitation for the period 2006 to 2100. A total number of 48 regional climatic projection charts have been developed, one for each combination of station, RCP, as well as both climatic indicators (i.e., temperature and precipitation).

As an example, Figure 5-3 provides results for Port Sudan station located near the Red Sea for RCP 6.0. The data are provided as box plots, with the yellow-colored portion of the plot representing the inter-quartile range of the projected change for each year. The extremes of the box plots are the 5% and 95% interval, while the marks represent outliers of individual models, which suggests some of the extreme conditions that some of the GCM project into the future. The dark line is the projected temperature and precipitation for one individual model (i.e., CCSM4).

As can be seen in Figure 5-3a, projected average annual changes in temperature clearly show substantial warming for the Port Sudan area, with the ensemble mean suggesting warming up to 3^{o}C by the year 2100. However, as can be seen in Figure 5-3b, projected changes in precipitation are more uncertain. The range of projected change in future precipitation in Port

Figure 5-3: Future projected annual average temperature and precipitation for Port Sudan

a) Temperature **b) Precipitation**



Sudan is quite wide, with the collection of GCM results showing both wetter and drier conditions depending upon the emission path and the GCM. Results for the other 5 stations throughout Sudan show similar results.

5.3 Improved observation networks

The development of a programme for improved observation networks was driven by the understanding within the NAP planning process that Sudan's current meteorological stations network is inadequate to keep pace with the unfolding circumstances regarding climate change. An assessment was needed to evaluate the adequacy of Sudan's current observation networks/systems, capacities, technologies and programmes to address medium and long-term climatic changes and their adequacy for supporting efforts to adapt to increased risks in the water, agriculture and health sectors. The capacity to undertake systematic observation of climatic change is important for Sudan because regional climatic modeling and vulnerability assessmentsrequire reliable data from a robust network of meteorological stations.

5.3.1 Objectives

The NAP process launched an effort to evaluate the current status of systematic observation in Sudan and identify measures and programmes to enhance future observations.Five objectives underline the assessment, as summarized in the bullets below. A technical report was produced that provides a detailed description of the assessment of observation network in Sudan (Ismail et al., 2013). The results of this report are synthesized in the paragraphs that follow.

- Support and further develop programmes and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation;
- Support efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses obtained from areas beyond national jurisdiction;
- To make an inventory and analyze potential gaps, barriers, constrains and short-comings) in the systematic observation system in Sudan Meteorological Authority (SMA);
- Propose achievable solutions, which can be translated into fundable projects to improve the adequacy of the systematic observation (e.g. reinforced and/or new component added, etc) to better response to need to address climate change adaptation in Sudan; and

- Propose sets of project ideas, policies and other recommendations on how to improve the adequacy of the systematic observation (e.g. reinforced and/or new component added, etc) to better response to need to address climate change adaptation in Sudan.

5.3.2 Key activities

This assessment activityinvestigated the current status of Sudan's climatic observation networks and developed recommendations for future enhancement. This has involved a number of key activities, as outlined in the bullets below

- *Conduct* an inventory of current status together with an inventory of ongoing efforts to improve observationnetwork capability;
- *Analyze* the adequacy and efficiency of current station network relative to the capability needed to adequately track climatic change; and
- *Propose*a set of recommendations for near-term and longer-term improvements to Sudanese capability in observations networks.

5.3.3 Approachand results

The overall approach to the assessment was to work closely with the Sudan Meteorological Authority in the inventory, analysis, and recommendation activities. The results of the analysis ofthe adequacy and efficiency of current station network relative to the capability needed to adequately track climatic change in Sudan identified several key issues, as summarized in the bullets below.

- *Gaps.* The current meteorological network has significant gaps in some areas and is silent in others.
- *Technical capacity.* Sudan capability to maintain existing stations is limited. Many capable engineers and technicians choose to work in other private sector institutions where salaries are higher. There is a shortage of well-trained staff that leads to an inability to maintain basic instruments.
- *Resources.* The SMA typically does not have the financial resources to sustain the operation of some equipment need for effective observation (e.g. telecommunication, upper air devices).
- *Security.*The rain-gauge stations network is hampered by insecurity in remote sparsely populated areas in the west of Sudan. Electricity is a problem in some parts of Sudan. In other parts, there is limited accessibility due to road conditions.

5.3.4 Priority Recommendations

In response to the inventory and key problems identified, the recommendations noted below are considered to be high priority items for improving the adequacy and efficiency of the station network.

- *Upgrade current Network Adequacy and Efficiency.*Install Automatic Weather Stations in areas with gaps or sparsely populated in order to ensure data availability; implement a maintenance programme to ensure data continuity; integrate silent stations into data gathering/reporting activities; Improve telecommunications taking into account available technology; install upper air stations in states of poor coverage (i.e., north Sudan).
- *Improve observation infrastructure***.** Urgently improve telecommunication and software

capability at key stations; Use AWSs at key stations; prioritize capacity strengthening, particularly at the technician level; One MW31 sounding system (GPS) radiosonde is recommended where possible; Upper air soundings from GPS and R&D satellites should be used when available.

- *Strengthen technical capacity*. Recruit and train meteorologists, engineers and technicians; take advantage of training programmes and study tours abroad to obtain more advanced or specialized training.
- *Enhance institutional coordination.* Operate network in collaboration with other governmental entities (e.g., rural postal offices, police stations, railway stations) and institutions (hydroelectric dam sites and rural irrigation schemes). Encourage SMA collaborate with other agencies including Ministries of Water Resources and Electricity, Agriculture, as well as with governmental research stations.
- *Develop cost-effectives approaches.*To partially overcome lack of resources, innovative cost-effective approaches should be pursued. These include local manufacture of equipment (e.g., Stevenson Screens, rain-gauges, evaporation pans and produce forms), as well as maintaining the existing Hydrogen Plot Gas Generator, as this will produce hydrogen for balloons as well as pure oxygen that can be offered for sale.

5.4 Enhanced National Research for climate change adaptation

National research programmes and networks are an essential component of building adaptive capacity and to better position Sudan to cope with climate change. Data and information from research and systematic observations are also essential for sustainable national development and for ensuring the effectiveness of national adaptation programs at all levels.

Enhanced research systems and capacity to understand climate phenomena could provide key benefits. Under climate change, managing resources is more important than ever and will require scientific information from integrated research systems to allow for assessing and understanding the causes and consequences of changes in natural and managed systems (e.g. water, agriculture, livelihood and infrastructure).

5.4.1 Objective and key activities

The objectiveof enhanced national research for climate change adaptationis twofold, namely to support and enhance networks already in place in Sudan as well as to develop long-term capacity for climate-related research and systematic observation.As part of the NAP process, a key activity was an assessment was undertaken of Sudan's current research networks/systems, protocols, capacities, technologies and programmes. The focus of the assessment was on theadequacy of these elements to address medium and long-term climatic changes in support of efforts to develop effective adaptation responses in the water and agriculture sectors, together with potential research gaps and needs (Elkhidir and Mekki, 2013). The results of the assessment are summarized in the paragraphs below.

5.4.2 Approach and results

An underlying premise of assessment was the set of emerging findings of the vulnerability assessments that were carried out within the NAP process. Specifically, the most significant climate change impacts facing the water and agricultural sectors are summarized in the bullets below.

- Low &increasingly irregular/erratic rainfall regimes,

- Very high water evaporation rates on open surface water bodies (*hafirs*, dams and irrigation canal systems).
- Aggravation of water supply-demand imbalances (i.e., concurrence of increasing water demandswith decreasing water availability.
- Increasing frequency of recurrent drought episodes and prolonged dry spells
- Reduction in the length of growing season due to due to increasing temperatures and undependable rainfall resulting in lower agricultural productivity
- Socio-economic impacts such as, food insecurity, social unrest and internal migration

For the agriculture sector, the key results of the assessment are summarized in Table 5-2. Going forward, theseresearch and innovation areas are intended to form the basis for developing a cross-cutting programme to inform adaptation planning and policies that can promote food security under climate change.

Table 5-2: Research gaps and innovation needs related for responding to impacts from climate variability and change in Sudan's agriculture sector

Climate change and variability and impacts on agriculture	Research gaps and innovation needs
• Increased temperatures in critical periods (heat stress); • Shorter and warmer winter season	▪ Drought/ heat tolerant crop varieties. ▪ Water Use efficiency. ▪ Farming practices (e.g. planting date). ▪ Alternative crops/varieties/ cropping patterns. ▪ Alley cropping/intercropping.
• Reduction in the length of growing season and period of crop growth (rainfed sector)	▪ Early maturing crop varieties. ▪ Farming practices. ▪ Precision agriculture.
• Increased moisture stress(length and/or intensity of drought spells)/ decreased seasonal precipitation (rainfed sector)	▪ Drought tolerant crop varieties. ▪ Alley cropping/intercropping. ▪ Farming practices to conserving soil moisture. ▪ Water harvesting/ rainfall interception and harvesting.
• Increased crop water requirement and irrigation water requirement, decreased water availability (irrigated sector)	▪ Water Use efficiency. ▪ Techniques for conserving soil moisture. ▪ Crop rotations. ▪ Water saving devices (efficient irrigation systems). ▪ Water requirement under different climatic change scenarios.
• Increased soils and ecosystems degradation, • carbon loss from dryland soils	▪ Soil and water conservation practices (conservation agriculture). ▪ Land management practices to greater carbon sequestration.
• Distribution, incidence and severity of insect pests, diseases and weeds(increased pests pressure)	▪ Varieties and species resistant to pests and diseases. ▪ Pest, disease, and weed suppression management options (IPM). ▪ Early warning information systems.
• Shift of the current production systems zones	▪ Predicted shift in agro-ecological zonation based on recent and future climatic scenarios.
• Increase in carbon dioxide concentration in the atmosphere	▪ Alternative crops/varieties/ cropping patterns more suitable to CO_2 levels change. ▪ Major implications to elevated CO_2 on crop productivity and the growth and composition of natural plant communities. ▪ Effects of increases in carbon dioxide on crop/weed and crop/disease, insect pest interactions.
• Socio-economic impact and climate change policy research	▪ Economic and social vulnerability due to climate and environmental change. ▪ Potential resilience mechanisms to climate stress. ▪ The role of forecast based -farming in reducing vulnerability and climatic risks.

For water resources, the key results of the assessment are summarized in the bullets below. Going forward, these innovation initiatives and options are considered priority research areas that are intended to be within a cross-cutting programme to inform adaptation planning and policies for water resource management.

- *Climate models:*A number of research initiatives can be based on development and application of climate models, which are likely to be of great value to national adaptation planning on issues such as the potential of regions, the likelihood of crop failure, or the probability that new species or crop cultivars will succeed.
- *Ground water-related research:*In surface water scarcity area, groundwater reserve can represent an alternative option to reduce vulnerability to drought and give the country a better position to cope with the harsh climatic conditions. Groundwater development offers major opportunities for communities to withstand the major cause of their vulnerability and less resilient and adaptive capacity through crop, vegetable and animal production for food and income generation and improved livelihoods of increased water supply for domestic and health hygiene.
- *Reducing evaporation from water surfaces:* No economical method exists for reducing evaporation from large, multipurpose reservoirs; research in this area is desperately needed. Extended field trials are needed to test the practicality of the floating covers, such as expanded-polystyrene rafts or wax layers on water reservoirs. Research is needed to overcome the mechanical difficulties of stabilizing evaporation-control system on water surfaces subject to wind, wave, and current. It is likely that some radically different approaches to evaporation control await discovery; research into novel methods is encouraged. The sand storage dam is a technology that needs field testing in many arid areas. Research is needed into rational design, e.g. for the height of stages in relation to the extent of the catchment.
- *Reducing Seepage losses:* There is a major need for widespread field trials, particular in arid parts and water-scarcity areas, to test and compare the effectiveness of different systems of seepage control and consider the economics of their application.
- *Reducing evaporation from soil surface:* Mulching with rock, gravel, sand and crop residues are poplar methods for conserving soil moisture, nevertheless, their potential today in Sudan is not fully appreciated. Minimum tillage agriculture, which leaves crop-standing stubbles and with minimum soil disturbing has only recently been widely appreciated as a desirable conservation practices. The main needed is to develop mulches specifically for arid areas, particularly mulches that maximize the use of local resources.
- *Research on sedimentation:* This can include a research approach of trans-boundary nature, such as collaboration with Ethiopian authorities and other Nile riparian countries in dealing with source of runoff where occurs. Typical research themes may include issues such as watershed management through conservation aspects to control surface erosion.
- *Research on optimization of crop water requirements:* For a better understanding of changing climactic factors and their interrelationship which influences the water demand of a specific crop, the research needs may include issues such as determination of crop water requirements for various field crops, using reliable input climatic data, develop and modeling e.g. soil-plant-air-water and test irrigation systems based on optimized crop water requirements to establish water use volumes for improved irrigation development

5.4.3 *Priority recommendations*

In response to the above inventory of impacts, research gaps, and key innovations, the recommendations noted below are considered to be high priority items that offer tangible benefits for enhancing climate change adaptation research in Sudan.

- Strengthen global institutions such as the Consortium of International Agricultural Research Centers (CIARC) and regional such as Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) cooperation with national research organizations for effective exchange of knowledge and experience among the scientists to deal with the issues related to climate.
- Build institutional partnerships and effectivecoordination among research groups, institutions and organizations working on different aspects of climate change and development of agricultural and water sectors.
- Develop a multi-disciplinary climate change research team including natural science,agronomy, climatologists and socio-economics researchers for climate change and variability impact assessment studies.
- Support and establish systems of innovation to promote development and transfer of technologies[4] for adaptation to enhance the resilience of the agriculture and water sectors to climate change.
- Assessand document existing indigenous knowledge and options to overcome climate vulnerabilities, and amalgamation of climate-friendly agriculture technologies with the rich indigenous knowledge and practices to enhance resilience.
- Advance agro-meteorological research so as to get required information about weather events and seasonal forecasting of weather and establish early warning systems to collect and communicate weather data in a timely manner.
- Support information-sharing and data networking on climate change throughout the country while ensuring researchers needing data have adequate access to such data.
- Promote climate-friendly agriculture through strengthening extensions services and integrate with agricultural research institutions to build the capacity of farmers through climate field schools, videos, radio, seminars, training, field days and field demonstrations.

5.5 Vulnerability hotspot mapping

The incorporation into the Sudan NAP process of vulnerability hotspot mapping was driven by the view that such maps are useful in visually representing the vulnerability of a particular region, sector or system to climate change. Understanding the nature and characteristics of this vulnerability is one of the most important steps toward efforts to minimize impacts. Ultimately,*vulnerability* translates a *natural hazard* into *risk*. Thus, high vulnerability typically means high risk, and low vulnerability is usually associated with low risk, depending on the

[4] Technologies for adaptation to reduce the negative impact of Climate change in Sudan may include, early maturing and Heat tolerant varieties, integrated Pest Management (IPM), cultural practices such as seed priming and fertilizers micro-dosing, mulching, sowing dates, alley cropping, water harvesting such as water saving devices, water harvesting techniques, *Hafir* construction, etc

magnitude of the hazard in question. Importantly, while anthropogenic activities do influence hazards, policy changes are likely to have a more immediate effect on vulnerability.

The capacity to develop climate change vulnerability hotspot maps is important for Sudan because such maps indicate potential areas of *high* climate change vulnerability or risk. This can be a useful tool for policymakers to prioritize areas in which to invest in adaptation, conduct further research, and/orcarry out other efforts to reduce exposure and sensitivity to climate variability and change. At the time the NAP process was undertaken, no vulnerability hotspot mapping programme had yet been developed in Sudan, although the analytical tools (i.e., GIS) and skills (vulnerability indicator development) were readily available among certain members of scientific and planning communities. For this reason, pre-NAP groundwork activities identified the development of vulnerability hotspot maps as an essential input to improve an understanding of the nature and characteristics of vulnerability, one of the most important steps toward subsequent efforts to minimize the adverse impacts of climate change.

