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Sudd Wetland Monograph – Volume 1: Overview of the Sudd Wetland – Ecosystems and Land use

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FOREWORD

Natural ecosystems, particularly wetlands, play a central role in the current and future development of South Sudan and the Nile basin countries. Due to their unique ecological conditions, wetlands form transitional zones between land and water that create rich and diverse ecosystems characterised by hydrology, soils and vegetation, serving as habitat and breeding grounds for fish, amphibians and migrating birds. Wetlands help to offset the human effect on rivers by cleansing the surrounding ecosystems and are as vital to the health of all other biomes, wildlife and humans in the Nile basin and beyond. Wetlands provide natural buffers, similar to a sponge that absorbs water during rainy seasons, thus prevent flooding, while reducing impacts of drought through a steady release of water in dry seasons, to help keep river levels normal while filtering and purifying the surface water.

Defined by NBI as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions", wetlands are found throughout the Nile ecoregions. They encompass a broad range of different habitats in the basin, including a variety of swamps, marshes, seasonally inundated grasslands and sedgelands, swamp forests, floodplains, deltas and the wetland edges of lakes and rivers.

From an economic perspective, wetlands form a key part of 'natural' water infrastructure in the Nile basin – the stock of equipment, facilities and services that are required for the region's societies and economies to survive, grow and prosper. Wetland ecosystem services, "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment 2005a), range from water storage, flow and quality regulation, through watershed protection, drought mitigation, flood control and disaster risk reduction, to the generation of a wide range of goods, products and raw materials that underpin local livelihoods, large-scale industrial production and even international trade flows.

Unfortunately, and despite these vital functions, wetlands are in retreat the world over. According to the authoritative Ramsar Global Wetlands Outlook (2018), 35% of the world's wetlands were lost between 1970 – 2015, resulting in a staggering loss of 81% of inland wetland species populations. The Nile basin shows a similar trend with wetland land cover classes also having decreased by 35% between 1985 and 2015 (NBI, 2021). The loss rate is accelerating, driven by population increase, urbanisation, and changes to land and water use and agriculture while the ones left are under threat from water drainage, pollution, unsustainable use, invasive species, disrupted flows from dams and sediment dumping from deforestation and soil erosion.

Within the Nile basin, 68 major wetlands of relevance for the hydrological system have been identified by the riparian countries, concentrated in two areas: the Equatorial Lakes region and South Sudan; and yet wetlands comprise only 4% of the area of the entire watershed. Considering the vital role these wetlands play in water quality and stabilising river flow, the Nile basin Initiative (NBI) decided to proactively establish a framework to prevent further encroachment and start to reverse the degradation through a Wetland Management Strategy approved by the Nile Council of Ministers in 2013. As part of the efforts to implement that policy, NBI with support from German International Cooperation (GIZ), on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) under the International Climate Initiative (ICI) has been working with South Sudanese stakeholders – the South Sudan Wetlands Working Group – to advance and strengthen knowledge regarding wetlands of transboundary significance within the world's youngest nation; specifically the Sudd.

Comprising an area of about 60,000 km^2 and an increase of 50% area during the wet season, the Sudd is Africa's largest wetland. It has been designated as a Ramsar site since 2006 due to its ecological uniqueness and importance in a biodiversity rich landscape that expands from Mongalla in the south, to Malakal in the north. It consists mainly of rich, undisturbed, inaccessible habitats for flora and fauna; and

it is and important wintering ground for migratory birds. For the more the 1 million inhabitants of the Sudd, a wetland of transboundary significance, it is an important source of income and livelihoods. The Sudd contributes provisioning services to its inhabitants in the form of food (fish, game and fruits), freshwater, building materials and medicinal products. From a basin wide perspective, the Sudd also has a great value as it provides regulating ecosystem services such as water flows, nutrient retention, purification of water and climate regulation.

This Sudd Wetlands Monograph provides a framework for the sustainable management of natural wetland related resources and planning in the Sudd, and the implementation thereof should be a premise for more focused wetland development planning in the future. The document should inform technical negotiations and decision-making over Sudd Wetlands use and benefit sharing based on reliable, non-biased technical data. In this way the Sudd Wetlands Monograph can become the backbone for national sustainable development, environment protection and transboundary wetland cooperation within South Sudan and in the Nile basin. Ultimately, it represents an important pillar in support of South Sudan to strengthen its national management capacities in benefit of nature and the citizens' well-being and livelihoods.

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Minister of Water Resources and Irrigation
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Valuable contributions were made by the South Sudanese Stakeholders through the South Sudan Wetlands Working Group – during different face to face and online meetings organised for this purpose. The implementation team benefited from the guidance of Mr. Francis Wajo, water resources regulator; as well as Mr. Thomas Jang Kan, head of water resources management; Mr. Paul L. Demitry, Deputy Director for Biodiversity, Ministry of Environment and Forestry; and Mr. John Ater, Ministry of Environment and Forestry focal point for the Ramsar Convention - all members of the South Sudan Wetlands Working Group.

Our sincere appreciation also to the colleagues from the Ministry of Livestock and Fisheries, Ministry of Transport, Ministry of Wildlife Conservation and Tourism, Ministry of Agriculture and Food Security; and Directorate of Climate Change, Ministry of Environment and Forestry of South Sudan who have supported the development process of the Sudd Monograph and Management Action Plan. The consultations and validation process also benefited from inputs by colleagues from the University of Juba, the South Sudan representative of the Nile basin Discourse (NBD); as well as other actors from civil society.

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Sylvester Matemu
Executive Director
Nile Basin Initiative

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ACRONYMS

CBD	Convention on Biological Diversity
CBO	Community based organisation
CEPA	Communication, Education, Participation and Awareness
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CMS	Conservation of Migratory Species
DPSIR	Drivers – Pressures – State – Impact – Response
EIA	Environmental Impact Assessment
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
Ha	Hectare
IBA	Important Bird Area
IGA	Income Generating Activity
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
LULC	Land use land cover
MEA	Multilateral Environmental Agreements
MoU	Memorandum of Understanding
NAPA	National Adaptation Programme Actions
NBI	Nile Basin Initiative
NDCs	Nationally Determined Contributions
Nile-COM	The Nile Council of Ministers
Nile-SEC	The Nile Basin Initiative Secretariat
Nile-TAC	The Nile Technical Advisory Committee
NGO	Non-Governmental Organisation
SDGs	Sustainable Development Goals
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total economic value
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
Yr	Year

1. INTRODUCTION

1.1 Overview of the Sudd

Wetlands in the Nile basin are highly productive ecosystems and they play a critical role in sustaining the livelihoods of its people, contributing significantly to national economies. In addition to sustaining livelihoods and providing economic benefits, these wetlands support extensive biodiversity with high conservation value and their sound management can contribute to climate change adaptation and mitigation schemes.

The Nile basin water resources have a history where control have been predominantly accomplished through hegemony and colonization processes with strong political, military and economic dominance. As a result of mounting pressures on the Nile basin water resources, this has been the cause of prolonged diplomatic instability with fragile relationships between the Nile basin countries and a constant potential for conflicts arising from unsuccessful negotiations, thereby destabilizing the area and hampering the vision of joint commitment and the sustainable future of Nile basin water resources. In recent years however there has been an intensification of efforts/interventions to drive the coordination of Nile basin water resources management, to reveal the synergies of actions taken and show the tradeoffs of working together. South Sudan has a major role to play in this process.

About 20% of the Nile basin lies within South Sudan, 7% of which is covered by vast expanses of tropical freshwater wetlands, making it regionally significant and an important part of the Nile basin water network. It is the major source of water for domestic, livestock and wildlife use, and an important source of fish. The Sudd (8.3804° N, 30.7120° E) is an inland delta that is only located within South Sudan, however in the context of the entire Nile basin, the Sudd wetland is particularly significant given its ecological and strategic importance.