5.5.1 Objectives

The NAP process launched an effort to build capacity to integrating available information into a map or series of maps of spatially disaggregated vulnerability indices that convey areas of very high, high, moderate and low vulnerability by sector, by geography, or by hazard. Five objectives underline the initiative, as summarized in the bullets below. A technical report was produced that provides a detailed description of a systematic approach to be used for developing vulnerability hotspot maps (Nuh, et al, 2013). The results of this report are synthesized in the paragraphs that follow.

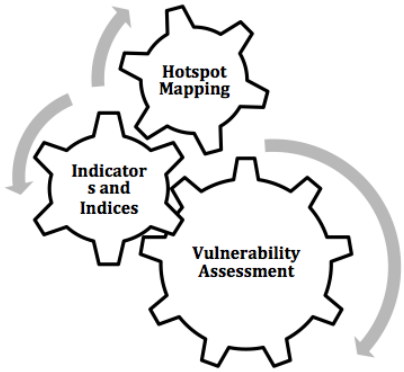
- *Build technical capacity:* This involved establishing a collaborative relationship between Sudanese scientists/planners and international experts, as well as the convening of on-site and remote capacity strengthening programme.
- *Establish the framework:*This involved identifying the range of key questions,policies, audiences, and decisions that the information contained in hotspot maps can help address or resolve.
- *Develop indicators:* This involved the development of a suitable set of vulnerability indices appropriate for Sudanese conditions. Issue of scale of analysis, aspects of vulnerability they cover, and limitations for their use.
- *Conduct analysis:* This involved the transformation of vulnerability indices, which were qualitative in nature, into a quantitative format for use as inputs for mapping.
- *Develop hotspot maps:*The final objective was to develop hotspot maps using GIS software to convey information about vulnerability in an actionable way for adaptation planning.

5.5.2 Key activities

The development of hotspot mapping capability is considered essential for influencing decision-maker audiences. Given the accumulated knowledge developed in the state- and sector-level vulnerability assessments, hotspot mapping was viewed as being able to capitalize on this emerging knowledge to begin to spatially disaggregatevulnerabilitiesin order to identify regional priorities for adaptation.Overall, there were three key activities emphasized in hotspot mapping activities, as illustrated in Figure 5-4, and summarized in the bullets below.

- *Vulnerability Assessments*lay the foundation for understanding Sudan's vulnerability to climate change.
- *Indicators and Indices* are needed in order to transfer vulnerability information into key vulnerability determinants that can then inform the identification of hotspots.
- *Hotspot Mapping*itself involves integrating the information generated in the previous two activities into a map or series of maps of spatially disaggregated vulnerability indices that convey areas of very high, high, moderate and low vulnerability by sector, by geography, or by hazard.

Figure 5-4: Key activities associated with Hotspot Mapping



The NAP process has developed a programme to identify vulnerability "hotspots" in Sudan that accounts for existing knowledge and understanding of vulnerability to spatially disaggregate vulnerabilities in order to identify priorities for adaptation.Training activities have been implemented to strengthen national capacity for developing systematic state-level hotspotmaps.

5.5.3 Approachand results

The overall approach to developing hotspot maps consisted of several major steps. These included defining the vulnerability focus; obtaining the needed data; developing a limited set of vulnerability indicators, and producing a series of hotspot maps. Each of these steps is briefly summarized in the paragraphs that follow.

The focus of the effort was on the exposure and sensitivity of key climatic hazards, key communities, and key sectors. That is, to a great extent, the intent was to develop as broad a framework as possible by which to identify potential hotspots. In this way, it was possible to combine developmental, social, institutional, and other factors (e.g., extreme poverty, illiteracy, etc.) that make social groups or systems exposed and susceptible to multiple risks. As a working framework, climatic hazards were limited to droughts and floods; key communities were limited to traditional rainfed farmers and transhumant communities; key sectors were limited to agricultural, water resources, and public health.

Obtaining the needed data to identify a vulnerability hotspot map was a time- and labor-intensive process that was launched during the NAP process. The initial step consisted of identifying the type of data needed subject to three criteria, namely they were of reliable quality; could be obtained at national, regional, and local scales; and could be characterized by information/data typically assembled in the course of a vulnerability assessment. A total of 7 key factors were identified as necessary to inform data collection for the subsequent development of vulnerability hotspot maps, as outlined below.

- *Magnitude of impacts:* This was be characterized by data on the number of people affected (scale) or degree of damage caused (intensity)
- *Timing of impacts:* This was characterized by data on the expectation of the impact happening sooner rather than in the distant future (e.g., drought-affected areas)
- *Persistence and reversibility of impacts:* This was characterized by data on the emergence of near-permanent drought conditions or intensified cycles of extreme flooding that were

previously regarded as anomalous events, or by changes in regional or global biogeochemical cycles and land cover, species extinction.

- *Likelihood of impacts and vulnerabilities, and confidence in those estimates:* This was characterized by data on the probability of occurrence (e.g., the higher the probability of occurrence of an impact, the higher its risk)
- *Potential for adaptation:* This was characterized by data on the availability and feasibility of effective adaptation, or low capacity to adapt of individuals, groups, and nature
- *Distributional aspects of impacts and vulnerabilities:* This was characterized by data on vulnerabilities that are highly heterogeneous or which have significant distributional consequences across regions and population groups e.g. income, gender, and age.
- *Importance of the system(s) at risk:* This was characterized by data on the differences in values on the significance of impacts and vulnerabilities on human and natural systems influence the importance of different vulnerabilities

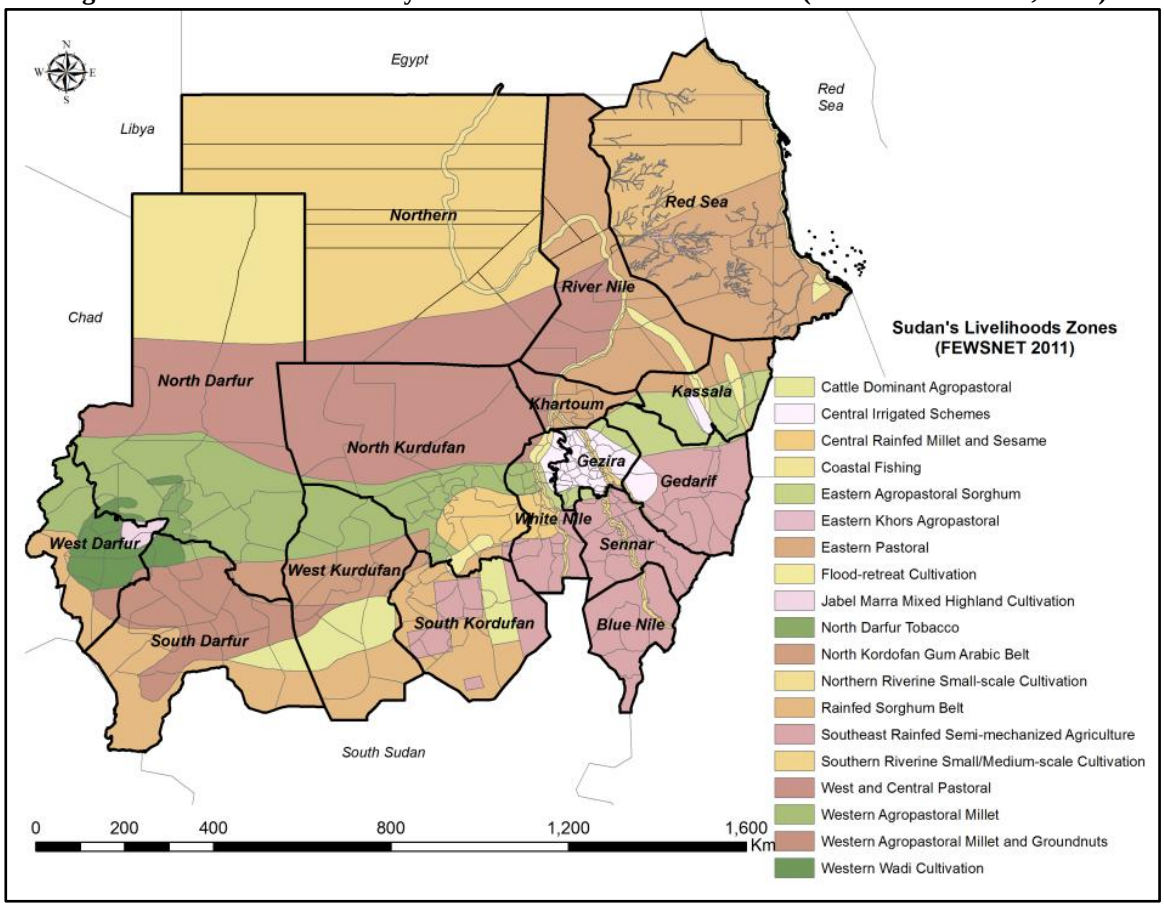
The development of vulnerability indices is the next step in the process. This has first involved the identification and quantification of vulnerability indicators as proxies for vulnerability which itself cannot be directly measured or observed. These indicators are then being aggregated into a series of vulnerability indices to facilitate an examination of vulnerability across exposure, sensitivity and adaptive capacity. This process focuses on portraying relative vulnerability (e.g. between places or over time) in the absence of any detailed vulnerability assessments emerging from the use of outputs from the regional climatic scenarios described previously.

5.5.4 Key recommendations

The following bullets represent the key recommendations regarding the future development of vulnerability hotspot mapping in Sudan:

- *Be data-driven:* Data availability and quality is a major issue in Sudan. It should be addressed by focusing on data credibility rather than data volume or precision in measurement; and avoiding selecting too many indicators with their accompanying data demands.
- *Understand scaledependency:* Understanding climate change vulnerability at the community level is a key priority in Sudan. The emphasis is on the development of indices based on smaller scales of analysis as these better reflect the reality of vulnerability than larger, comparative scales, which can diminish their relevance.
- *Develop context-sensitive indices:* The development of vulnerability indices that are highly linked to local development contexts is the desired outcome of this step of the hotspot mapping process. The required integration of physical and social variables should involve the collective inputs of a range of experts in Sudan in order to develop context-sensitive vulnerability indices.
- *Construct vulnerability hotspot maps:* In Sudan, maps are widely used as powerful information communication tools. GIS software should be used to create maps from various inputs of data layers, including the vulnerability indices. Such maps enable visualizations of the spatial components of these layers; making information on climate risks more understandable and actionable for planners and administrators. Figure 5-5 provides an example of the types of maps being prepared, showing livelihood zones by district in Sudan

Figure 5-5: Livelihood zones by administrative districts in Sudan (source: FEWSNET, 2011)



5.6 Adaptation investment and financial flows

An understanding within the NAP planning process that the costing of adaptation options is currently limited drove the development of a capability for rigorous analysis of adaptation investment and financial flows. For the purpose of this assessment activity, *investment flows* were defined as the capital costs of a new physical asset with a life of more than one year, such as the capital cost of a new agricultural irrigation system. Investment flows are limited to new physical assets as such investments have climate change implications for the duration of the operating lives of the facilities and equipment purchased. *Financial flows*, on the other hand were defined as ongoing expenditures on programmatic measures. Financial flows encompass expenditures other than those for expansion or installation of new physical assets.

The capacity to assess the future financial cost of adaptation to climate change is important for Sudan because such efforts can lead to morecost effective future choices regarding climate change adaptation options and strategies. Moreover, the analysis of investment and financial flows to address climate change can assist policymakers to prioritize areas in which to invest in adaptation and rule out adaptation responses that are inconsistent with national priorities or circumstances. At the time the NAP process was undertaken, no financial analysis protocols or systematic processes had yet been developed for adaptation in Sudan, although the economic analysis skills were readily available among certain members of the financial and academic community. For this reason, pre-NAP groundwork activities identified the analysis of adaptation investment and financial flows as an essential input to future adaptation planning.

5.6.1 Objectives

The NAP process launched an effort to build capacity to analyze adaptation investment and financial flows for potential adaptation strategies in the agriculture, water resource and public health sectors. Four objectives underline the initiative, as summarized in the bullets below. A technical report was produced that provides a detailed description of a systematic approach to be used for developing vulnerability hotspot maps (Mohamed, et al, 2013). The results of this report are synthesized in the paragraphs that follow.

- *Build technical capacity:* This involved establishing a collaborative relationship between Sudanese economic analysts and international experts, as well as the convening of on-site and remote capacity strengthening programme.
- *Understand available methods and tools:* This involved identifying the range of terminology, costs parameters, data requirements and analytical approaches required to undertake an analysis of adaptation investments and financial flows.
- *Undertake a financial assessment of adaptation strategies:* This involved the application of financial analysis methods and tools to assess the cost effectiveness of a range of adaptation options for the vulnerability hotspots identified through previous hotspot mapping efforts.
- *Make recommendations:* The final objective was to propose a set of recommendations for developing a programme for the systematic evaluation of adaptation strategies in a way that keeps pace with emerging vulnerability hotspot information at the community, sector, and system levels.

5.6.2 Key activities

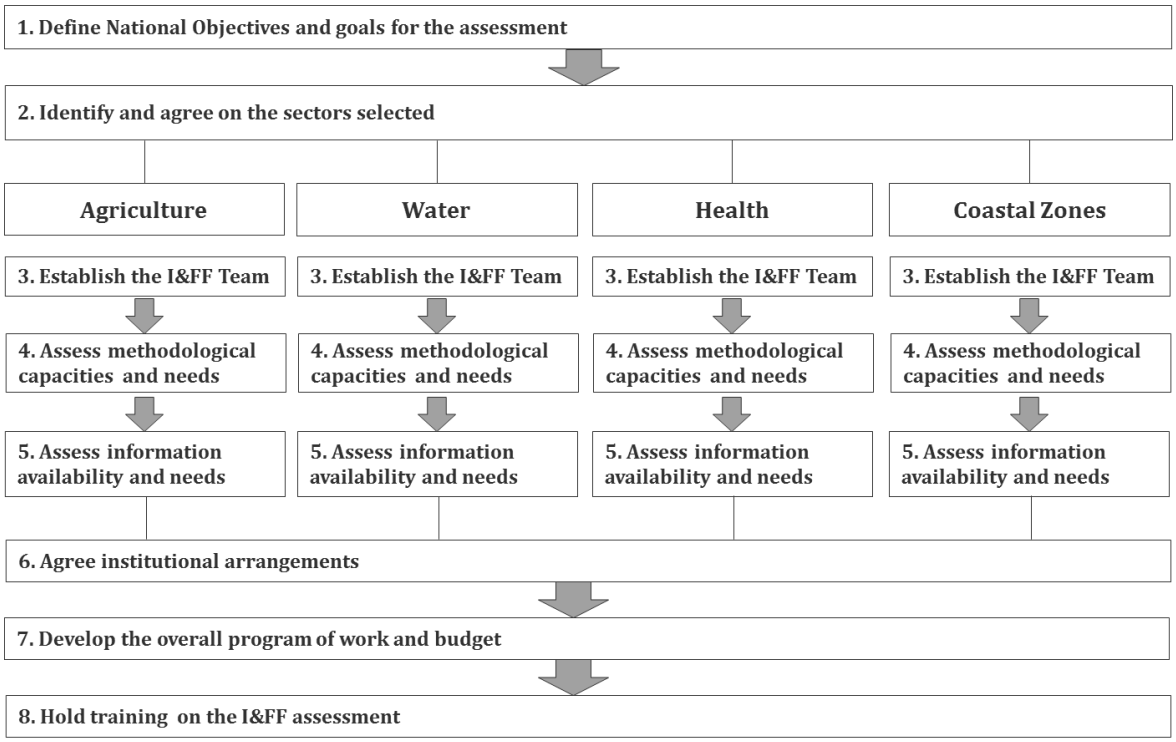
The major activity of this assessment is the development of use of *scenarios*. As generally understood, a scenario is an internally consistent and plausible characterization of future conditions over some specified time period. In order to undertake a policy-relevant assessment of adaptation investment and financial flows on the basis of the results of the state/sectoral assessments and the vulnerability hotspot mapping, it was important to construct two internally consistent scenarios for Sudan for each of the three priority sectors, as outlined below.

- The *Baseline Scenario* is a reflection of business-as-usual conditions (i.e., it is a description of what is likely to occur in the absence of new policies at the state and/or sectoral level in Sudan to address climate change).
- The *Adaptation scenario* is a reflection of conditions resulting from the implementation of adaptation strategies and measures at the state and/or sectoral level in Sudan to address climate change (i.e., it is a description of what is likely to occur with new policies to address climate change).

5.6.3 Approach and results

The overall approach to undertaking an assessment of adaptation investment and financial flows consisted of several major steps. These included defining the adaptation investment focus; obtaining the needed cost and performance data; and conducting the financial assessment itself. Each of these steps is briefly summarized in the paragraphs that follow. A further breakdown of these major steps into a sequence of the various specific activities involved is illustrated in Figure 5-6.

Figure 5-6: Specific activities for the Sudan adaptation investment and financial flow assessment



Defining the adaptation investment focus involved both substantive and practical considerations. At the substantive level, it was recognized that an analysis of a large number of potential adaptation options was desirable would provide decision makers with specific information needed to design climate-sensitive financial planning around domestic investment arrangements and/or determine the additional capital needed from international donors to address climate change. At the practical level, it was recognized that capacity would first need to be built and extensive experience gained before the results of investment and financial flow analysis could be expected to influence national planning decisions regarding adaptation investments. For these reasons, the adaptation investment focus was limited to a number of options in the agriculture sector.

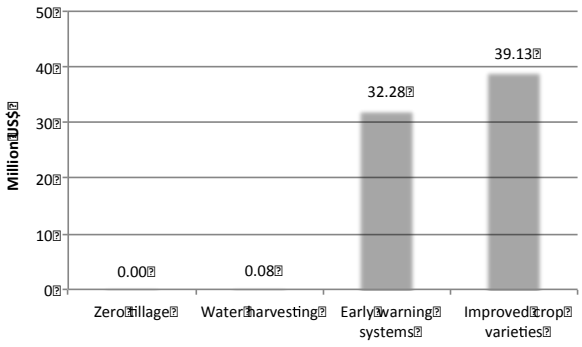
Obtaining the needed cost and performance data is very important for populating the analytical tool to be used with accurate numerical information. The data required consisted of historical annual data for investment flows (IF), financial flows (FF) disaggregated by investment entity and source, operation and maintenance costs (O&M) and subsidies based on the assessment period. Historical data allows for the identification of investment patterns not only by the public sector but also by the private sector. It was important that data are available for the Base Year of the analysis (assumed to be 2010) and at least two years prior. Historical data collection of ten years before the base year, although ideal, is not expected to be readily available for sectors other than agriculture.

Data sources were identified at the national level, sectoral level, and by subsector or investment entity based on the data needed. For some options, actual O&M cost data was not available but was estimated based on data from other countries and adjusted to Sudanese production and consumption rates. In other cases, proportional relationships between O&M costs and total costs or capital costs were used to estimate O&M costs. Finally, data on subsidies was also collected as available. For the purpose of the I&FF analysis, subsidies were defined as financial assistance given by national or state governments for the support or development of another party.

At the sectoral level, conducting the analysis involved the development of baseline and adaptation scenarios and comparing the incremental costs associated with the adaptation scenario. However, at the current stage of implementation in Sudan, the investment and financial flow analysis was focused at the technology level. Specifically, four potential adaptation options in the agriculture sector were considered, each of which is briefly described in the bullets below.

- *Zero tillage:* is a way of growing crops from year to year without disturbing the soil through tillage. Given potential water shortages from climate change, zero tillage can increase the amount of water and organic matter in the soil. The technique can also help to reduce erosion and increase biodiversity.
- *Water harvesting:* Most rainfed areas in Sudan are not in close proximity to rivers, and depend solely on rainfall for crops and animals. With frequent drought and high evaporation rates - conditions that are expected to worsen with climate - change - water harvesting technologies are increasingly viewed as essential to sustain rural livelihoods in Sudan.
- *Early warning systems:* This is an information communication systemthat consists of various sensor and detection subsystems working in conjunction to forecast and signalclimatic disturbances; thereby providing sufficient time in advance for implementing response actions aimed at minimizing the adverse impact.
- *Improved crop varieties:* Improved crop varieties are typically genetically engineered seeds that are designed to overcome the major challenges posed by climate change, namely reduced and/or unpredictable rainfall patterns or increased prevalence of pests.

Figure 5-7: Investment and financial flow results for agricultural adaptation options (Ali, 2013)



The results of the analysis of investment and financial flows for each of the options are presented in Figure 5-7, based on an analysis by Ali (2013). The results are distinguished by the large differences in the net present value of the investment and financial flows for each adaptation option. For example, the zero tillage option (US$ 0.0002 million) consists mostly of the introduction of new practices with very little capital investment, while early warning systems (US$ 32.3 million) represent the installation and maintenance of state-of-the-art information and sensor technology. It is important to note that each option shows a positive net present value indicating that the benefits of the measure exceed the expected costs. Finally, from a planning perspective, the analysis is useful in highlighting the high of the financial benefits associated with improved seed varieties and early warning systems.

5.6.4 Key recommendations

The key recommendation is focused on building capacity for the analysis of adaptation financial flows for adaptation projects and initiatives. This need cuts across all vulnerable sectors in Sudan. This involves capacity building in human resources development, institutions, methodologies, technology and equipment, and information and networking. In particular, this would involve focusing capacity-building efforts to aid stakeholders in the identification and use of specialized tools for planning and implementing adaptation activities.

5.7 Climate-proofing

The incorporation into the Sudan NAP process of climate proofing was driven by the view that such efforts are needed to ensure that current and future development projects integrate climate change consideration into their design. Specifically, to *climate proof* a project means to identify risks to the project as consequence of climate change/variability and ensuring that those identified risks are reduced to acceptable levels through environmentally sound, economically viable, and socially acceptable changes. While climate proofing often refers to the protection of *existing* projects and programs; the approach used in the NAP process was to extend the concept to include planning of *future* projects.

The capacity to climate proof existing and new development projects is important for Sudan because such efforts can help to ensure that future effectiveness under conditions of climate change. Moreover, climate proofing is considered a key action amid other actions that will contribute to the mainstreaming adaptation concerns in Sudan's planning and policy dialogues. At the time the NAP process was undertaken, no protocols or systematic processes had yet been developed for climate proofing in Sudan, although the project appraisal and other skills were readily available among certain members of the scientific community. For this reason, pre-NAP groundwork activities identified methods and tools for climate proofing as an integral input for future project development initiatives.

5.7.1 Objectives

The NAP process launched an effort to build capacity for climate proofing development projects. Three objectives underline the initiative, as summarized in the bullets below. A technical report was produced that provides a detailed description of a systematic approach to be used for climate proofing development projects for cotton and wheat production (Sanjak, 2013). The results of this report are synthesized in the paragraphs that follow.

- *Build technical capacity:* This involved establishing a collaborative relationship between Sudanese engineers/planners and international experts, as well as the convening of on-site and remote capacity strengthening programme.
- *Establish the framework:* This involved identifying the range of potential climate proofing toolkits and selecting the approach that is most suitable for application under Sudanese conditions.
- *Conduct assessment for cotton and wheat production:* This involved the application of the climate proofing framework to two specific development projects in the agricultural sector, namely the Elrahad Agricultural Scheme for cotton production and several small/large schemes in Sudan where wheat production is practiced.

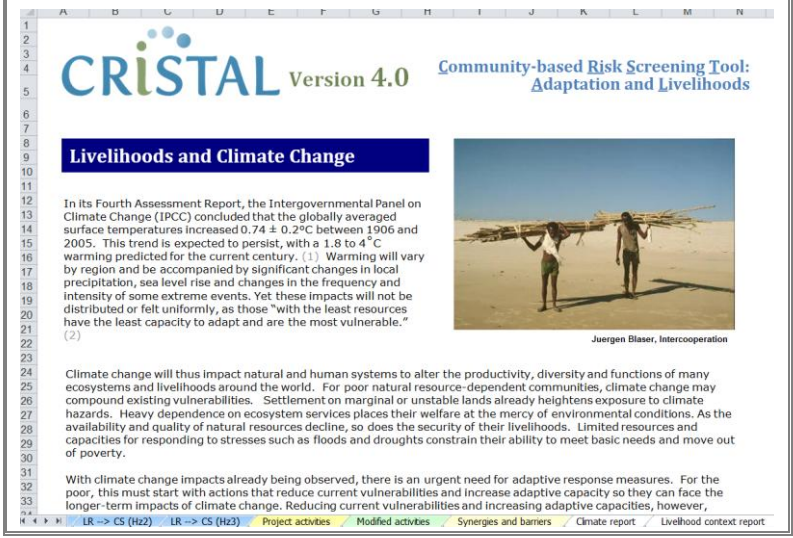
5.7.2 Key activities

The major activity of this assessment is the identification and use of a suitable framework for climate proofing. In the last decade, several guidance documents and toolkits to aid in climate proofing have been developed by well-known institutional actors:ADB (2005) *Climate Proofing*, the Red Cross and Red Crescent Society's *Climate Guide* (2007), USAID's guidance manual for development planning (2007), CARE (2010), the OECD *Policy Guidance* on climate adaptation (2009)and the subsequent GIZ (2010; 2011) *Integrating climate change adaptation into development planning*, which are among the suite of adaptation related tool kits reviewed by Hammill and Tanner (2011) and currently under review by UNEP's programme of research

on vulnerability, impacts and adaptation (PROVIA 2012). These resources were first evaluated as a basis to define realistic NAP objectives concerning climate proofing.

One tool consistently mentioned by other institutions' tool reviews and continually suggested as a complement to the tool's designed by those institutions for their own operations is *CRiSTAL* (Community-based Risk Screening Tool – Adaptation and Livelihoods).*CRiSTAL*is a project planning and management tool (see Figure 5-8) that helps users to integrate risk reduction and climate change adaptation into their *community-level work* (IISD 2011). CRiSTAL enables users to analyze the links between climate risks, livelihoods and development projects and recently, has been adapted to analyze these same linkages in agriculture value chains. It provides a logical, user-friendly process to help users better understand the links between climate-related risks, people's livelihoods, and project activities. Unlike other tools, CRiSTAL is not explicitly tied to an institution's project cycle or development process and was designed with a broad audience and user-base in mind. Between 2007 and 2012, CRiSTAL has been applied in over 20 countries in the developing world.

Figure 5-8: CRiSTAL Background Page and Navigation tabs



For these reasons, CRiSTAL was selected as the framework for undertaking climate proofing efforts in Sudan. At the time of the NAP process, only initial training on the tool had been carried out. Therefore, for the purpose of climate proofing cotton and wheat development projects, the organizing framework of CRiSTAL was applied using a simplified approach. The remainder of this section provides a summary of the results of the climate proofing assessment.

5.7.3 *Approach and results*

The overall approach to climate proofing consisted of several major steps, framed within climate proofing toolkits available. Climate proofing for cotton focused on the Elrahad Agricultural Scheme. This is a large irrigated scheme of 126,000 hectares established in 1977 by the Rahad Agricultural Corporation. The main objectives of the Rahad scheme were to increase the export value of medium stable cotton and groundnuts, to increase quantity and quality and value of domestically consumed crops, to provide employment for national agricultural labor and improve the welfare of the population in the area. The productivity of crops in irrigated agricultural sub-sector is low and fluctuating due to low producer prices, lack of foreign currency and import regulations which have limited the availability of vital production inputs and spare parts.

Cotton is especially adapted to semi-arid and arid environments, where it is either grown rain-fed or through irrigation. It is fairly resilient to high temperatures and drought. The crop is, however, sensitive to water availability, particularly at the height of flowering and boll formation. Rising temperatures favor cotton plant development, unless day temperatures exceed 32º C. Limited increases in atmospheric CO_2 also favor the cotton plant's development.

However, cotton has limited capacity to respond to future heat stress associated with climate change, and production levels are likely to be seriously adversely impacted in coming years. The climate proofing assessment of cotton production has yielded the following recommendations:

- *Adopt new techniques:* These include soil conservation, the use of organic fertilizer, improved crop monitoring, diversification of cotton seed varieties by introducing heat-resistant cotton varieties while supporting an enabling environment for their development, and enhanced pest control
- *Improve natural resource management:* This involves protection of drainage basins, strengthening adaptive capacity, and adopting canal side plantations to prevent crop damage during droughts.
- *Improve irrigation efficiency:* This involves the rehabilitation of the current system, promoting integrated water resource management through new codes, improving drainage conditions, and introducing high efficiency irrigation technologies (e.g., center pivot sprinklers).

Climate proofing for wheat was broadly focused on several areas in Sudan where wheat production is prevalent. The climate proofing initial assessment of wheat production has yielded some recommendations such as:

- Establishment of shelterbelts and tree planting along the canal sides through enforcement of forest laws and policies which emphasize the allocation of 10% of rain fed agricultural schemes and 5% of irrigated schemes for tree planting. These could ameliorate the microclimate and reduce higher temperature effects and enhance wheat production.
- Intensification of capacity building focusing on implementation of best agricultural practices and techniques, environmental measures, and diversification of crops. Strengthen farmers local organization and networks, and improve marketing. Awareness raising among farmers, all actors to actively engage them in the long process of strategic planning and institutional arrangements
- Provisions of timely agro-climatic information to farmers including information on temperature forecast, irrigation intervals, the likelihood of outbreaks of best and diseases to reduce the negative impacts on wheat production.
- Provisions of suitable technologies and know-how especially proven technologies that have been tested in other similar locations could be easily adopted and replicated.
- Research focusing on producing improved varieties such as disease-resistant, high-yield, heat tolerant, early maturing varieties to cope with high temperature and reduced length of growing season because of climate change. Also research on the best cultivation practices such as sowing dates of wheat, minimizing soil tillage, irrigation, etc.

5.7.4 Key recommendations

The key recommendation is focused on building capacity for climate proofing of existing and future planned adaptation projects and initiatives. This need cuts across all vulnerable sectors in Sudan. This involves capacity building in human resources development, institutions, methodologies, technology and equipment, and information and networking. In particular, this would involve focusing capacity-building efforts to aid stakeholders in the identification and use of specialized tools for planning and implementing adaptation activities.

6 Implementation strategy

The UNFCCC Cancun Adaptation Framework calls upon all Parties to the UNFCCC to enhance action on adaptation by undertaking, planning, prioritizing and implementing adaptation actions, including projects and programmes. The same decision established the NAP process to enable least developed country Parties to formulate and implement national adaptation plans, building upon their experience in preparing and implementing national adaptation programmes of action, as a means of identifying medium and long-term adaptation needs and developing and implementing strategies and programmes to address those needs.

The Cancun Framework also stipulates that enhance actions on adaptation require impact, vulnerability and adaptation assessments, including assessments of financial needs as well as economic, social and environmental evaluation of adaptation options. It also requires strengthening institutional capacities and enabling environments, enhancing climate change related disaster risk reduction strategies, measures to enhance understanding, coordination and cooperation with regard to climate change induced displacement, migration and planned relocation, where appropriate, at national, regional and international levels. Also there is a need to improving climate-related systematic observation, research, transfer of technologies and capacity-building for adaptation.

The Sudan's NAP process initiated work on most of these elements of the Cancun Adaptation Framework. It is clear that NAP concept was conceived asa dynamic process which would evolve over time in response to new and emerging scientific knowledge and information on impacts, vulnerability and adaptation. Therefore, the implementation of the NAP process in Sudan should be periodically evaluated to assess progress made, effectiveness of adaptation measures, and the identification of critical knowledge gaps. In addition, periodic evaluation(e.g., every five years) will help to integrate new scientific data and experiences in updated NAP documents.

6.1 Establish a working framework for NAP implementation

There are two main aspects of the framework for implementing NAP recommendations in Sudan. First, coordination activities are organized around both federal-level and state-level functions. At the national level, this NAP document provides an overview of the whole process, including the framework, approach, syntheses of the state vulnerability & adaptation assessments, enabling environment, programmes, policies and implementation strategy. At the state level, each of the eighteen (18) states produced state adaptation plans (SAPs)in Arabic language. These SAPs contain details of the adaptation programmes and activities that build off the national NAP process and endorsed by the respective State's governments. These documents are the basis for adaptation planning, implementation, integration into development process at all levels, outreach and fund raising as well as for monitoring and evaluation and future updates of the NAP.