Figure 1: Aerial photo of the Sudd (Photo source: HYDROC)

The Sudd is an important habitat for biodiversity and has therefore been designated as a Ramsar Wetland of International Importance on 5 June 2006 for its tremendous value on local, regional and international scale for meeting the eight RAMSAR criterion to be designated as such (MEF, 2018).

Table 1: RAMSAR criterion (Ramsar, 2006)

1	Contains a representative, rare or unique example of natural or near-natural wetland in an appropriate biographical region.	The Sudd is the best-known natural wetland in Africa for its size and location on the longest river in the world. The wetland is an important source of water for domestic use and wildlife as well as livestock production especially for the Nilotic cattle that play a significant role in the cultural history of the Nilotes in its catchment.
2	Supports vulnerable, endangered or critically endangered species or threatened ecological communities.	The Sudd supports rich biota and is an important habitat for endangered and vulnerable wildlife species. Among the mega-herbivores found in the wetland, the elephant (Loxodonta africana) is vulnerable. Some antelope species that use the wetland are listed by the IUCN as vulnerable which includes the Mongalla gazelle (Gazella rufifrons albonotata), the tiang (Damaliscus lunatus tiang), the Nile sitatunga (Tragelaphus spekii) and the shoebill stork (Balaeniceps rex).
3	Supports population of plant and/or animal species that are important for maintaining biological diversity of a biographical region.	The area supports plant species which are important for the biodiversity of the Sudd region. The Sudd is the home of Suddia, a plant genus which is only known to exist in the Sudd region. The Nile lechwe (Kobus megaceros) is threatened and is endemic to the Sudd. This antelope species is of potential socio-cultural value to the Shilluk tribe and is utilised on a very limited scale as a source of animal protein and skins for the royal household. Over 350 plant species have been identified in the Sudd area. It is also home to over 100 fish species, 100 mammalian species and 470 bird species and an unknown number of reptilian and amphibian species. Over 120 insect species of economic importance have been identified in the Sudd area of which 63 are mosquitoes.
4	Supports plant and/or animal species at a critical stage of their life cycles or provides refuge during adverse conditions.	The Sudd provides an important breeding habitat and support the largest population of resident species of shoebill stork (Balaeniceps rex) in Africa. It also acts as stopover and wintering ground for various migrant water birds such as white pelican (Pelecanus onocrotalus), black crowned crane (Balearica pavonina), white stork (Ciconia ciconia) and white-winged black tern (Chlidonias nigra) among others. Migratory mammals depend on the wetland for their dry season grazing. Among these are white eared kob (Kobus kob leucotis), tiang (Damaliscus lunatus tiang), elephant (Loxodonta africana), Mongalla gazelle (Gazella rufifrons albonotata) and zebra (Equus bruchelli). The Sudd is also a habitat for many species of freshwater mammals, reptiles and amphibians such as hippopotamus (Hippopotamus amphibius) and crocodile (Crocodylus niloticus) which depend entirely on the wetland for their livelihood. The diverse invertebrate communities support the large fish populations of the wetland and freshwater crabs of the genus Potamonautes occur in the wetland. Also, rare

		freshwater shrimps such as Caridina nilotica, Palaemon nilotica and Cyclestheria hislopi are found in the wetland.
5	Regularly supports 20,000 or more water birds.	The Sudd is an important site/stopover area for water birds including significant numbers of migratory species. It is of great ornithological importance as it has over 20,000 water birds throughout the year. Estimates show that the Sudd wetland supports among others about 300,000 open bill storks (Anastomus lamelligerus); 100,000 cattle egret (Bubulcus ibis); 100,000 spur-wing goose (Plectropterus gambensis) and more than 20,000 black crowned crane (Balearica pavonina). About 1.7 million glossy ibis (Plegadis falcinellus) spend the dry season in the Sudd wetland (Howell et al, 1985; Postel, 1992).
6	Regularly supports 1% of the individuals in a population of one species or subspecies of water bird.	According to Wetlands International's Waterbird Population Estimates (third edition, 2002), the world population of shoebill stork is between 5,000 and 8,000 birds. The number of shoebill stork (Balaeniceps rex) in the Sudd alone is estimated to be over 5,000. The increase in shoebill stork in the wetland is said to be a result of increased wetland area that was caused by the high floods of the early 1960s.
7	Supports a significant portion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	Fish diversity in the Sudd appears to be a response to the favourable environmental conditions offered by the mosaic of habitat types. The fish communities in the wetland are comprised of 31 Siluroids, 16 Characoids, 14 Cyprinoids, 11 Momyrids, 8 Cichlids, and 7 Cyprinodonotids. Fish species whose life cycles start and end in the wetland belong to the following genera: Polypterus, Heterotis, Hyrocymus, Alestes, Distichordus, Citharinus, Labeo, Sarotherodon, Synodontis, Auchenoglaris, Oreochromis, Ctenopoma, Clarias and Protopterus. Eight dwarf fish species of the Nile are endemic to the Sudd wetland and are Cromeria nilotica, Nannaethiops unitaeniatus, Barbus stigmatopygus, Chelaethiops bibie, Andersonia leptura, Aplocheilichthys loati, Epiplatys marnoi and Electris nanus. Nilotes of the Sudd who have no cattle depend on fishing for their livelihood. Although fishing in the wetland is mostly of subsistence nature, commercial fishing has also been practiced since the 1970s.
8	Fish food source, spawning ground & nursery	The permanent and seasonal aquatic systems of the Sudd wetland play important roles in the life cycles of identified wetland fish species. Different habitat types from open water, riverine, lacustrine to palustrine offer spawning, rearing, growing, feeding and survival grounds for over hundred species of fish in the Sudd area. Clarias, Polypterus and Protopterus Spp, for example, are amphibious because they aestivate in the mud during the dry season. Also found in drier reaches of the Sudd is the annual fish Nothobranchus that spends the dry season in the egg stage. The different species found in the Sudd have a rich supply of food that appeared to have evolved with them. The diverse populations of microphytes, benthos, invertebrates, mollusks and detritus feeders probably created the diversity in the herbivore, omnivore and carnivore fish consumers. Recruitment, growth and survival of most fish species take place within various

		habitat types of the wetland, though lateral and longitudinal migration may take place.

The people living within and adjacent to the Sudd region are entirely dependent on the Sudd wetland and its annual floods and rains for their socio-economic and cultural activities. The wetlands of South Sudan are responsible for controlling and normalizing water quality, and significantly attenuating flows of the White Nile and its tributaries, reducing flood peaks and supporting dry-season river flows, thereby minimizing the seasonal variation in the flow of the White Nile. (UNEP, 2018). In addition, the Sudd is a key element of the hydrology of the River Nile. The dominant contributor to the water balance of the Sudd is the White Nile. Nearly half of the water that enters the Sudd at Mongalla is lost through evapotranspiration on its course thorough the wetland system. A number of studies have attempted to understand the hydrologic processes of this wetland. Still the complexity and vastness of the system makes it one of the least understood wetlands in the Nile River basin.

The Sudd is also regarded as pristine and untouched areas in terms of industrial or agricultural development (Moghraby et al. 2006). It has extensive freshwater and grassland habitats that are characterised by the seasonal rain fed flooding. A wide variety of adaptive responses by humans and wildlife have evolved to cope with the Sudd's resource dynamics. Under these adaptive strategies, carrying capacity for herbivores (both domestic and wild) has been maximised and current herbivore numbers rival population numbers across other African countries (UNESCO, 2017). However, floodplain degradation leading to habitat alteration and disappearance of wetland are increasingly becoming a greater risk as a result of flow and flood control, pollution, development and cultivation.

Poorly managed human activities to sustain livelihoods and build economies has a major share in the ongoing destruction of wetlands in the Nile basin. For the Sudd, access is a major challenge that makes management difficult. Due to activities such as encroachment for settlement, conversion into agricultural lands owing to population pressure, grey infrastructural development and weak implementation of policies protecting wetlands, wetlands are being degraded at an alarming rate. Floodplain degradation leads to habitat alteration and the disappearance of wetlands. Loss of wetlands means losing the valuable ecosystem services that they provide and this impacts negatively on Nile basin communities. It is usually the poorest people, that live close to and depend directly on wetland ecosystems to sustain their livelihood, that are the least able to cope with the impacts of wetland loss.

Climate change adds another dimension to the continuing destruction of wetlands and therefore brings a greater imperative for their protection and sustainable management. Across the Nile basin and also for the Sudd, there is growing evidence that climate change will result in more intense droughts and floods, causing serious damage to wetland habitats. Better management and protection of wetland ecosystems is required to help vulnerable Nile basin communities to build resilience and adapt better to the impacts of changing climate.

Various historical plans for the Sudd exist and since the creation of South Sudan, various sectoral developments, some of which could have potentially detrimental effects on the Sudd, have been planned. Major threats to the Sudd include oil exploration – the Sudd contains South Sudan's largest oil block – and the Jonglei Canal project, which was not finalised, but would reduce wet and dry season flows by 20% and 10% respectively, thus impacting the wetland's ecology and consequently its inhabitants. (Ramsar, 2006) These threats may influence wildlife or activities such as pastoralism, fisheries and agriculture which will have a direct effect on the inhabitants of the Sudd region. Changes to this large wetland landscape, could also potentially have significant impacts on downstream countries such as Sudan and Egypt (Mohamed et al, 2005).

Wetland protection therefore needs to be made a priority in development planning and implementation to find and maintain a balance between wetland protection and socio-economic development. This Sudd Monograph aims to highlight some of the fundamental issues, challenges and emerging threats to the Sudd which will enable all acting stakeholders to make decisions on the Sudd based on improved knowledge about

its hydrological functions and the interlinkages with the ecosystem services that it provides, thereby progressing initiatives for the conservation of the Sudd.

1.2 Sudd Wetlands Monograph Purpose and Development

The Sudd Monograph is a key output of the NBI's Wetlands Programme support to South Sudan through the South Sudan's Wetlands Working Group. This "Volume 1 – Sudd Wetlands Monograph" is the 1st of a 4-part series that aims to develop a comprehensive information and knowledge base on the existing conditions of the Sudd that can be used as an aid by decision makers to help guide future planning and development initiatives. Supplementary volumes follow with specific focus on detail aspects such as hydrological modelling, TEEB and environmental flows. These documents will be important sources from which to reference critical information that is required to ensure sound management of the Sudd.

Volume 1 – Sudd Wetlands Monograph

Volume 2 – Sudd Eco-Hydrological Planning Model

Volume 3 – The Sudd Economics of Ecosystems and Biodiversity

Volume 4 – The Sudd Environmental Flows Assessment

The development of the Sudd Monograph has been based on active and sustained stakeholder engagement by consulting with local government officials, NGOs and local communities. Additional consultative meetings and discussions were held with officials from national and regional agencies. This approach enabled the use of significant local expertise and knowledge to understand local issues, challenges, and solution opportunities. The development of the Sudd Monograph can thus be seen as a collaborative effort among NBI and the Sudd stakeholders at regional, national, and local levels.

The development of Volume 1 entailed a detailed review of all relevant documents and reports that are available in the public domain to gain a thorough understanding of the Sudd features, key issues and ongoing and planned efforts to address them. A detailed list of the documents that have been reviewed is contained in the references section at the end of this report.

1.3 Outline of the Report

The Sudd Wetlands Monograph and Management Strategy consists of the following chapters:

Chapter 1 gives a brief overview of the Sudd, outlining the purpose of the document and how it has been developed.

Chapter 2 provides the latest information that represents the physical baseline of the Sudd by focusing on various environmental aspects including climate, hydrology, biological features, ecosystem values and services etc. The findings of this section provide the information required to understand the functioning of the wetland landscape.

Chapter 3 provides an overview of the policy, legal and institutional arrangements that are in place. It also specifies the various stakeholders that are involved with wetland conservation and management.

(Photo source: HYDROC)

2. STATUS OF THE SUDD WETLAND LANDSCAPE

2.1 Locality and Topography

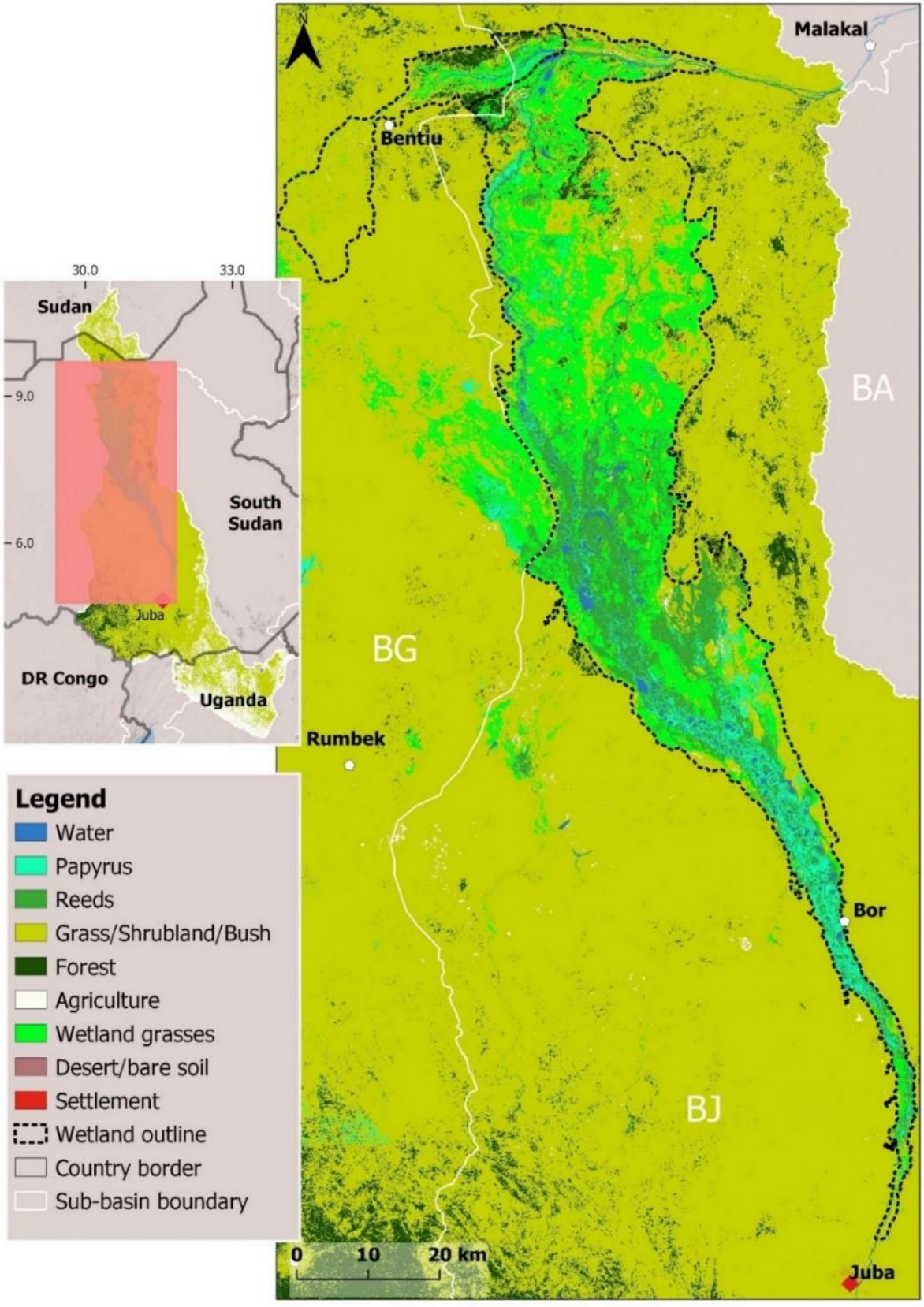

Figure 2: Locality of the Sudd in 2015 (NBI, 2020a)

The Sudd wetland is the largest tropical wetland in the world, covering a vast area of approximately 60 000 km² and situated in South Sudan in the lower reaches of Bahr el Jebel (MEF, 2018) at an elevation of 380m-450m (Ramsar, 2019). The nearest large towns are: Bor (Jonglei State), Malakal (Upper Nile State) and Rumbek (Lakes State). The wetland area is mostly flat, sloping gently to the north with a gradient of 0.1m/km (Riak, 2006).