The establishment of state NAP institutions is the other fundamental aspect of the NAP implementation strategy in Sudan. This was undertaken in direct response to the requirement of Cancun Adaptation Framework of the UNFCCC (2010) that requires developing countries to strengthen institutional capacities and enabling environments for adaptation, including for climate-resilient development and vulnerability reduction. The establishment of these institutions is highly aligned with Sudan's national objective of strengthening the framework for environmental action in all the States. This institutional network is also vital for effective coordination on planning and implementation of the general policies, strategies, plans of

environmental protection and sustainable development. The state institutions constitute the main modality for the planning, implementation and integration of the NAP programmes and measures as well as the monitoring and evaluation and future updates of the NAP.

The implementation of the strategies and initiatives described in the previous sections spans a number of key themes across project-level and programmatic themes. A synthesis of the main implementation themes from the state-level assessments and other activities is provided in the subsections below.

6.2 Integrate adaptation programme into state-level policymaking

As a result of the state-level assessments and enabling environment activities, specific and high-priority adaptation policies and measures have been identified. These are provided in Table 6-1 through 6-5, each table contains priority adaptation programmes, policies and measures of a group of States have some similarly in terms of socioeconomic and environmental conditions, livelihoods, sharing resources, etc (Darfur, Kordofan, Central, Eastren and Nile states). The initiatives represent the outcomes of the NAP consensus-building process and the join work of the teams of experts from all the States and it has been accepted to be the policy basis for future adaptation actions in Sudan. Detailed information on the states adaptation policies, programmes, projects in addition to other measures such as institutional issues are provided in the Annex to this document.

The integration of these measures is already started to take place in Sudan as a result of the establishment of NAP-driven adaptation units within state-level environment or agricultural ministries. The immediate next implementation steps (up to 2017) to ensure the dissemination of NAP recommendations are summarized below:

- To ensure the official incorporation of all the NAP-driven adaptation units within all state-level environment or agricultural ministries. This will serve to codify NAP project outcomes into long-term administrative arrangements that can continue to promote the integration of adaptation into state-level policymaking and planning processes.
- To increase state-level awareness of the NAP process and understanding of the impacts of the climate is changing and their implications on people livelihoods and development opportunities. This will involve the sponsoring of climate change workshops to share information about the impacts of climate change on the mission, programmes, and operations of state-level institutions, and explore ways to coordinate activities with federal authorities.
- To develop a roadmap for the implementation of the strategies and measures identified in Table 6-1 to 6-5. This will ensure a codification of the NAP into practical donor assistance plans and funding procedures that are well-integrated with state-level planning processes. The roadmap should reflect, reinforce, and advance crosscutting federal adaptation planning efforts.
- To initiate the implementation of the strategies and measures identified in Table 6-1 to 6-5. This will involve the development of state-level institutions including financial mechanisms to coordinate donor assistance with federal authorities. It will also involve technical and institutional support and sponsoring of implementation workshops to share lessons learned with other state-level agencies.

6.3 Enhance technical capacity for State-level adaptation planning

In parallel with the implementation of activities proposed for next immediate steps in the period up to 2017, state-level capacity should continued to be strengthened, particularly with the newly established adaptation units within the environment institutions and ministries of agriculture. These institutions are still in the process of establishing themselves and need to be supported to ensure their continued functioning and stability, and recognition of their vital role at the state-level. Moreover, some states still do not have environment institutions and would greatly benefit from setting up new institutions to promote better coordination with national and other state institutions and HCENR.

From the NAP experience, it is obvious that technical capacity varies substantially within and among the states and there is a critical need to further develop capacities and strengthen the State's institutions in a follow-up implementation phase. Capacity strengthening activities will need to focus on making better use of available tools and methods for climate change vulnerability assessment and adaptation planning. Priorities includes integrated management systems for natural resources, national and regional cooperation for exchange of information needed for assessment of climate change, development of climate models and scenarios in order to be able to assess climate change, and consensus-building processes to identify adaptation priorities.

Table 6-1: Priority adaptation measures for Darfur States

- **Goal :**To achieve food security to human beings and livestock in the face of a changing climate

(A) Development and Improvement of the Agricultural Production, farmers and pastoralists livelihoods

1. Water harvesting.
2. Technology transfer and extension.
3. Diversification of incomes.
4. Management of the rangelands and grazing in a sustainable manner.
5. Rehabilitation of the natural rangelands and management of animal rotes.
6. Environmental and forest conservation.
7. Soil conservation measures and best practices.
8. Wildlife conservation.
9. Alternative renewable energies to reduce dependency on biomass.
10. Improving animal productivity and animal breeds.
11. Upgrading and improving veterinary services.

(B) Water Sector

Programme: Integrated Management of the Water Resources

1. Management and development of the water resources to meet the current and future needs.
2. Achieving water security.
3. Water harvesting (dams, *hafirs*, terraces, etc.).

(C) Health Sector

- Programme: Reducing Climate Induced Diseases and Mortalities
  1. Combating vectors and insects that borne diseases.
  2. Improving primary health care services.
  3. Providing services for a healthy environment.
  4. Improving the general health services and build awareness.

(D) Capacity Building

Programme: Increasing Production and Productivity through the technical cadres and the CBOs

1. Building the capacities of all the relevant stakeholders in adaptation to climate change.
2. Raising awareness about building resilience in the agricultural, water and health sectors.

(E) Scientific Research

- Development and dissemination of technologies for adaptation to the impacts of climate change in the agricultural, water and health sectors.

Policies and measures:

- Establishment of databases.
- Provision of political support at the state level.
- Mainstreaming of the adaptation programmes in the strategic plans of the states.
- Activation and enactment of legislations that ensure the conservation of natural resources.
- Transparency, responsibility and accountability.
- Establishment of the CBOs and ensuring their active participation in all the adaptation programmes.
- Government commitment and provision of support to local component to encourage the external funding by donors.
- Undertaking concerted efforts to achieve effective horizontal and vertical coordination between all the stakeholders (the Climate Change Unit and the line ministries, the states and the relevant state organizations, the local leaders, the CBOs, etc.
- Commitment to training and capacity building and awareness raising among relevant actors at all levels.

Table 6-2: Priority adaptation measures for Kordofan States

<table>
<tr><td colspan="2">Goal: To build the resilience of the most vulnerable communities to the adverse impacts of climate change.</td></tr>
<tr><td colspan="2">Specific Objectives:
1. To diversify incomes and reduce poverty.
2. To increase productivity.
3. To attain rational use of the natural resources.
4. To provide potable water and other basic services (e.g. health and education).
5. Enhancing the participation of women and youth in the development process and in environmental conservation.
Specific Policies and measure:
1. Combating desertification through using underground water.
2. Making use of the available microfinance opportunities.
3. Poverty reduction.
4. Establishing early warning systems to minimize the impacts of climatic hazards.
5. Political reform in the region and social coherence to achieve food security.
6. Establishing coordination and cooperation councilswithlinkto the national, regional and international research institutions.
7. Develop policies that support the local and international market needs.
8. The rational use of the natural resources and developing heat and drought resistant varieties.
9. Providing support to agriculture and scientific research to overcome production barriers.
10. Providing support to scientific research in water harvesting, agro-forestry and the use of renewable energy (solar and wind).
11. Provisions of technologies to build the resilience of the vulnerable communities.
12. Enhancing knowledge about adaptation and mitigation through developing suitable audio-visual media messages.
13. Studying the impacts of climate change on the soil.
14. Encouraging the use of non-woodforestry products.
15. Providing technical support in the area of meteorological and research.
16. Undertaking surveys and follows up of the climate change impacts on the biodiversity especially in the parks.
17. integration of climate change in the curricula of the universities.
18. Integrated waste management through awareness management, recycling and reuse.
19. Ensuring the participation of all the relevant stakeholders especially the CSOs in the adaptation to climate change activities</td></tr>
<tr><td>(A) Programmes of the agriculture sectors
1. Programme: Increasing agricultural production and productivity and developing the Livelihoods
Components
• Using modern appropriate technologies
• Achieving food security
• Adding value to the agricultural products
• Rebuilding/restocking the animal herds in affected areas
• Supplementary feeding</td><td>2. Programme: Conservation and development of the natural resources
Components:
Rangelands:
• Replanting of the palatable range plants
• Establishment of range enclosures to study the effect of climatic changes
• Establishment of community ranches
• Introducing the manufacturing of concentrated fodders
• Joint management of the natural resources
• Raising environmental awareness</td></tr>
</table>

• Improving the environment for the local breeds • Training and capacity building • Improving marketing • Improving veterinary services • Better management of animal stock and composition • Conserving the germplasm	• Using the agricultural residues **Forestry:** • Encouraging the establishment of community forests • Introducing agroforestry practices • Planting shelterbelts • Planting the high economic value trees • Establishing community tree nurseries • Using alternative energies to reduce dependency on unsustainable biomass sources -
(B) Water programme: • Undertaking geophysical studies of the aquifers • Establishment and rehabilitation of hand pumps • Digging and rehabilitation of *Hafirs*. • Establishing water networks in the rural areas (provisions of drinking water). • Building capacities to achieve integrated water resource management	**(c) Health programme:** • Establishment and rehabilitation of health centers • Building the capacities of the health cadres • Supporting family and school health programmes • Promotion of ventilated improved latrines • Combating transmitted disease • Raising the health awareness of the communities
Legislation: 1. Proper implementation of the current legislation related to environment, forests and protected areas. 2. Establishing a Land Commission and enacting legislation that guarantees equitable access to land for all the users.	**Institutional Set up** 1. Establishing climate change units within the development and strategic planning sectors. 2. Establishing partnerships. 3. Involving the CSOs, Farmers and Pastoralists Unions and Traditional Leaders in adaptation programmes and projects. **4.** Establishing Environmental Councils in the states that have no councils. **5.** Announcing a national environmental day in which the movement of vehicles would be stopped as a symbolic gesture of emission reduction

Table 6-3: Priority adaptation measures for Eastern States

<table>
<tr><td colspan="2">Objectives
1. Sustainable management of the natural resources to satisfy the present needs without jeopardizing the rights of the future generations.
2. Achieving food security for both human beings and livestock.
3. Reducing maternal and infant mortality.
4. Achieving human wellbeing and provision of basic services especially in the marginalized areas.
5. Supporting scientific research.
6. Reduce vulnerability of coastal zones</td></tr>
<tr><td>(A) Programme: Water harvesting to provide water for humans and livestock
Components:
• Establishment of hafirs
• Digging wells
• Installing hand pumps
• Establishment of small dams
• Establishment of water quality laboratories
-</td><td>(B) Programme: Rehabilitation of forests
Components:
• Planting shelterbelts
• Establishment of community forests
• Establishment of enclosures
• Rehabilitation of the Gum Arabic gardens
• Collection of tree seeds and planting them
• Establishment of tree nurseries
• Promotion of alternative energy
• Protection of forests and activation of the pertinent laws</td></tr>
<tr><td>(C) Programme: Agricultural Revival
Components:
• Collection and reseeding of the range plants
• Establishment of range enclosures and ranches
• Opening fire lines
• Awareness raising
• Protection of range lands and activation of the pertinent laws
• Introduction of proper land preparation technologies
• Breeding of crop varieties that are adapted to the climate change
• Introduction of modern irrigation technologies
• Raising awareness about the hazards of pesticides and insecticides
• Establishment of transformative industries
• Capacity building of the stakeholders
• Planting date palm trees
-
•</td><td>(D) Programme: Health Improvement
Components:
• Establishment of dispensaries and health centers
• Provision of primary health care services
• Raising health awareness
• Provision of water quality testing equipments

(E) Programme: Improving Livestock and Fish Production
• Mobile clinics
• Provision of vaccines
• Controlling of diseases shared between humans and animals
• Provision of production facilities (animals, boats, nets, etc.)
• Conservation of aquatic and terrestrial ecosystems</td></tr>
<tr><td>(G) Programme: Capacity building and Women Empowerment
Components:
• Building the capacities of all the stakeholders</td><td>(F) Programme: Rehabilitation of the Rain fed Sector
• Application of suitable technologies for water harvesting</td></tr>
</table>

• Establishing early warning units and meteorological stations • Exchange visits between the states for experience sharing • Undertaking research and studies related to reducing the impacts of climate change and increasing the resilience of the communities and the ecosystems • Literacy classes • Making the concepts of climate change part of the education curricula • Raising the awareness of the politicians and the decision makers about the climate change issues • Encouraging the establishment of women cooperative societies • Supporting participatory research programmes	• Diversification of crops • Breeding of crop varieties that are adapted to the climate change • Establishment of transformative industries • Organising the farmers in agricultural cooperatives • Digging *Hafirs (water storges)* • Improving the infrastructure • Capacity building of the stakeholders • Establishing dams and terraces • Marketing -
(H) Programme: Involvement in the A PERSGA/GEF Project titled: "Red Sea and Gulf of Aden Strategic Ecosystem Management"	
Components: **1:** Strengthening coastal communities to use Ecosystem Based Management approaches to improve fisheries management and achieve other marine resource benefits; **2:** Strengthening the principles of marine managed areas through achieving selected MPA functionality in the Dunonab Bay area **3:** Environmental and Socioeconomic Monitoring Supporting Ecosystem Based Management (EBM) and Community Benefits	**Activities:** • Scoping and establishment of community-based fishing organizations within Dungonab Village & Mohammed Qol. • Assessment of distribution of benefits among communities and demonstration of benefits associated with collective and collaborative resource stewardship. • Demonstration of educational, communicational, capacity-enhancement and training opportunities for local communities in Dungonab and Mohammed Qol villages. • Developing employment opportunities for locals in local tourism-based activities as forms of alternative livelihoods to expand local opportunities and to lessen fishing pressure. • Involvement of community-based organizations in MPA zoning and boundary demarcation and in monitoring and stock assessment activities for better compliance/enforcement and protection from overfishing, particularly of foreign fleets. • Demonstration of best practices for low-impact aquaculture of coral reef species.
(I) Programme: Improved coastal zone management to reduce vulnerability to climate change **Components:** • Protection of critical areas, specifically areas sensitive to climate related risks. • Restoration of degraded areas to enhance their resilience to climate change • Management of mangrove areas and addressing multiple stresses using approaches based on science and participation. • Provisions for alternative livelihoods for mangrove-dependent communities to address drivers for mangrove destruction.	

• Integration of adaptation options into coastal zone management planning to increase adaptive capacity of ecosystems and people. • Assessment and monitoring of coastal ecosystems (including area, resources, resilience etc) • Integration of ecosystem-based and resilient building approaches in coastal zone management and development • Exploration of options for investment and finance flow to support ecosystems conservation and maximization of their benefits to livelihoods
Policies and other measures • Establishment of community based committees that are linked to the NAP technical committees. • Ensure consistency between the federal and state laws that govern the environment and natural resources • Building the capacities of the institutions working in environmental conservation and food security • Fund raising at the local, national and international level to support the adaptation programmes • Provision of local component to all the donor funded projects • Tapping the resources available at the micro finance institutions to increase the resilience of the communities • Introduction of appropriate modern technologies • Making use of the local knowledge and encouraging exchange of experiences between the states • The rational use of pesticides and insecticides • Conservation of biodiversity • Provision of primary health services • Legislation to protect the communities' rights in their local resources • Empowerment of local communities for more active involvement in decision making and practicing stock assessment and protecting their local resources

Table 6-4: Priority adaptation measures for Nile States

<table>
<tr><td colspan="3">Goal: Vulnerability Reduction and Building Resilience in the Agricultural, Water and Health Sectors to Achieve Sustainable Development</td></tr>
<tr><td>(A) Health Sector
Objective: Reducing the incidence of climate change related diseases
1. Primary health care.
2. Environmental health.
3. Vectors control.
4. Water borne diseases.
5. Epidemics early warning systems</td><td>(B) Agricultural Sector
Objective: Enhancing the resilience of the agricultural sector to the impacts of climate change
10. Rain fed Agriculture
• Resettlement and alternative sustainable livelihoods.
• Provisions of improved early maturing varieties.
• Rangelands improvement (rehabilitation and management).
• Trees planting through reseeding.
11. Irrigated Agriculture
• Crop diversification and introduction of improved varieties.
• Improving the current irrigation systems to suit the fluctuations of the River water flow levels.
• Provision of small irrigation pumps to the farmers.
• Establishing of shelterbelts, community forests and agroforestry.
• Production of fruit trees.
• Utilization of the treated sanitation water to irrigate the shelterbelts.
12. Livestock Production
• Increasing productivity through selection of the best breeds.
• Improving the veterinary services and the abattoirs.
• Aquaculture and sustainable fishing.
• Establishing fodder units and increasing irrigated fodder crops.
13. Research
• Demonstration farms and training of the farmers.
• Studying the impacts of climate change on the production of fruits especially date palm.
14. Urban Sector
• Management of the manure and agricultural residues to produce energy.</td><td></td></tr>
<tr><td colspan="2">Policies and measures:
General
• Mainstreaming of the NAP in the development plans of the states.
• Updating and activating the environmental policies and legislation.
• Attaining sustainable development and poverty reduction.
• Supporting the sustainable use of the fisheries and encouraging investments in this sector.
• Implementing the best environmental practices to conserve the vegetation cover.
• Water policies should be developed to gurantee the sustainable use of this resource.</td><td></td></tr>
</table>

• Policies should be developed to increase the vegetative cover (forests and range lands). **Institutional** • Establishing Environmental Councils at the states and activating the ones that currently in existence. • The Technical Committees of the NAP and NAPA at the states level can form a good basis for sustaining future work in the area of adaptation to climate change. **Research** • Introducing technologies best practices in the agricultural sector to increase production and productivity. • Providing resources for research in the area of adaptation to climate change. **Awareness raising and Capacity Building** • Drawing policies that clearly define the capacity building needs in adaptation and the modalities of their implementation. • Capacity building of all the stakeholders. • Raising the awareness of the decision makers about climate change issues. • Raising the awareness of the local communities about adaptation to climate change.	