The Bahr el Jebel sub-basin stretches over Uganda, South Sudan and Sudan and comprises the upper reach of the White Nile River (Rebelo & McCartney, 2012). It crosses a mountainous region between Nimule and Juba before spreading into the Sudd wetland area. From Juba to Bor the river meanders from side to side through an incised trough. From there the water flows in various meandering river stretches, channels and lagoons. During flood levels, the river spills over its alluvial banks and the floodplains receive water.

Between Bor and Shambe the Bahr el Jebel is delta like, forming an area of unrestricted flooding. During the flood season, large areas are inundated through spill. In this area the average slope of the ground level is 0.1 m/km (Petersen et al., 2008a). Wide papyrus beds, lagoons, and meandering or submerged channels characterise the wetland area between Shambe and Lake No. Just north of Shambe, the Bahr el Zeraf splits from the main river and flows in north-north-westerly direction, only to join the White Nile again downstream of Lake No. At Lake No, the Bahr el Jebel is joined by the Bahr el Ghazal from the west.

There is an ongoing debate about the boundary between the Sudd and the neighboring Bahr el Ghazal swamps and their interconnectedness. In some cases the systems are connected even during the dry season (Sosnowski et al., 2016) however, water flow from the Sudd into the Ghazal basin is very unlikely due to dense vegetation and high evapotranspiration (Petersen et al., 2008b). After the confluence, the riverbed becomes more defined with relatively high banks and the Bahr el Jebel is known as the White Nile (in literature the names Bahr el Jebel and White Nile are often used interchangeably). Further downstream to the east, the White Nile is joined by the Sobat and leaves the swamps at Malakal.

2.2 Wetland Extent and Land Use/Cover

The name “Sudd” is derived from an Arabic word meaning barrier or obstacle and historically it has been an obstacle for exploration. It is characterised by a thick layer of floating vegetation that covers the area which includes permanent marshlands and swamps, seasonal inundations and a braided system of rivers. This vast wetland covers roughly 10 % of the total land area of South Sudan (Wilusz et al., 2017). However, defining clear boundaries for the Sudd wetland is a challenge. Due to the wetland size, limited accessibility, and political instability in South Sudan, collecting enough in-situ data to delineate the flooding extents has not been possible (Di Vittorio & Georgakakos, 2018). Previous studies about the Sudd have demarcated relatively small areas of 8,000 km² (Allam et al., 2018) or relatively large areas of 105,000 km² (Shamseddin et al., 2006) as the wetland boundaries. Other studies (Rebelo et al., 2012; Wilusz et al., 2017) delineated the watershed by the catchment boundary to the east of Bahr el Jebel and the west of Bahr el Zeraf with Lake No as the northern limit and Juba as the southern boundary. Malakal, after the confluence with Sobat can be seen as the downstream endpoint of the Sudd.

The exact area of the Sudd is not known as it is subject to fluctuations of river discharge and rainfall (Riak, 2006). For at least ten months a year, 11.9 % of the Sudd wetland is flooded while 29.2 % is flooded during the wet season (Wilusz et al. 2017). Areas of higher elevation have flood frequencies less than 24 % of the time and can thereby be defined as intermittent flooding (Wilusz et al. 2017). The extent of inundated areas in the Sudd corresponds to seasonal rainfall patterns upstream and within of the Sudd. The wetland area expands more than 4 times the size of the permanent swamps in response to seasonal flood pulses (Rebelo et al., 2012). Di Vittorio and Georgakakos (2018) show that the best statistical relationship between inflows and outflows in the Sudd is when inflows are lagged forward by three months. This suggests that the total flooded area of the Sudd is at its maximum extent three months after the water inflow into the Sudd is at its annual peak.

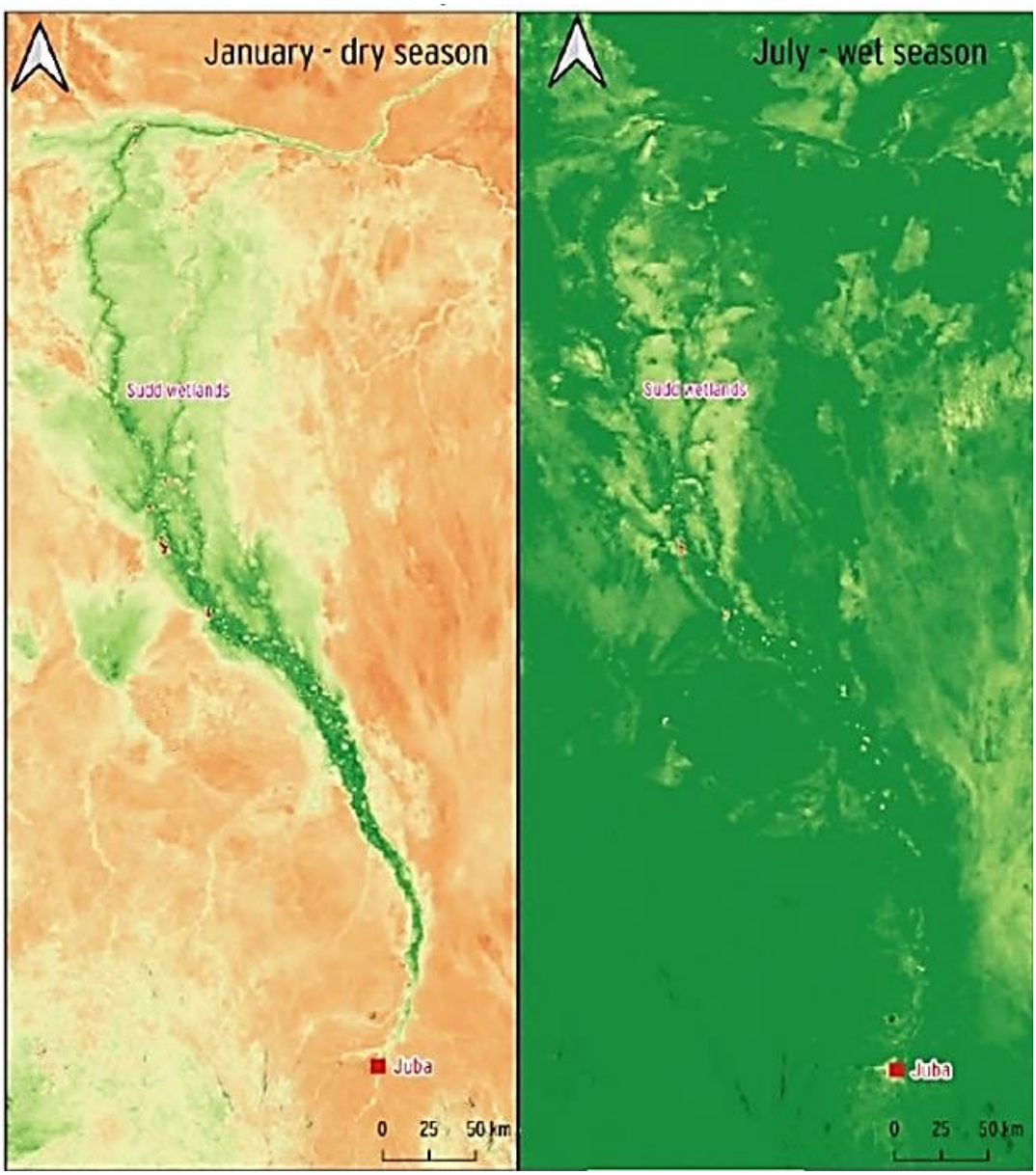

Figure 3: Vegetation cover of the Sudd as a result of seasonal climatic variation (NBI, 2020e)

The flooding begins around May/June with the start of the rainy season and increases in magnitude, as the river flows increase from October to December (Sutcliffe & Parks, 1999). Annually, the maximum extent of flooding occurs between October and December. In September, the area of open water is lowest but at the same time the expanse of vegetated area is greatest during this month. In December and January, the area is flooded and mostly covered by open water while vegetated area is at its annual minimum. However, different areas may flood at different times of the year. If all sites are included that have been inundated at least once during a 12-month period, total wetland area can be larger than 50,000 km^2 (Rebelo et al., 2012).