Table 6-5: Priority adaptation measures for Central States

<table>
<tr><td colspan="2">Strategic Objectives
• To contribute to food security.
• To conserve the natural resources.
• To reduce poverty.
Policies objectives and measures:
• Optimal use of the water resources (the Nile and underground waters) and adopting effective water harvesting techniques.
• Sustainable use of the fish and livestock resources.
• Using the results of the scientific research in the area of climate change to increase agricultural production.
• Preparing both land use and investment maps.
• Poverty reduction and environmental conservation.
• Improving the working environment and provision of the basic infrastructure in the health, water and agricultural sectors.
• Improving the primary health care services, epidemics control and reduction of climate change induced diseases.
• Establishment of databases and early warning units.
• Increasing production and productivity through the local knowledge, new skills, and attitudes and enabling legislation.
• Preparation of land use and investment maps.
• Poverty and unemployment reduction.
• Allocation of governmental funds to achieve sustainable development and provide basic services in the areas of primary producers.
• Provision of primary health care services, eradication of endemic diseases and dissemination of healthy environment principles and preventive health attitudes.
• Empowerment of women.</td></tr>
<tr><td>(A) Programme: Modernization of the Agricultural Production Systems, Natural Resource Conservation and rehabilitation of the Livestock Sector
Components
1. Using suitable agricultural technology and best practices to cope with climate change.
2. Breeding of new crop varieties that are more adaptive to climate change.
3. Rehabilitation of the meteorological networks.
4. Rehabilitation of the vegetative cover.
5. Rehabilitation of the rangeland.
6. Establishing a botanical garden to conserve biodiversity.
7. Improving the veterinary services.
8. Improving livestock and fish production.</td><td>(C) Programme: Control of Endemic and Epidemic Diseases induced by Climate Change
Components
1. Control of Schistomiasis, Leishmaniasis, Dengue Fever, Malaria and Lymphatic filariasis.
2. Control of malnutrition and diarrhea among children under five.
3. Provision of treatment and basic medical services.
4. Building institutional and human capacities.
5. Early warning and response to health emergencies.</td></tr>
<tr><td>(B) Programme: Water Management and Conservation
Components
1. Water harvesting.
2. Establishing centers for measuring the amount of floods in the valleys and Khors.
3. Management of surface and underground water.</td><td>-</td></tr>
</table>

6.4 Promote enabling environments

A cross-cutting implementation theme is to continue the various processes in order to build an enabling environment for adaptation activities. Critical priorities are outlined in the bullets below.

- *Institutional development.* Establishing and strengthening State's environment institutions requires financial and technical support and cooperation between UNEP, HCENR and collaboration with all state governments. This collaboration should focus on identifying needed legislative initiatives, redefining institutional mandates/responsibilities, enacting new coordination mechanisms between state/federal institutions, communities and civil society organizations, ensuring government support for database and training needs.
- *Support to rural communities.* This corresponds to the need to encourage rural communities to diversify annual income generation through a focus on new cash crop varieties that are drought-resistant and new programmes, as well as the improvement of animal production techniques, which are common themes across all state actions of Tables 6-1 to 6-5. Other critical support to rural communities includes the assessment of the available water resources in the light of climate scenarios, increasing water use efficiency by using modern technologies, and making greater use of integrated water harvesting techniques in order to improve vegetation and rangeland.
- *Information access:* This corresponds to the need to improve knowledge management through the future establishment of a climate change information bank and the establishment of a national climate change and drought center. This can also be a center for early warning systems and suitable technology that can systematically make better use of maps and remote sensing images in order to forecast potential future climate change impacts on water resources and the sustainable use of ground water.
- *Awareness raising:* This corresponds to the need for greater public and policymaker awareness to facilitate the integration of adaptation concerns in sustainable development planning. Specifically, this includes greater use of renewable energy, new legislation to increase of forest areas and limit deforestation, new regulations to promote better agricultural practices, and extension services to farmers regarding sustainable agriculture techniques in the face of climate change.
- *Planning and financial systems*. This corresponds to two strategic priorities for moving forward on the above themes, namely the development of good quality concept and project proposals for priority adaptation options at the state level on the basis of Tables 6-1 through 6-5 and fund raising for NAP implementation activities targeting government, UNFCCC funds, and other multilateral and bilateral sources.

6.5 Gaps and needs for further work to strengthen the NAP process

The final element of the NAP implementation strategy focuses on the identification of gaps and needs for strengthening Sudan's NAP. Critical priorities are outlined in the bullets below.

- *Capacity building. T*echnical and institutional capacities of the state institutions need to be further strengthened and enabled to coordinate the implementation and integration of the NAP into development planning in addition the review and update of the NAP in the future
- *Regional climate scenarios.* Further development of climate scenarios to cover all the states to enable identification of mid and long terms adaptation needs based on sound scientific

approach. The study on climate scenarios provided information on projections of future temperature and precipitations based on 6 MET stations representing the different climatic zones of Sudan. This information provides very important input for selecting and using impact models (e.g. crop or water models) to assess future vulnerabilities of specific systems or sectors to climate change. Therefore further follow up work on introducing impact models and their know-how is vital to use these climate scenarios for better understand future vulnerabilities of the development sectors in Sudan.

- *Methods and tools.* Building technical capacity and knowledge about methods and tools (impacts models) for assessing future impacts of climate change and assessment of future vulnerability of the water, agriculture and food security and health sectors and their implication on national development
- *Awareness-raising.* Improve awareness and knowledge about the climate risks and adaptation responses and their implications on people livelihoods and development opportunities at the state and local levels
- *Planning and financing*. Improve the quality of the adaptation planning at the state level, including the policies, programmes and preparation of good quality adaptation projects for financing through the available funding opportunities.
- *National-state coordination.* Elaborate and improve modalities for NAP implementation and integration into development planning at both national and state level
- *Enabling environments.* Undertake further work on enabling environment programmes, in particular on vulnerability hotspot mapping, adaptation finance and investment, climate proofing of ongoing development projects
- *Monitoring and evaluation.* Elaborate NAP monitoring and evaluation system, including data collection, modalities to engage affected communities, sharing of knowledge and experience on implementation and integration and reporting.

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Annex A - State-Level Summaries

This annex provides a synthesis for each of the eighteen (1) states regarding the following NAP key findings:

- Impacted sectors
- Climatic hazards
- Climate change impacts
- Vulnerable locations/communities
- Non-climatic factors influencing vulnerability
- Proposed adaptation initiatives

Regarding the organization of this annex, the bullets below provide a summary of the state-level composition of each major region:

A. Darfur States: There are five (5) sates in this region: North Darfur, West Darfur, South Darfur, Central Darfur, and East Darfur

B. Kordofan States: There are three (3) sates in this region: North Kordofan, South Kordofan, West Kordofan

C. Eastern States: There are three (3) sates in this region: Kassala, Gedaref, Red Sea State

D. Nile States: There are three (3) sates in this region: River Nile State, North State, Khartoum State,

E. Central States: There are four (4) sates in this region: Gezera, Sennar, Blue Nile, White Nile

A. Darfur States

North Darfur State

Sector	Climate Factors	Effects	Vulnerability & Location	Non – climate factor	Adaptation Programme
Water,	Drought, Desertification	Alterations in ecosystems that threatening food security, livelihood and other services provided to people	El Fasher, Kulbus , Masteri Komoi, Malhah	Poverty, Conflict and displacement	Water Services through construction and maintenance of Water Points Water harvesting project for the purposes of agriculture and drinking Water Project
Agriculture and natural resources	recurrent drought, scarce and uneven distribution of rainfall	Inadequate number and poor distribution of water points and reduced water and fodder availability in the dry seasons Degradation in natural environments including forests, range lands and water catchments	Mileet, Almalha, Umkadada, Um baro, Karnoy, Alteena **Rangelands and forest:** AlMalha, Al Komah, Um Kaddadh, Elfashir, Maleet	Inadequate agricultural inputs, armed conflicts, uncontrolled crop pests	Maintenance of forest environment and natural resources Project to improve the natural pastures and livestock production Poverty combating through diversification of households' income Sources, Establish rural women development programme Improvement of rangeland and livestock production Conservation of forests and natural resources.
Health					Project to improve the environment and the fight against vector-borne diseases Protecting of water sources from pollution Control of malaria, leishmania and bilharzias diseases

West Darfur State

Sector	Climate Factors	Impacts	Vulnerability & Location	Non – climate factor	Adaptation activities
Agriculture and food security	- Increase of temperature - Decrease of rainfall amount and variability of rainfall - Drought - Increase of wind speed	- Decrease of production and productivity - Deterioration of rangelands - Deterioration of forestry cover - Frictions and conflicts between farmers and herders - Disappearance of some rangelands' plants - Migration of wild animals	- Gargar north of Elginana - Karty west of Elginana - HabilaKanakry east of Elginana - Atyah south of Elginana - AeshBarah west of Elginana	- Poverty - Limitation of income - Civil conflicts - Deforestation - Overgrazing of rangelands - Appearance of crops' pests and diseases - Traditional practices of farming - Lack of environmental awareness - Farmers use low quality varieties (low production) - Lack of land use policy - High population in the state and dependency on biomass for energy - Increase in animals numbers that exceed carrying capacity of rangelands	▪ Development program and improvement of agricultural production. ▪ Water harvesting projects ▪ Technology transfer and know-how ▪ Income generating activities ▪ Horticultural crops and agricultural development project ▪ Proposals for the development of policies and institutions to implement national adaptation plan. Proposals in the areas of research and continuous monitoring of climate change and its effects.
Water Sector	- Increase of temperature - Decrease of rainfall amount and variability of rainfall - Drought - Increase of wind speed - Decrease of relative humidity	- Conflicts around water sources - Migration of herders from north to south Elgenina - Concentration of local people around water sources - Pollution of water sources (sudds, hafiers, tanks) - Negative impacts on ground water basins	- Gargar north of Elginana - Karty west of Elginana - HabilaKanakry east of Elginana - Atyah south of Elginana - AeshBarah west of Elginana	- Poverty - Misuse of water sources - Civil conflicts - Lack of awareness in use of water - Ground water is not good for human drinking - Distribution of water points is not following needs and scientific bases - Lack of financial support for implementation of water projects - Lack of periodical maintenance for water	- Development Project of the water resources to meet current and future needs. - Raising the rate of access to water for human and animals to achieve water security and social development. - Water harvesting project (Dams, *Hafir* and water yard).

Health Sector	- Increase of temperature - Decrease of rainfall amount and variability of rainfall - Decrease of relative humidity - Drought - Increase of wind speed	- Spread of diseases that are connected with water such as malaria and skin diseases - Spread of epidemics such as yellow fever and cholera - Spread of malnutrition diseases	- Gargar north of Elginana - Karty west of Elginana - HabilaKanakry east of Elginana - Atyah south of Elginana - AeshBarah west of Elginana	- Poverty - Illiteracy - Lack health awareness - Civil conflicts - Lack of health services in the area - Lack of nutritional education - Lack of finance - Interaction with neighbouring countries	- Project anti-vector-borne diseases and insects. - Project to improve basic health care services. - Project to improve environmental sanitation services. - Project to upgrade health services.

South Darfur State

Sector	Climate Factors	Impacts	Vulnerability & Location	Non – climate factor	Project
Agriculture and Food Security	Fluctuation in the rate of rainfall High temperatures Activity and speed of the wind Droughts Shortage of rainfall (amount and distribution) Heavy rains and floods	Weakness of feeding of seasonal streams led to reduction of horticultural production Decrease in production per unit area Expansion and increase of cultivated areas in degraded and marginal lands at the expense of rangelands and forest cover Change in livelihoods Decline in crop yield	Northern and central parts of south Darfur State (semi-arid zone), most vulnerable are the following localities: Malam, Nitaiga, Mershing, Bilail, Kas, Nyala, Al Salam	Weakness of agricultural services and inputs Poor awareness of climatic changes Severe deforestation caused by expand cultivated area and over grazing Resources mismanagement Communities displacement and out-migration Poor soil fertility Competition over natural resources Extreme poverty Tribal conflict Poor livestock infrastructure e.g. markets Poor community participation and involvement in projects Husbandry of livestock on remote and marginal areas, difficult to access IDPs from South Sudan Desertification	**Programme:** Securing food for people and animals 1 - water harvesting 2 - development and improvement of horticultural crops 3 - Develop and improve agricultural production 4 - Management and protection of forests and grasslands 5 – Improvement descendants of small ruminants and poultry breeds 6 - Improve the health and production of animals 7 - Rehabilitation of rangelands
Health	Drought Floods and events of High rainfall High temperature	Occurrence of diseases due to lack of water such as skin and eye infections Diarrhea. Scabies. Water related vector diseases such as Malaria and Flarias Water born disease such as cholera, Typhoid and dysentery. Water based disease such as	Netaga, mershing , Al salaam (vulnerable because of water shortage) Tulus , Buram , Umdafog , Al radum, Alrehaid and IdElfrsan (vulnerable because of high rainfall)	Poverty Population Movement and displacement Lack of awareness	**Programme: Eradication of Schistosomiasis (bilharzias), intestinal worms**, **Malaria andleishmaniasis** Improve theenvironment Health education andmass communication Community Empowerment(raise the technical capacityof services tolocal communities (Mobile Klink)

		schistosomiasis Poor air quality Allergies and other nuisances	Kass , Netaga , Ed Alfursan Nyala (vulnerable to High temperature)		Provision of clean safe water. Provisions of Treatment. Capacity building. Partnerships: to coordinate with partner agencies within the UN system Endemic disease control. Advocacy. Health system strengthening
Water	Rainfall increased in variability, change in distribution and decrease in amount over the past decades Shift of 400 mm isohyet southward of Nyala Isohyet 600 mm become the highest amount of rainfall instead of 900 mm and the latter become restricted to the small area of Jebel Mara	Shortage of water Decrease in groundwater levels. Decrease of the water consumption per capita/head. Contamination of the surface and groundwater.	Nyala, Menwashi Wadi Nyala, Bulbul, Sindo, Kaya, Ibra and Mershing	Competition on the existing water resources. High population density on the water points. Miss use of the water.	**Programme: Implementation of Water harvesting techniques** 1 – Construction of interceptions dam. 2 – Expansion of ponds 3-Drilling of ground water 4-Construction of pumps and wells.