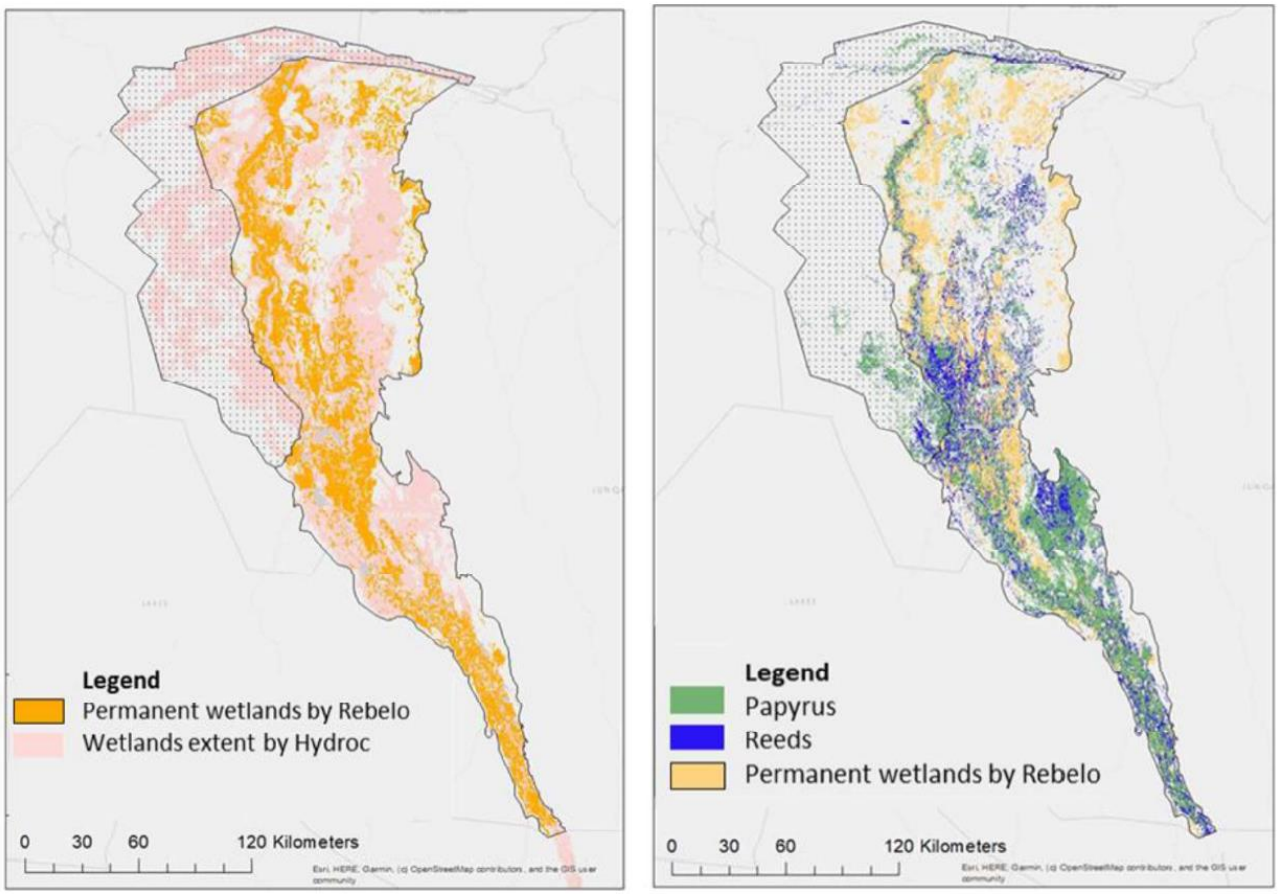

Figure 4: Left: Sudd extent from Rebelo et al (2012). Right: Sudd extent from Sentinel-2.

Estimating the total size of the Sudd wetland involves many uncertainties and difficulties, due to the great extent of the wetland, its isolated location, uncertainty in wetland delineation, the variability in intra-and interannual flood levels, the poorly resourced monitoring network and political instability. Several attempts have been made in the past to assess the wetland area. In a literature review, Sutcliffe (2009) concluded that estimates of the wetland extend range from approximately 7,000 km^2 to 90,000 km^2.

Methods for estimating the wetland extent include remote sensing (Di Vittorio et al., 2018; Rebelo et al., 2012; Wilusz et al., 2017), hydrological modelling (Sutcliffe & Parks, 1999) and a combination of remote sensing of evaporation and hydrological modelling (Mohamed et al., 2004). Table 2 shows a summary of results from different studies on the extent of the Sudd.

Table 2: Comparison of monthly minimum (km^2) & maximum (km^2) estimates of Sudd flooded area.

Reference	Study period	Study area*	Peak flooding	Wetland area	
				min	max
Di Vittorio & Georgakakos (2018)	2000-2016	NA	Oct-Dec	12,500	25,900
Wilusz et al. (2017)	2007-2011	60,100	Sep	4,200	28 900
Sosnowski et al. (2016)	2000-2014	NA	Dec	16,000	45,000
Rebelo et al. (2012)	2007-2008	59,400	Jan	22,900	32 700
Shamseddin et al. (2006)	2001-2005	105,900	Oct	15,600	24,700
Sutcliffe & Parks (1999)	1961-1980	NA	Nov	17,400	28,700

*The study area (km^2) is the area that the respective authors have defined as the boundaries for the Sudd.

A dramatic increase of the White Nile flow due to high rainfall over Lake Victoria in 1960/61 impacted the extent of the Sudd substantially. Immediately after these high rainfall years, the area of the Sudd tripled. Subsequently in- and outflow also almost tripled in the early 1960s. At that time, the highest flow values were > 60,000 and >30,000 10^6 m^3/ year, for in and outflow respectively. Overall, the wetland area doubled during the second half of the 20th century, compared to the first (Mohamed & Savenije, 2014).