Central Darfur State

Sector	Climate Factors	Impacts	Non – climate factor		
				Adaptation Programme	**Project**
Agricultural ,Forestry and rangeland	1) Increase of temperature degree. 2)increaseFrequency of drought. 3)Shortage and uneven rainfall distributions. 4)Long duration of dry spell. 5)increase frequency of Floods	1-Soil fertility reduction. 2-Reduction of total forest area. 3-Reduction yield of drymatter/Hectare in the range lands. 4-Decrease the productivity of crops. 5-Decrease the underground water stock and seasonal streams. 6-Outbreak of diseases (malaria, typhoid and yellow fever etc.)	(1)Deforestation (cutting of trees for fuel , constriction etc. (2)Over grazing. (3)Land degradation	1-Raising of community awareness regarding the important of natural resources and utilization of ecosystems. 2- adoption of Legislations and laws for protection of natural resource. 3- Implementation of water harvesting and cropping systems training. 4- Targeting of pastoralists through introduction of special programs *e.g.*use of artificial insemination for improving the races of flocks. 5- provision of health of health services, Raising health awareness and combating disease vectors. 6- improvement of extension services particular with regard to agroforestry and range and pasture.	1-Agro forestry and Rehabilitation of degraded forest areas 2- Water harvesting technical. 3- Soil conversation. 4- Livelihood project. 5- Water pumps and huffier. 6- Compacting of diseases vectors insect. 7- Energy alternatives.

East Darfur State

Sector	Climate Factors	Impacts	Vulnerability Locations	Non – climate factor	Adaptation Programme
Water	-Decrease in rainfall Increase in temperature -Increase in evaporation rate	Decrease in water level in artizian wells Decrease in water resources	-Abu Kranka,Yassin, Asalaia, Abu Matarig, Aldeain Abu Gabra	Ill-legal tree cutting -Desert creeping -Lack of awareness towards water utilization -overgrazing	• Geophysical Studies. • Drilling of new water yards. • Rehabilitation and upgrading old excavations. • Water harvesting (Dams and *Hafirs*). • Models of work to cement tanks (water harvesting in the north of the state). • Construct earth dams (water harvesting in the south of the state) use worldwide abolition green around the sources. • Formulation and the rehabilitation of the water committees • and linked to other committees for the integrated management of resources.
Natural Resources	Rain variation and low rainfall Icrease in temperature -Drought Wind and dust storms	-Detoriation of pasture -Detoriation of forests -Decrease in Anmial wealth	Shairia, Yassin, Aldeain, Adila, North of Bar Alarab, Alfordous,Mahgriia, Abu karank Labado.and Salaa west	Poverty, -absence of production tecknologies -Migration and conflictsd -low income Boarder conflict with the South goverment	• Expansion of water harvesting techniques (pastures). • Environmental extensions. • Improve the physical properties of the soil to increase its ability to retain moisture. • Fenders and cultivation belts. • Community forest. • Planting winds break. • Use agro forestry system. • Open lines of fire.
Agriculture and animal Resources	Variation of rain fall -late rainfall season -High temperature -Wind and dust storms	Low production and productivity -shortage in food security -low soil fertility -migration to cities	North and east parts of the state., Yassin, Salaa, Aldeain, Abu Gabra	Low income -Limited Extension services -Migration Conflicts Absence of agriculture technologies	• Introduction of water harvesting technology to increase agricultural production. • Agriculture Bad tree-free trees with economic return. • Strengthen the network extension. • Quick introduction of maturity. • Organic Fertilization. • Strengthen agricultural extension environment and take advantage of surface water and groundwater to work farms. • Introducing of drought-resistant varieties. • Rebuild the herd - additional feed. • Eugenics. • Income-generating activities. • Planting drought-resistant varieties, which are used for animal feed. • Fish farming.
Health	-High - Temperature -Drought -Dust storms	Inflammations -Epidemic diseases Dihria Meningitis	-Sbu Matarig,Abu Gabra,Aldeain	-Poverty -Low health awareness -Management	• Provision of vaccines • Rehabilitation of personnel health • Created health centers • Guidance and preventive health

B. Kordofan States

North Kordofan State

Sector	Climatic Factors	Non-Climatic factors	Impacts	Adaptation activities
Crops: Agricultural production, rangelands, and forestry	Shortage of rainy season, Uneven distribution of rainfall Increase of Drought and Floods cycles,	Low income & high % of illiteracy among communities. Migration Conflict Poor technologies Lack of agriculture production technique packages up scaling Weak of extension	Crops season failure, Lack of Food security, Deterioration of rangelands, Deterioration of forests	Water harvesting for crop and rangelands production, Introduction of early mature varieties (crops and rangelands), Improvement of the nutritive value of crops residues, Introduction of perennial rangelands plants Establishment of early warning system, Mapping of flood area, Establishment of disaster management unit, Introduction of technologies which increase Crop production
	Increase of Temperature	services Weak institutional building & organization of the communities. Degradation of soil fertility	Mortality of tree seedlings, Increase of water requirement (for both drinking and irrigation), Decrease of feed resources, Pest and diseases infection	Introduction of heat resistant varieties, Establishment of irrigated farms, Introduction of agro -forestry plating technology, Diversification animals' feed, Capacity building of communities
	Wind and storms		Deterioration of soil Formulation of sand dunes, Decrease of crops production, Plant seedlings motility	Planting of wind breaks, Cultivating land cover crops (water melon peas) Opening of fire lines, Establishment of public nurseries (for both shade and fruit trees) capacity building of communities
Animal Production	Uneven distribution of rainfall, Shorter rainy season, Increase of drought and Floods cycles, Increase in temperature	Poverty, Poor pasture, deterioration of rangeland, lack of technologies, lack of technical know how about production technologies packages, and low production and productivities	Water shortage Heat stress, poor Pastures, Waste of energy searching for pasture and water, Infestation of internal and external parasites, high % of animals mortality, Drop in animal production, migration to cities	Herd restocking, supplementary feeding (for fattening & milk production), early weaning systems, improvement of animal breeds by selection, support of Income generating activities (Bee keeping, poultry improvement, carpeting, agriculture etc.) Capacity building.

			Displacement of people from south Kordofan And Darfur, Poor pasture and dimensioning of rangelands areas, water shortages and high prices for water purchase	
Water	Decrease of rainfall amount and variability in `mount and distribution, Shorter rainy season Drought heat degree increase Wind storms	Poverty, Prevalence of Basement rocks complex, Water pollution Deforestations, Lack of awareness about optimums water sanitation and uses.	Increase water requirement, Decrease of agriculture, Production Increase water table, Lack of water resources	Conduct geo-physiological soil studies to determine ideal sites for digging wells, Water harvesting, Construction of *Hafirs*, boreholes and concrete basin, Rehabilitation of water units (wells hand pumps boreholes) Capacity building of water committees, Integrated water management and use Of water pipes
Health	Decrease in rainfall amount, high variability in rainfall amount and distribution, Lack of water , Increase of temperature, Drought and Wind storm	Poverty, High cost of living and limited income, Migration, Poor environment activities and lack of awareness.	Malnutrition diseases, Spread of Malaria disease Respiratory system disease, Lack of awareness, Increase of waterborne diseases Eyes diseases	-Construction of health units, well equipped and run by qualified medical cadres -Cleaning and purification of drinking water -Construction of latrines in village -Provision of drinking water -Conducting research studies on different waterborne diseases in Rahad -Awareness raising of local people -Training and capacity building for local health committees

South Kordofan State

Sector	Climatic Factors	Non-climatic factors	Impacts	Vulnerability, Area System	Adaptation programs
Agriculture	-High temperatures and evaporation -Fluctuation of rainfall, and low rainfall -Wind and haboobes	-Civil war, -Conflict on the limited resources, -Soil erosion -Poverty, -Hunger and disease -Technology transfer	Migration -crop failure, - -water shortage Crop failure, insect pest and disease Low fertility, weeds Desertification	-Rural in east part of state -Rashad, -Kadugli -Abasia, Wacra, El goz, Erreef Al shrgi Algoz, Abasiya	-Water harvesting--afforestatin -Reforestation -Improved seeds -Alternative comprehensive cropping -Aroforesiry
Natural Resources	Temperature rise and evaporation -Fluctuation of rainfall, and low rainfall -Wind,Soil erosion,	-Laws, regulations and sanctions, -poverty, -hunger -lack of jobs -Lack of control, over grazing crop expansion	-Cutting trees, - over grazing, -Weeds, -unwanted tree species -Death of trees, and endanger trees	Northern of the state Northern the state Talodi, GadiarAbugubiyha Talodi, GadiarAbugubiyha	-Gum Arabic production, - -seeds and seedlings -Improve non-wood forest product -Seedling, reservation forest
Animal Resources	Drought, desertification, heat, humidity,floods,	-War, -poverty, -hunger, -lack of pasture	-Grassland degradation- disease outbreaks	El gitaa El garbi, Abugubayha, kadugli	-Health Awareness, -Pastoral and therapeutic camps - Seeds dispersal or distribution
Water	-Temperature rise and evaporation -Fluctuation of rainfall, and low rainfall -Wind and haboobes	-Lack of health -Lack of drinking water, vegetable production is low-technology transfer	-Disease, -hunger, -poverty -migration, -conflict conflict	Dalling, Habeela, Dalami, Kawiak, kadugli, Elgoz Elgoz, Elgarbiya	-Water harvesting, - drip irrigation, -upplementary irrigation -new system of irrigation
Health	-Low rainfall, -high temperature, -desertification, -floods	Migration-legislationawareness	-Diseases, -Hunger, -death -conflicts -war -migration	South areas, rural areas, western and eastern side of the state	-Increased the health unit cadre -Awareness raising of women on hygiene, environmental health and harmful social practices -Maintenance of health units and supply of drugs and training of health cadre
Improving economical situation, awareness, legislation	Low rainfall, higher temperature, desertification, flood, sanitation	Lack of awareness, laws and Sanctions	Epidemic diseases	South areas, rural areas, western and eastern side of the state	Improving economical situation, awareness, legislation

Western Kordofan State

Sector	Climatic Factors	Non-climatic factors	Impacts	Vulnerability Area System	Adaptation programs
Agriculture	1- rise in temperatures	Civil war, Conflict on the limitedresources, Poverty, hungeranddiseases	Migration, crop failure, water shortage	Communities inthe South and the east	Water harvesting, Afforestation Reforestation
	2-Low humidity	Institutional problems	Migration	Baba nousa and Muglad	Use of improved seeds
	3- Fluctuation of rainfall, and low rainfall		Infestation of insects pests and diseases	South mugladElnohoodGebaish	Alternative, comprehensive cropping
	4-inceease of wind speed	Technical applications	Low soil fertility, weeds Desertification	Northern of the state	Agroforestry
Natural Resources	1- rise in temperature	Laws, regulationsandsanctions, poverty, hunger lack of jobs	Cutting trees, over grazing	Baba nousa, South mugladand The northern state	Gum Arabic production, seeds and seedlings
	2-Low humidity	Lack of Laws,regulationsandsanctions, poverty, hunger lack of jobs	Weeds, spread of invasive trees species	All the state	Improve non-wood forest product
	3-Fluctuation of rainfall, and low rainfall	Over-grazing, crop expansion and	Death of trees, and endanger trees	Northern of the state	Seedling production,
	4-Increase of wind speed	Over-cropping	Death of trees, and endanger trees	Elnohood, Elodia, Baba nousaandFula	forestreservation

Animal wealth	Drought, heat, low humidity, floods	War, poverty, hunger, disease, lackof good pasture	Grassland degradation, disease outbreaks	All the state	Health Awareness, rehabilitation of rangelands (Seeds dispersal/ distribution, water harvesting, vet. Services etc.) and improvement of Pastoral life
Water	Fluctuation of rainfall, and low rainfall Wind, Low minimum humidity	Lack of safe drinking water, lack of technical know how of water harvesting, lack of technologies, conflict over resources, high illiteracy rate	Disease, hunger, poverty, migration, conflict	Dalling, Habeela, Dalami, Kawiak, kadugli, Elgoz Elgoz, Elgarbiya	Water harvesting, drip irrigation, Supplementary irrigation Use of new/modern system of irrigation
Health	1-Low rainfall, high temperature, flood,	Migration, weakness of legislation, Lack of awareness, laws and Sanctions	Diseases, Hunger, death, conflicts, war, migration Epidemic diseases	All the state	Improving economic situation, awareness, legislation, provision of health services, capacity building

C. Eastern States

Kassala State

Sector	Climate factors	Non–climatic factors	Impacts of climate change:	Adaptation Activities
Agriculture	Fluctuation of Rain fall, Increase frequency of drought and flood cycle, -Rise of temperature	- Civil war in the eastern region and neighbouring countries, - Refugees influx and internal displacement -Migration of rural residents to urban areas. -Poverty and epidemic disease like tuberculosis. - High percentage of illiteracy within rural people. - Desertification and Spread of mesquite trees.	- Reduction of crop production and productivity. -Deterioration of land vegetation cover. -Reduction of animal production. -Increase of desert -Migration of villagers to neighbouring towns. -Increment of poverty rate.	Water harvesting and spreading, Range Improvement, Introduction of community forest, Utilization of short maturing varietiesand capacity development of rural people.
Water	-Fluctuation of Rain fall -increase of drought and flood cycle, -Rise of temperature	-Civil war in the eastern region and neighbouring countries -Refugees influx and internal displacement - Migration of rural resident to urban areas. -Poverty and epidemic diseases like tuberculosis. - High percentage of illiteracy within rural people. - Desertification and Spread of mesquite trees.	Decreasing of water resources	**-**Introduce suitable water harvesting techniques into the area. -Encourage farmers in the area to adopt efficient and modern irrigation system via and intensive awareness campaigns. -Feeding of underground water by using suitable techniques. - Clean and de-siltation of available wells and Hafiers -Drill more wells -Organize water sucking and feeding of underground water through efficient laws and regulations
Health	-Fluctuation of Rain fall - Drought and flood cycle -increase of temperature	-Civil war in the eastern region and neighbouring countries -Refugees influx and internal displacement -Migration of rural residents into urban areas. - Poverty and epidemic disease e.g. tuberculosis. - High percentage of illiteracy within rural people. - Desertification and Spread of mesquite trees.	Spread of malaria and tropical diseases	-emphases to control diseases like malaria and tuberculosis. - - Eradication of mesquite from potential water resources.