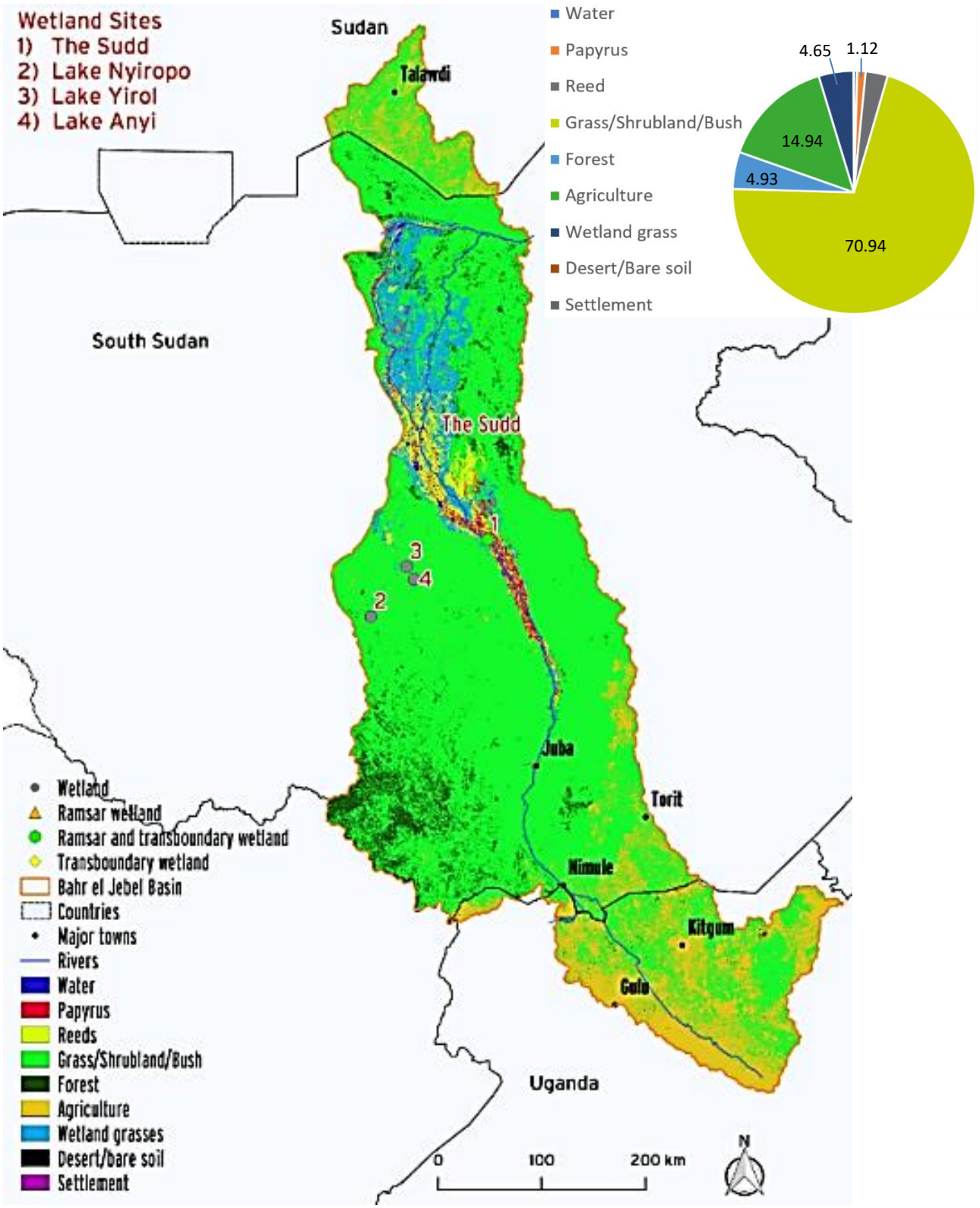

Figure 5: Percentage land cover of the Bahr el Jebel sub-basin (NBI, 2020e)

The land cover of the Bahr el Jebel consists of 70% grass, shrub and bushland, 15% agricultural land, 5% forests and 9% wetland area (NBI, 2020e).

The areas surrounding the Sudd wetland are heavily utilised for grazing and crop production. They also form the major settlement areas and contain trading centers like Bor town. Most of the tribes living within the Sudd are nomadic and move with their large herds of cattle in response to the annual discharge of Bahr el Jebel and rainfall. Fishing is the second most important occupation of the inhabitants of the wetlands especially the Shilluk and Nuer. Subsistence hunting is another activity by the Nilotes of the Sudd catchment. Crop production is not an important occupation of the Nilotes though some subsistence agriculture is carried out in the highland area during the wet season. Agricultural potential of the area is limited by the vagaries of the climate, soil fertility, pests, weeds and diseases (MEF, 2018).

There are a number of lakes, especially in the Eastern and Western Lakes States of Sudan, which are connected to tributaries of the Sudd. Three lakes of local importance are listed in the African Wetland Atlas (Hughes & Hughes, 1992), as these lakes are part of the Sudd system, they have international relevance.

Lake Nyiropo

This small lake is 5 km long and 1.5 km wide at high water, and is oriented SW-NE at an altitude of 500 m. It is a shallow lake, probably does not exceed 3 m in depth and drains to the Lau River, 2 km distant from its northern end. It is situated 150 km west of the Bahr el Jebel as it flows past Bor. It is a permanent lake, with dense beds of aquatic vegetation and fringing swamps. It has a narrow peripheral floodplain and is unprotected (Hughes & Hughes, 1992).

Classification of Lake Nyiropo

Inland wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover of Lake Nyiropo

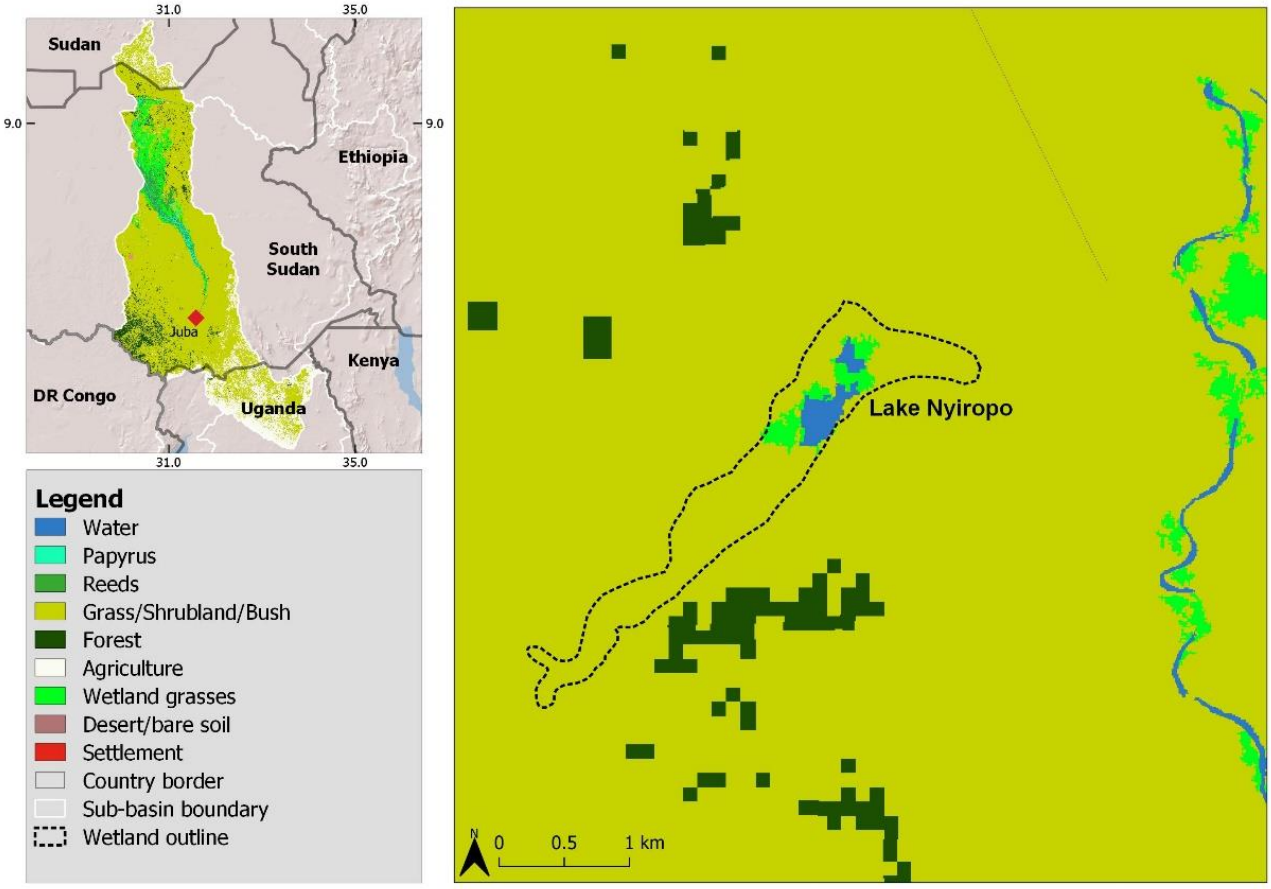

Figure 6: Land cover of Lake Nyiropo in 2015 (NBI 2020a)