Gadaref State

Sectors	Climatic Factors	Impacts	None Climatic Factors	Projects and activities
Water	-Scarcity and fluctuation of rainfall - The lack of under ground water -Increase of frequency of drought periods and cycles - Repeat of flooding of rivers and creeks - Scarcity of Underground water and changes in its quality	Lack of drinking water for human and animals - Soil degradation and encroachment of the desert - decrease in productivity of crops and vegetables -Rising prices - increase of poverty -The emergence of diseases -Immigration and displacement -The deterioration of pasture and tree cover	Disqualification of water in theaquifers dueto increase of salts percentage , -chemicalcontamination of underground water - Biotic contamination of surface water	**- Water Sector** **Program of water harvesting for human and animal utilization** The components are: -Construction andrehabilitationof reservoirs -Digging of wells - Hand pumps - Dams construction - Construction ofdesalinationand Water Testing Laboratories
Agriculture	- Scarcity and fluctuation of rainfall - Increase in temperature - increase in frequency of drought and floods	-Decrease in productivity of agricultural crops - The emergence of animal diseases - decrease in pasture and the decline of tree cover and pasture species - Rising prices - increase of Food security gap - Displacement and migration - The emergence of diseases of malnutrition - Instability -Increasing illiteracy - Famine	-illegal felling of trees - Overgrazing - Frictions and disputes over resources - Traditional mining - migration - weak laws and policies - Lack of knowledge and capacity weakness - Increasing demand for forest products	**2- Agricultural sector** **a-Program of reconstruction andreforestation:-** The components are - Shelter Belts -Community forests -Rehabilitation of gum arabic belt -Collection and broadcasting of tree seeds -Establishment of nurseries -Utilization of energy alternatives -Forest protection **b-Program of Rehabilitation of irrigatedsector** The components are: -Introduction of new technologies - development and provision ofappropriatevarietiesto adapt toclimate change - The introduction of modern irrigationsystems -Safety uses of pesticides -Development of agricultural product industries -Awareness raising of the stakeholders **c-Program of Rehabilitation of the rainfed sector**

				The components are: -Adoption oftechnology packagesandwaterharvestingtechniques - Diversification in crops varieties - development and provision ofappropriatevarieties adapted to the climate changes -Development of agricultural product industries - Organization of farmers inproductiveassociations and committees -Establishment of reservoirs and dams within agricultural project for supplementary irrigation - Improvement of infrastructure - Improvement of the marketing system
Animal wealth	-Increase of temperature - increase in frequency of drought and floods - Scarcity and fluctuation of rainfall	-Animal deaths - deterioration of animal route (weeds, water, veterinary services Narrow tracks) - deterioration of pastures and appearance of unplatable species disintegration of soil texture.	-spread of disease - Pastoral high load capacity - increase in fires incidents in grasslands - Overgrazing. - felling of trees.	**a-Program for improvement of animalandfishproduction** The components are: -Provision of production tools and equipments(poultry, goats , fisheries nets and Others) -Development of fish farms **b-Program of maintenance and rehabilitation of pastures:** The components are: - Collection of seeds and broacasting of grasslands -Establishment of pastoral farms and nurseries - Opening of fire lines -Arrangement for pastoralist -Awareness raising - Pasture protection and strengthening of laws and legislation **c-Program for Improving veterinary services** The components are: -Mobile clinics - provision of vaccines - Control of animal and commondiseases

Health Sector	- Increase of temperature - increase in frequency of drought and floods - Scarcity and fluctuation of rainfall	-spread of water-related diseases and insects - Increase in malnutrition, disease - emergence of common diseases - High ratios of maternal and child mortality - increase of iliteracy - Health disasters	-water pollution -Lack of healtheducation - Illiteracy -Poor training andlack ofassistivedevices -lack of hygienic watersources -Displacement and migration	**Program of rehabilitation of health sector** The components are: -Establishment of healthcentersandunits -Adoption of control measure for Malaria, schistosomiasis, kalazaar, andsunstroke - Waste collection andrecycling Improvement of toilets systems Providing water testing equipments Awareness raising
Residents and Education	- increase in frequency of drought and floods - Scarcity and fluctuation of rainfall	- decreases in agriculturaland animal production, - poorpasture - Instability	- immigration -Displacement	**Residents**: they are in need of studies **Education**: need to improve education infrastructure and reduce iliteracy and introduce the concept of climate change in education **Decision makers**: awareness raising among the decision makers about the climate change **Women:** need empowerment and involvement in productive associations and committees **Agricultural Research**: supporting research programs **Program of Capacity Building (for all sectors)** The program components are: -Training and qualification of professionalsandtargetgroups - Establishment of early warning stations - Creation of a database and information unit - exchange visits betweenStates to share the experiences

Red Sea State

Sectors	Climatic Factors	Non Climatic Factors	Impacts	Adaptation activities
Water	- Drought. - Decrease of rainfall amount which also iritic -Increase in temperature - increase floods frequency	Problems in dam construction and layout, Displacement, Irrational consumption of water, Poor coordination between institutions.	- High evaporation rate - High salinity rate - Low discharge of aquifer - Shortage of water	Water harvesting for human and animal drinking, Construction of dams, Water wells, and *hafirs*.
Health	Decrease in rainfall amount Drought, High temperature. Floods.	Socio – economic factors related to attitudes & behavior. Occupational factors.	- Shortage and pollution of water - Spread of diseases such Diarrhea, malaria and bilharzias, malnutrition - Increase of morbidity rates of the stated diseases	Environmental health & Health hygiene. Provision of health services for the control of: Dengue fever, Heat stroke, Malaria & Malnutrition
Forestry	Drought. Low rainfall Increasing in temperature. Floods.	Poor coordination between institutions. Overgrazing. Deforestation for wood and charcoal production Invasion of miskeet.		Forest rehabilitation & Afforestation. Reseeding of forests. Forest nurseries. Energy saving techniques. Endangered species enclosures Enforcement of laws & regulations.
Pastures	Drought. Low rainfall.	Overgrazing. Pastoralistsmovements. Poor coordination between institutions.		Maintenance & rehabilitation of pastures. Seeds collection & broadcasting Pastures farms & enclosures. Pasture nurseries awareness.
Livestock	Drought. Low rainfall	Poor Vet. Services. Poor inputs to livestock production. Poor coordination between institutions.		Improvement of vet. Services & livestock productivity. Mobile Vet. Clinics. Provision of vaccines Control of prevalent diseases Improvement of livestock fodders quality.

Fisheries	Temperature Increase Low rainfall.	Land based pollution, Overfishing		Rehabilitation of mangrove & coral reefs. Marine environment monitoring. Mangroves reseeding. Coral reefs reseeding. Monitoring stations. Commercial fish Stock assessment
Traditional Agriculture	Drought. Low iritic rainfall. Increase in temperature.	Lack of agriculture inputs. Miskeet invasion. Poor coordination between formal institutions Deterioration of natural resources	- Food insecurity and malnutrition - Low per capita energy intake. According to FAO estimates of energy intake in the state, almost two thirds of the state population has a per capita energy intake below the minimum average requirements and minimum level in African countries. - Loss of animals' herds, - High rates of urban growth - Collapse of the traditional coping and resilience mechanisms	Rehabilitation of traditionalagriculture sector. Construction of dams for water harvesting, Improvement of water harvesting techniques. Provision of certified seed stocks. Diversification of crop structure. Agriculture extension.
Horticulture	Drought. Low iritic rainfall. Increase in temperature.	Lack of horticulture inputs. Poor coordination between formal institutions		Rehabilitation of horticulture sector. Horticulture nurseries Farmers schools Horticulture extension.
All Sectors	-	-		Capacity building programme Training of technicians and targeted groups. Data base information units. Early warning system units. Monitoring Stations Cross-visits.

D. Nile States

River Nile State

Climate factor	Non–climatic factors	Impacts of climate change:	Adaptation Activities
-Increase of temperature. -Decrease of rainfall increase frequencies of drought and floods	-Increase of poverty rate -Illegal Cutting of trees -Over grazing of rangelands -Absence of environmental effective laws and legislations - Migration -Lack of finance -Lack of supporting policies -deforestation	Increase of poverty rate - Increase migration and displacement -Lack of finance -Lack of supporting policies. -Increase of cost of production. Increase of desertification. -Domination of un palatable grasses and disappearance of palatable species. -Increase of soil erosion rate.	Environmental improvement projects -Agricultural production projects -Agricultural research projects -Agricultural extension program -Vaccination campaigns -Livestock restocking -Water harvesting program -Wells drilling and installation of pumps (Provision of pumping sets) -Construction of feeding canals along the Nile and River Atbara -Control of River Bank erosion -Malaria eradication projects -First health care projects -Environmental health care -Water sanitation project -Establishment of rural latrines

North State

Sector	Climatic factors	Non climatic factor	Impacts	Vulnerability	A adaptation
Water	1-increased frequency of drought 2-low and irregular rainfall 3-high and excessive evaporation 4-high temperature 5-severe winds	1-poverty 2-low income 3-missuse of water resources 4- lack of primary studies for water resources in valley area	1-population migration (shift) 2-rangelands area and grass species decrease 3-livestock decrease 4-loss of water supply 5\sand dunes movement and desertification 6-soil salinity 7-evaporation increase	Wade and valley areas in rain fed just like wade elmagadum \el malik \ abodom….etc in elodea and marawi localities .and wadi elguhab in dongola locality.	1-digging of water wells (in umgawaseer area 2-digging of water wells for settled groups around valleys. 3-underground storage of 4-water harvesting (*hafir*- water catchment) etc. 5-regulations for careful use of modern irrigation system 6-digging bore holes for drinking purposes' in low land area 7-Conducting socio economies studies
Health	High temperature High humidity Severe winds	Poverty, low income, human behaviors, clean water shortage, socioeconomic factors, air pollution, the use of chemicals substance like mercury	Decrease human outcome, increasing of respiratory, eye and communicable disease, allergic and skin disease, urinary tract infection.	Wade and valley areas in rain fed just like wade Elmagadum, Elmalik, Abodom etc. in Elodea and Marawi localities .and wadi Elguhab in Dongola locality.	Provision of basic health services, malaria eradication program, raising awareness and establishment of treatment centers, capacity building

	Climatic factors	Non climatic factor	Impacts	Vulnerability	Adaptation
Agriculture (rain fed, nd animal production)	1-flood 2- reduction in the length of growing seasons 3- increased frequency of drought 4- low and irregular rainfall 5- high and excessive evaporation 6- high temperature 7- severe winds 8-High temperature 9-High humidity	1-poverty 2-low income 3-gold mining 4-degraded soil 5-competition of grasses for wheat 6-high price of fuel and spare parts 7- misuse of natural resources. 8-low price of crops	1- decrease of soil fertility 2- change in agriculture productivity 3- migration 4- decrease of livestock 5- decrease of rangelands area 6- water canals affected by sand accumulation 7- soil salinity 8- sand movement towards (house\land\highroad Irrigation canals etc. 9- desertification 10- bank erosion and formation of islands in the course of the Nile 11- fisheries 12- migration 13- early flowering in palm trees.	Rain fed area (wadi-valley) in Marawi \daba\dongola localities Irrigation schemes (Marawi\dongola \go lid\dialog/ bur gag localities	1\ introduction of improved varieties 2\ improvement of irrigation (utilization of sprinkler and utilization of renewable energy (solar\airpowe etc) 3\ Establishment of shelter belt and community forest\private forest 4\ seed broadcasting (trees\shrub\range species 5\ introduction of crop rotation 6\ rehabilitation of existing agricultural project and establishment of new ones just like Umgawaseer agriculture project. 7\ extension programs 8\ Study of bank erosion 9\ livestock improvement 10\ fisheries improvement 11\ use ofwater harvesting techniques,

Khartoum State

Sector	Climate Factors	Impacts	Vulnerability & Location	Non – climate factor	Adaptation activities
Water	- Rain fall - Temperature - Drought - Floods	-Shortage of potable biological and chemical water pollution -Water borne diseases - Shortage of water for irrigation -Decrease of agriculture production -Degradation of ecosystem Deviation of available drinking water from standards which cause health problems	- IDPs settlements - Nile system - Ground water resources - Communities in outskirts of towns such as western Omdurman eastern Nile& northern county side - Urban people	- Exploitation and mismanagement of ground water resources - Insufficiency of sewage system which contribute to pollution of surface & ground water - Mismanagement of solid waste - High price of water supply service - Lack of drinking water extraction and purification infrastructure - Poverty - Sanitation problems	Water Harvesting in Rural Areas (areas of basic rocks) Quality of Drinking Water Outside the Network Stations to Monitor Natural Resources for Rivers (six stations)
Agriculture	- Rainfall variability (amount and distribution) - Increase in frequency of Floods - Drought - Fluctuation in the Nile water (due to fluctuation of rainfall in the Ethiopian plateau)	-Yield reduction Crop failure -Soil degradation - Loss of arable land - Range land degradation Nile system - Change in water level - Insufficient quantity and high cost of animal and agricultural product which increase poverty - Increase in frequency of floods leading to loss of property, infrastructure, irrigation channels, negative impacts on water services spread of water-born diseases	- Winter crops - Horticulture - Food plain cultivation - Natural and cultivated forest 0 - Rangelands - Nile system flood farmers - IDP s - Low income communities	- Expansion of mechanized agriculture - Large scale migration - Mismanagement - Mesquite invasion - Poverty - Food insecurity - Deforestation due to expansion of physical planning and other reasons and forest cover lass of 28% in 2011 - Insufficient quantity (sacristy) and price increasing of milk , meet and crops which contribute to sever poverty	Rural Water Harvesting to Increase Soil Fertility Upgrade the Fodder Sector Green Belt Project Subsistence Project from Biodiversity Sources (fish) Certified Seeds Items Production Project

Health	Temperature Drought Flood Dust storms	- Malnutrition - Meningitis - Respiratory diseases - Change of insect vector distribution pattern - Thermal stress specially for elderly people & infant - Spread of endemic diseases during disasters - Increase of infant mortality rate - Spread of endemic diseases in new site and bringing unexpected diseases that are not recorded in the state - Water borne diseases - Spread of fungal disease due to drought - Spread of cutanousleshmanisis due to rain delay -	- Infant - Children - Elderly people - Pregnant women - Mothers	- Migration - Poverty - Influence of refugees &IDPs - Food shortage - Water shortage - Sanitation problems - Sewage &drinking water - Supply and insufficiency - Range land degradation - Increase of food cost - Decrease of insect natural enemies such as reptiles & birds - Weakness & high cost of health services - The number s of patient exceed the capacity of health care system	- Early Warning of the Spread of Disease Vectors - Health awareness - Creating partnership at all levels to face health risks resulted from climate change - Vector control (chemical & environmental control) - Cases treatment - Insurance of medicines stock during disasters & emergency - Improvement of livestock health by vaccination, training of workers and veterinary guidance - Rehabilitation of rangelands - Afforestation
Urban	Temperature Rain fall Flood Wind-Dust-Storm Drought	- Indirect effect of climate change in other state cause Migration to Khartoum. - Bringing endemic Diseases & epidemics spreading. - Increasing population pressure on already weak services. - Increasing amount of waste. - High consummation rates of water & energy. - Overcrowding. - Physical expansion over agricultural lands. - Adverse effect on biodiversity & green cover. - Increase of living cost.	- Refugees - Displaced - Country side - Communities - Urban people -	- Weak infrastructure and services - Poor urban planning - Lack of resources (financial and technological) - Environmental deterioration and conflicts in other state increase rate migration to Khartoum	Forestry Projects Irrigated by Treated Wastewater "Sondos-Soba-wad dafeiah" Management of "landfill" Gas and Methane Gas in "landfills municipality" Closed-cell Afforestation Project Radwan Project for Bio-Gas, Electricity and Fertilizers Production from Animal Waste

E. Central States

Gezera State

Sector	Climatic factors	Non-climatic factors	Vulnerability, systems, areas, ...etc	Impacts	Adaptation
-Forests	Low and fluctuation of rains Flood -Sever Wind, -High temperature -Drought	1) Over utilization of natural resources (deforestation, overgrazing...etc) 2) conflict (competition for land and water). 3) High cost of afforestation, including supplementary irrigation. 4) Lack of technology that links sustainability with community needs 5) Fire hazard 6) Erosion by Wind Poverty and other social pressures 7) High cost of establishment, maintenance and sustainability.	River Bank and other forms of land degradation. All Nile forests of Gazira State - Poor physical environment -Poor tree performance & products -It threatens biodiversity, including endanger of some valuable indigenous species. -Diminishing of silvopasture areas -Most of natural forest areas, especially NW, NE Gezira and Managil.	-Shortage of forest products -Poor physical environment -Short of fodder, especially during summer. -Low productivity, food insecurity, poverty… -Pressure on natural vegetation -Scarcity of forest products including fodder. -Failure of new plantations -Deterioration of tree and vegetation cover - Desertification and sand movement -Shortage of forest products -Poverty -migration - conflict over resources	-Agroforestry technology (i.e. alley cropping) to ensure high productivity and sustainability. -Adopting forest and agroforestry agronomic practices, including water-harvesting techniques. -Developing community-level projects that answer community needs for food, forest products, simultaneously protecting the environment. -Selecting stress-tolerant species that adapting fluctuation hazards -Designing canals and drainage for improving utilization of floodwater and avoiding excessive water that damage newly tree seedlings. -Afforestation using water management technique(water -harvesting) -creating alternate and reliable sources of income for the farming community.