Change Trajectories of Lake Nyiropo from 1985-2015

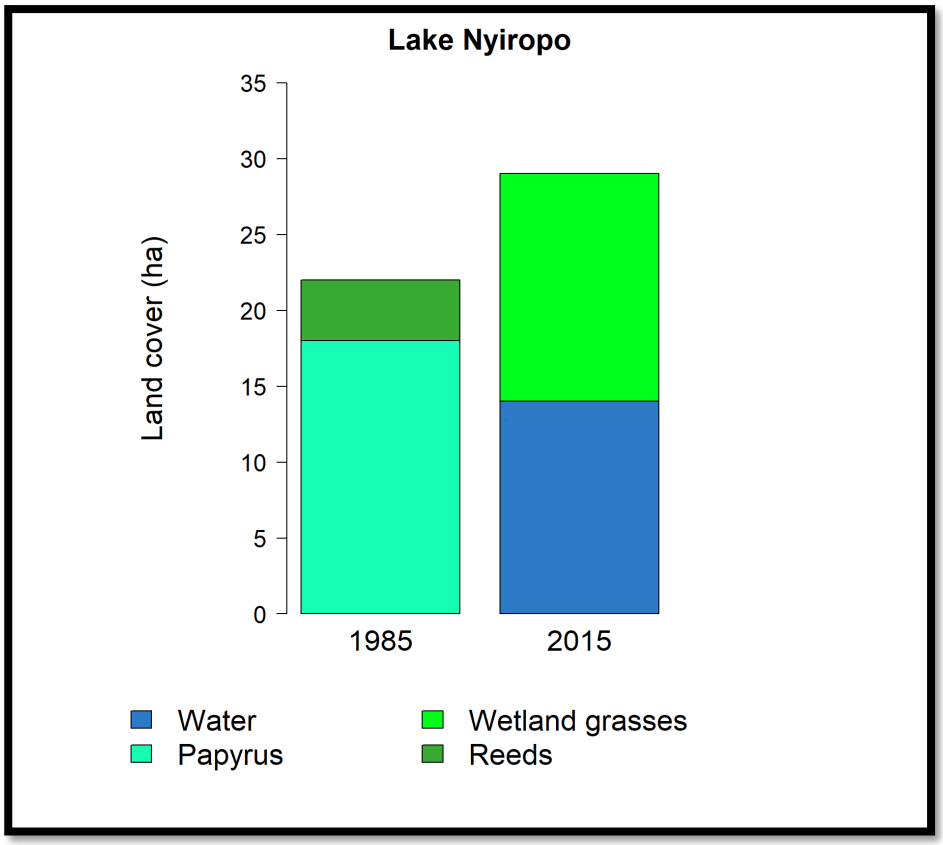

Figure 7: Land cover of Lake Nyiropo in 1985 and 2015 (NBI, 2020a)

Table 3: Land cover of Lake Nyiropo in 1985 and 2015 (NBI, 2020a)

Landcover class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	14	N.A.
Papyrus	18	0	-100.0
Wetland grasses	0	15	N.A.
Reeds	4	0	-100.0
Total area*	178	178	0.0

*Total area based on all 9 land cover classes

Lake Yirol

Lake Yirol is 9 km long and 2.5 km wide at maximum. It is fed by a local stream and lies in Yirol County, Eastern Lakes State, next to a small town with the same name. It is shallow, swamp-fringed, has a peripheral floodplain and drains from its southern end to the Lau or Yei River, which eventually peters out in the Sudd. The lake supports a small artisanal fishery and is an important watering point for wildlife (Hughes & Hughes, 1992). The Lake is unprotected and the area has a high conflict density, which possibly influences wetland extent (Sosnowski et al., 2016).

Classification of Lake Yirol

Inland wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover of Lake Yirol

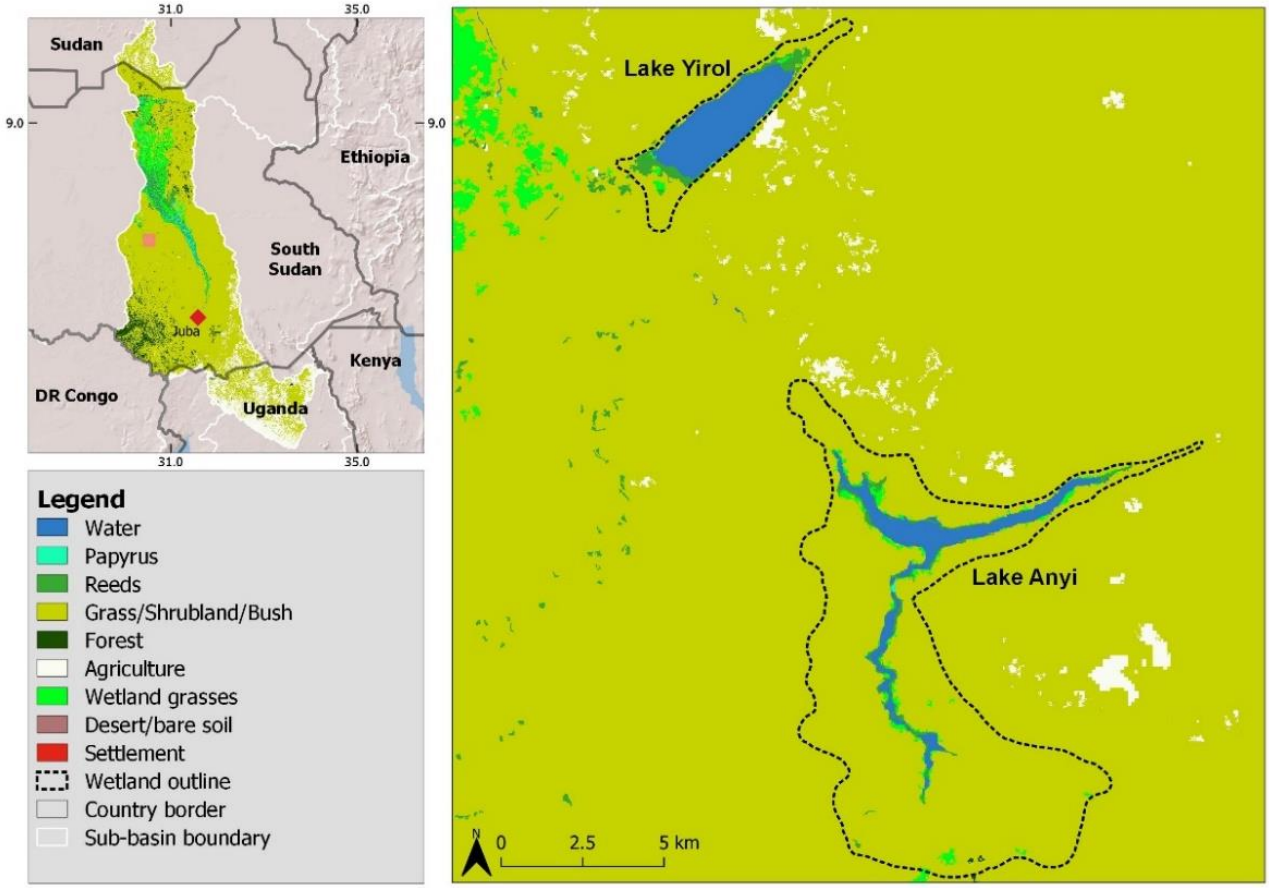

Figure 8: Land cover of Lake Yirol in 2015 (NBI, 2020a)