Irrigated Agriculture (Field crops & Horticulture sector) Traditional agriculture rainfed	- Increase temperatures, particularly during winter season. - Increase evaporation, -High wind speed -Short winter season - Floods - Rainfall (low or fluctuation), - Drought - Shorter Rainy season	Lack of strategies & absence of rationale plans, Non-statistical data & follow-up system, No adoption of technical package & released technologies, Weak link between research & extension, High production cost, Desertification, sand dunes movement & other form of land degradation, Excessive use of land, Mono-cropping, Over-use of external inputs, Poor practices, Lack of tech.-know	-Incidence of new insect pest at different crops (drought, striga, weeds, insects) -Crop seeds do not reach maturity. -Loss of crop lands due to floods -Crop damage /loss, decreased crop yield -Reduction in flowers abortion & fruit set. -Change of crop structure -Variation of irrigation water requirement -Low soil fertility Increase in the use of external input. -Insecticides -Water shortages, decrease water quality **<u>Vulnerable areas:</u>** Under drought prone areas of north Gezira and Managil localities.	Malnutrition and other disease related to nutrition, Food scarcity/food insecurity and hunger, Low yield of wheat push the country to import 1million $, Poverty, civil strife to urban areas Limiting horticultural areas Destruction of infrastructures and life loss, Lack of vegetables and fruits lead to vitamin deficiency, Land degradation, Desertification, Poverty, Migration to urban areas, Weaken human production capacity, Decreased income from crop selling	-Strengthening the Institutional and individual capacities to implement climate risk management responses in the vulnerable sectors. -Proper planning & rational strategies. -Adopting technical packages and other released technologies (i.e.). - Develop new technologies for coping with climate change (i.e. Alley cropping technology, developing heat stresses varieties and modern irrigation systems). -Protecting field and horticultural crops by adopting agroforestry technology and other form of tree planting activities.
-Water	Evaporation process (including its elements, wind, speed, temperature, relative humidity) - Recharge from rain fall Rain (climatic elements) Floods Drought	Water-misuse (improper harvesting techniques), unutilized water vulnerable to contamination) Sedimentation rational-use of Natural resource (i.e. soil erosion, removing of natural vegetation) Improper sewage disposal and possible, improper agricultural practices (pesticides, fertilizer), Over utilization, Pocket of saline ground water,	Topographic features (i.e. depression, sloping…etc). Poor designs for storage water (i.e. Haffirs & catchment basin) Soil composition (i.e. soil compaction) 1) Reduction of water storage reduces the saturation zone, thus affecting the domestic water use and agricultural areas (water availability and pumping cost), 2) Increase salinity 3) Poor and/or disappear of natural vegetation adjacent to river bank	Water loss through evaporation affecting negatively rainfed Agriculture (i.e. crop loss & reduction of rainfed crop area), Shortage of drinking water for both, animal & human being unsafe drinking water for human and animals causing disease & mortality for both human being and animals Reduction domestic water, agricultural areas, food	Proper planning and improving water-harvesting techniques, water-use efficiency. Raising awareness & building capacity of users (nomads, & communities)Other measures, such as borehole, irrigation, rainfall and water catchment basins. Introduce technology to enhance communal water storage systems. Proper management plan and strategies for monitoring, and optimizing water according to

		Unsustainable use for nonrenewable source, Nile Pollution due to industrial activities, Deforestation	Depletion and pollution for Gazira formation forced authority to utilize the non-renewable sources Low water quality and fishing activities, Unstable of pumps' intake areas	scarcity (leads to poverty) Salinity (low water quality), and poor vegetation leads to desertification Affecting the reserve water adversely. Threats to future generation Water shortage, high cost of infiltration and chemical treatments	availability and suitability. - Enforcement of environmental laws. Early warning system Initiation and encouragement of environmental civil societies. Upstream& downstream cooperation
Health -Epidemiology -Emergency -Environmental health	-Rainfall -Floods -Temperature -Solar Radiation heat wave of summer -Wind speed -Relative humidity -Drought	-Desertification -Water scarcity -Lack of safe water - Famine -Open deification & urination	All populations in poor condition, especially, people living in Small Island and other riverin.(a) Infant (b) under five (c) pregnant (d) preschool children (e) elder, and people with infirmities or pre-existing medical conditions -Increase occurring of climate-sensitive disease (major killers such as diarrheal, malnutrition, malaria). - Populations affected by civil strife are deprived of access to health services	Flood causes drowning and physical injuries, damage homes and disrupts the supply of medical and health services. Meningitis spread of flies (i.e. Typhoid fever, diarrheal diseases). Spread of some diseases e.g. diarrheal diseases / Arthritis, Reduction of human production capacity Floods contaminate freshwater supplies, heighten the risk of water-borne diseases, and create breeding grounds for disease-carrying insects such as mosquitoes. Epidemic diseases (i.e. diarrheal diseases), Increase in diseases (malaria, dysentery, cholera).	1) To raise awareness on climate change and human health 2) Heath education, and training 3) Support technology transfer 4) Education into water, sanitation and hygiene and livelihood projects . 5) Improve drug supply through Revolving Drug Fund 6) Increase capacity in local health policy and program implementation 7) Research on climate vector-borne diseases.

Sennar State

Sector	Climatic Factors	Non-climatic factors	Impact	Vulnerability, Area System	Adaptation programs
Agriculture	Fluctuation of rainfall Increase in temperature Increase in frequency of floods and drought incidents Increase of wind speed	Over grazing Deforestation Over cropping Desertification Lack of use of agriculture packages and inputs Lack of policies Deterioration of soil fertility	-Decrease in production and productivity Deterioration of quality of production Decrease of farmers income Deterioration of rangelands Change of cultivated crops Change of animal types Deterioration of vegetation cover	Sennar Locality: Fanguga, Jabel Mwia, Jabel Sagadi Eastern Sennar locality: Doba, Goz Abourwaf, Elbagia, UmmRahabah Dinder Locality: Albardanah Awra, Awd Masri, Hwbua	Water harvesting Cultivation of wind breaks and forests Introduction of improved crop varieties adapted to the new climatic changes Digging of *hafiers* for water storage Establishment of weather stations Capacity building and awareness raising programmes Establishment of demonstration farms Production of early maturing sorghum varieties Utilization of Zero- tillage technology and cultivation inside the farrows in order to improve sorghum production
Forestry	Fluctuation of rainfall Increase in temperature Increase in frequency of drought	Deforestation Negative impacts of agriculture on forestry Lack of implementation of regulations regarding cultivation of shelter belts Cultivation of forest's lands Pests	Reduction of forest areas Decrease of forest production	Nilotic forests (*Acacia nilotica* (*sunt* forest) Irrigated forests (Eucalyptus plantations) Savannah open woodland (*Dahrah* forests	Cultivation of wind breaks and shelter belts Implementation of regulation and rules Cultivation of forest lands Rehabilitation of nurseries Awareness programmes Legislations Water harvesting Use of alternative energy sources

Grazing	Fluctuation and decrease of rainfall Increase in temperatureIncrease of frequency of drought	Overgrazing Over cutting of forest Encroachment of agriculture over grazing lands Spread of insects and epidemic diseases Separation of Southern Sudan Wars Animals Malnutrition Spread of poisonous invasive rangelands species Significant Increase of animal numbers because of the separation of government of Southern Sudan	- Deterioration of rangelands Soil deterioration Poverty and ignorance of herders Lack of drinking water	Adali wa Almazmoum, Senjah, Sennar, Asuki and Dinder	Rangelands Rehabilitation projects for enhancing biodiversity (broadcasting of ranges' seeds) Provision of water sources Ranges' farms Awareness raising programme Capacity building Establishment meteorological stations Rehabilitation of migrating tribes routes Establishment of rangelands enclosures Water harvesting Good distribution of animals Improvement of veterinary services Improvement of animal species and rangelands species (reseeding of) Para vet training Introduction of solar energy for improvement of veterinary services (specific areas were identified around Almazmoum for improvement of veterinary services
Water	Decrease and variability of rainfall Increase of temperature Increase frequency of drought and floods	Increase of displacement Accumulation of animals around water resources Wars and conflicts Separation of Southern Sudan Lack of strategies and polices deforestation	Lack of watersources Reduction of ground water level Increase of epidemics Shortage of safe drinking water	Adali wa Almazmoum, Senjah, Dinder, Asuki	Digging and rehabilitation of hafiers Construction of dams Establishment of hand pumps Utilization of modern irrigation systems
Health	- Fluctuation of rainfall Increase of temperature Increase frequency of drought and floods	Increase of displacement Accumulation of animals around water resources Wars and conflicts Malnutrition	Lack of safe drinking water Pollution of drinking water Increase of epidemics Increase of morbidity and mortality rates Appearance of new diseases Spread of malaria,	Adali wa Almazmoum, Dinder, Asuki	Provision of safe drinking water Extension and awareness raising programmes Establishment of health units and insurance Provision of medicines -

			Bilharzia ,Kala-azar, Diarrhea and other water borne diseases		
Horticulture	Increase of temperature Increase of frequency of floods Increase of wind speed	River banks erosion Pests Lack of storage facilities Heightening of Al-Roseires Dam Bad roads inside the state affect the efficiency of transport of horticultural products to markets. Most of the roads become completely blocked during the rainy season	Reduction of cultivated horticultural areas Poor quality of horticultural production	Blue Nile, Dinder river banks	Construction of protecting bridge/barricade for orchard to reduce the destructive effects of flood Planting of shelter belts Need for production and introduction of new adapting varieties of both vegetables and fruits Rehabilitation of nurseries by improving propagation and irrigation methods Awareness raising programmes Rehabilitation of roads

Blue Nile State

Sector	Climate Factors	Impacts	Location	Non – climate factor	Adaptation options
Agricultural and food security	1 - Fluctuation of rain fall and distribution2 - Floods and water run off 3 - High temperatures 4 - Activity and speed of the wind	1- Low production and productivity 2 – conflicts between pastoralists and farmers 3- Migration from the country side to the cities 4- removal of forests 5 - The disappearance of desirable types of range land plants 6 –poverty and loss of livelihoods support and alternatives	1 – North Damazin include Ban gadid, Desa, Sero, Haroon and Shamar 2 – Eastern area include Azaza, Gary, Gadala, TaybaBillab, Hamda, Bados and Dawa 3- westDamazin include Agadi, Roro, Gerawa, Garabeen, Golly and Boot	1 - Effects resulting from war 2 – over grazing in large areas of the western state 3 -Weak extension services 4 - Spread of diseases and agricultural pests	- Testing of new crops varieties under different environmental conditions of the state - Theimpactofclimaticfactorsonthebehaviorandideology ofinsectsandsorghum midge American and African boll worm - Support Agriculture home garden (Gobraka)with agricultural inputs(seeds vegetables-corn lobby-Sesame. etc.) for women - Open animal routes and services provision - Establishment of modern Meteorological stations - organizing the communities in the form of cooperative societies to use modern technologies in agricultural production (zero tillage) - Application of farmers and herdsmen Schools Methodology - establishment of standard pastoral farm with new module - Establishment of shelterbelts - Establishment of social forests for theaffecte dcommunities - alternative energy sources (e.g. LPG) - Establishment of Botanical Garden to keep plantsources - Organization of women in the form of women's operative societies to provide the Extension services - provision of moving means for the Nomads (Mobile link)
Health	1 - Fluctuation in the amount and distribution of	1 - spread of malnutrition and disease	1 – North Damazin include Ban gadid, Desa, Sero, Haroon and Shamar	1 - Poor roads 2 - Illiteracy resulting frompoor	1 - Provision of medicines andvaccinesfordiarrhea, malariaandpesticidesto combat thewormFrendid 2 – provisionsforhealthinsurancefor local communities

	rainfall 2 - Floods 3 - High temperatures 4 - Activity and speed of the wind	epidemics(cholera - diarrhea-malaria) 2 - Outbreak of meningitis 3 - Spread worms Alfrendid and viral hepatitis and scabies	2 – Eastern area include Azaza, Gary, Gadala, TaybaBillab, Hamda, Bados and Dawa 3- west Damazin include Gadi, Roro, Grewa, Grabeen, Goly and Boot And other areas in Kurmk ,gassan and Baw	healthawareness 3- Weak healthservices 4 - Lack of healthstaff	1 - Training on ther apiddetection of malaria 2 Trainingvolunteersto detectearlycases of malnutrition 3 Training of health workers in cases ofepidemics 4Implementation of environmentsanitationcampaignsandhealth education
Water	1 - Fluctuation in the amountand distributionofrainfall 2 - Floods 3 - High temperatures 4 - Activity andspeedofthewind	1 - Filling reservoirs, dams, bysilt 2 - Change streams and valleys 3 - Analysis of rock and metalcomponents 4 –spreadof water - born diseases 5 - Increase theacidityofwater	1 – north Damazin include: Ban gadid, Desa, Sero, Haroon and Shamar 2 – eastern area include Azaza, Gary, Gadala, TaybaBillab, Hamda, Bados and Dawa 3- west Damazin include Gadi, Roro, Grewa, Grabeen, Goly and Boot	1 - Civil conflicts 2- limited water storage capacities at different levels of thestate 3 - Poor community awareness 4 - Lack of skills	1 - Drilling and installation of hand pumps 2 - Provide machineriesforthemaintenance andcleaning(excavations) of hafeer 3 -construction of Dams 4 - Raising community awareness forrationaluse ofwater 5 –Conduct technical training inChlorinationfor water managementcommittees 6 –establishment of flowforecasterfor the valleys

White Nile State

Sector	Climatic Factors	Non-climatic factors	Impact	Vulnerability, Area System	Adaptation programs
Agriculture	-Rainfall fluctuation - Increasing temperature - Winds and storms - Drought - Delay in rainy season	- Low training and awareness-Use of deep plowing in Goz. - Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	-Delay in rainy season -Decrease in humidity and increase in evaporation. - Soil infertility -Failure in crop production -Low survival rate of rainfed crops. -Low standards of living. - Desertification and desert creeping that affect . -Competition in natural resources	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar, Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	-Provision of improved seeds to small-scale farmers. - Application of water harvesting technology of in areas with few rains. - Construction of roads to facilitate the movement during the autumn. - Agricultural extension services and field demonstration and training of farmers - Estaqblishment of services center to the farmers.
Range and pasture	-Rainfall fluctuation - Increasing temperature - Winds and storms - Drought - Delay in rainy season	- Low training and awareness-Use of deep plowing in Goz. - Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	Decrease in fodder and rangeland area Mortality of rangeland seedlings.	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar, Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	-Provision of water in the rangeland -Introduction of high nutrients fodder in the rangeland -Construction of nurseries. -Construction of fences to fix sand dunes and prevent desert creeping. -Awareness raising campaign. -Activation of rangeland protection act.
Animal Resources	-Rainfall fluctuation - Increasing temperature - Winds and storms	- Low training and awareness-Use of deep plowing in Goz.	- Deterioration in animal health - Spread of animal diseases and deaths -Disappearance of wildlife	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar,	-Establishment of veterinary care centers(Project vaccination - rehabilitation of slaughterhouse) -Veterinary extension

	- Drought - Delay in rainy season	- Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	-Weak breeding for varieties with high productivity.	Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	-Establishment of fish farms
Water	-Rainfall fluctuation - Increasing temperature - Winds and storms - Drought - Delay in rainy season	- Low training and awareness-Use of deep plowing in Goz. - Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	-	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar, Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	-Establishment of an integrated water stations on the. -Construction of dams on streams and Lagoons to save water for drinking and feeding -Drilling boreholes for drinking and
Helth	-Rainfall fluctuation - Increasing temperature - Winds and storms - Drought - Delay in rainy season	- Low training and awareness-Use of deep plowing in Goz. - Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	-	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar, Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae	-

				SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	
Forestry	-Rainfall fluctuation - Increasing temperature - Winds and storms - Drought - Delay in rainy season	- Low training and awareness-Use of deep plowing in Goz. - Illegal felling. - Poverty and low income resources - Migration from rural to urban areas. - Spread of pests and diseases	-Decrease in forests products -Ecological imbalance - Low survival rate of seedlings. - Spread of forest fire	-Um rimta, Eldoeim Kosti Tandalti, Elsalam, Elgabelin, Elgzala, Abiddammirak, Ommhanie, RodatElmktar, Bagbagt, Eltbrate Aboraia, EialEzirege, Omdbakire Om dbaker, Elmrabe, Elrasrsa Korwdgber, Geziraba, Salima, Omnaam, Wddalbliblie, Omzoribae SalimaElhilla, WdGebre, wd sarih Habila, Egit Eltair, Elzriga	-Planting of forest trees around the rainfed projects -Awareness raising. -Establishment of community forests. -Encouragement of forests reservation -Rehabilitation of community nurseries.