Change Trajectories of Lake Yirol from 1985-2015

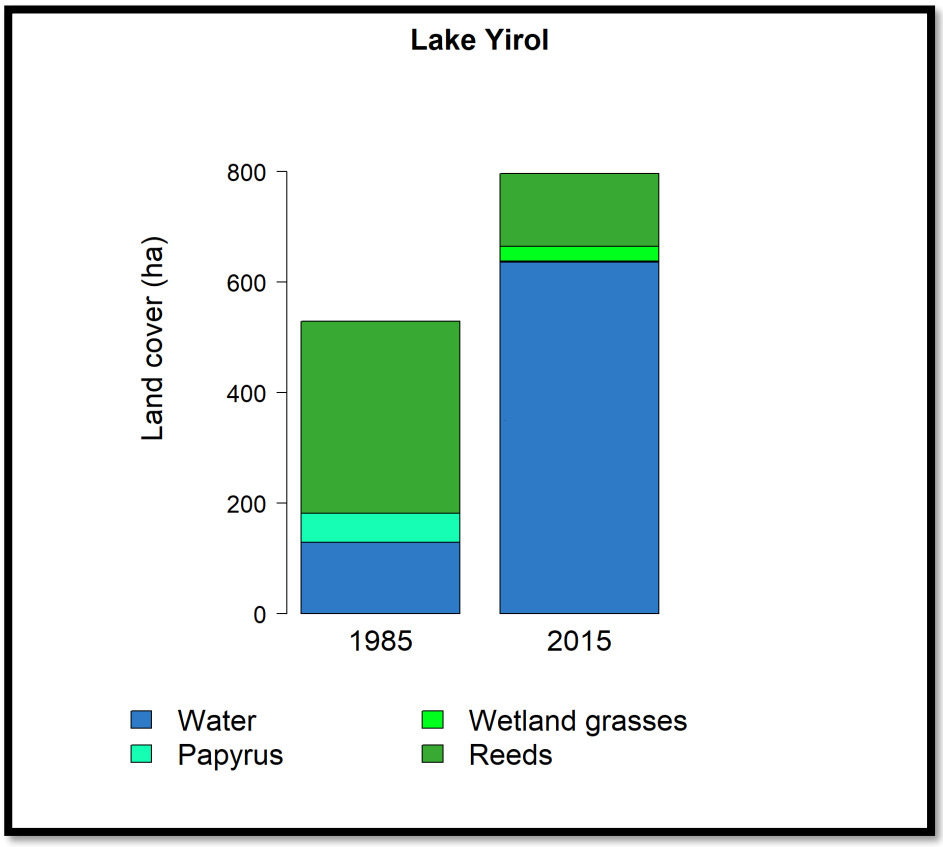

Figure 9: Land cover of Lake Yirol in 1985 and 2015 (NBI, 2020a)

Table 4: Land cover of Lake Yirol in 1985 and 2015 (NBI, 2020a)

Landcover class	1985 (ha)	2015 (ha)	% Change 1985-2015
Water	129	636	393.0
Papyrus	53	2	-96.2
Wetland grasses	0	27	N.A.
Reeds	347	131	-62.2
Total area*	1154	1155	0.1

* Total area based on all 9 land cover classes

Lake Anyi

This lake has two main arms, with each arm 6.5 km long and 1-2 km wide. It is shallow, swamp-fringed, and has a peripheral floodplain. It has a rich avifauna and supports a small artisanal fishery. It is fed by two streams at the southern end, the largest of which, the Rara River, is 40 km long and rises only a few meters higher than the lake. It drains to the Lau or Yei River from the northwestern end. It is unprotected (Hughes & Hughes, 1992).

Classification of Lake Anyi

Inland wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover of Lake Anyi

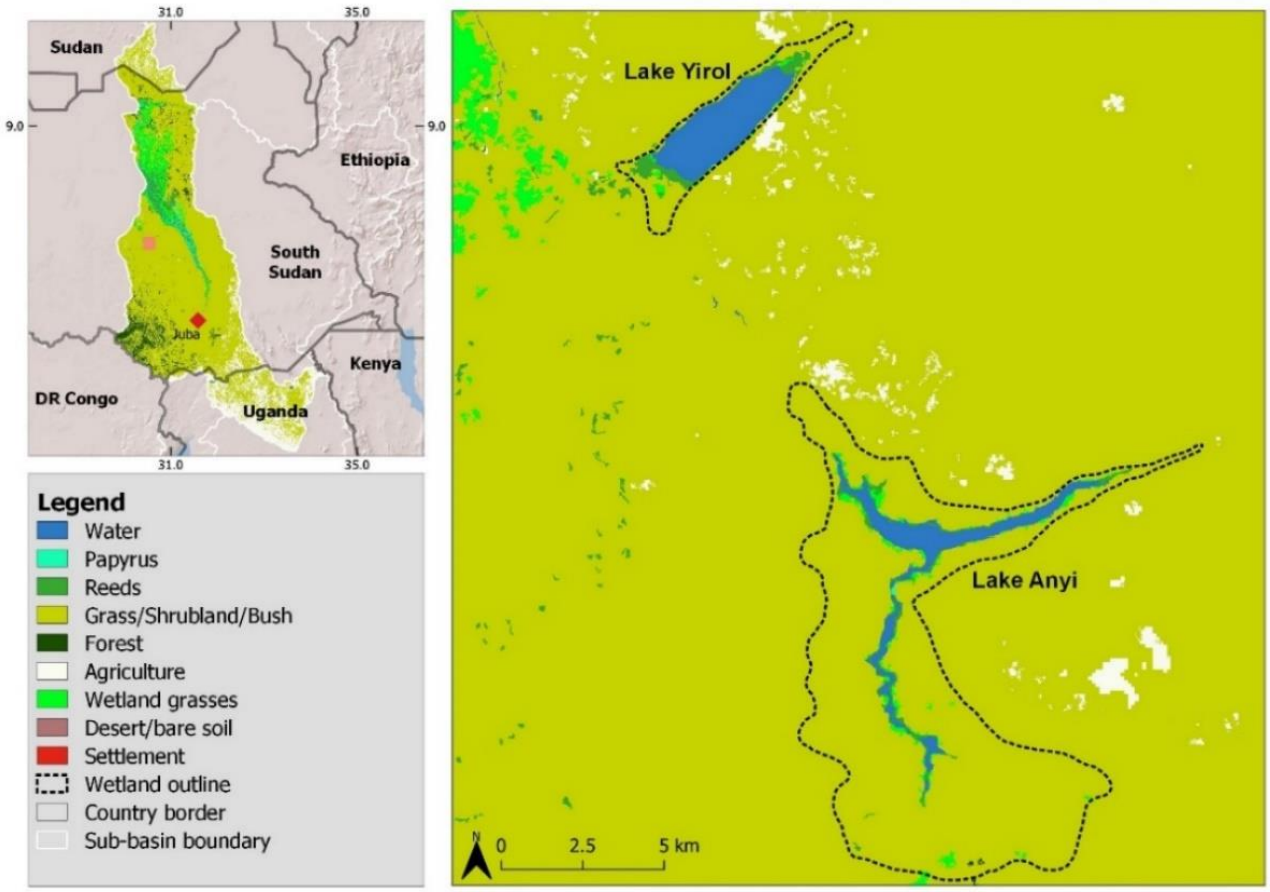

Figure 10: Land cover of Lake Anyi in 2015 (NBI, 2020a)

Change Trajectories of Lake Anyi from 1985-2015

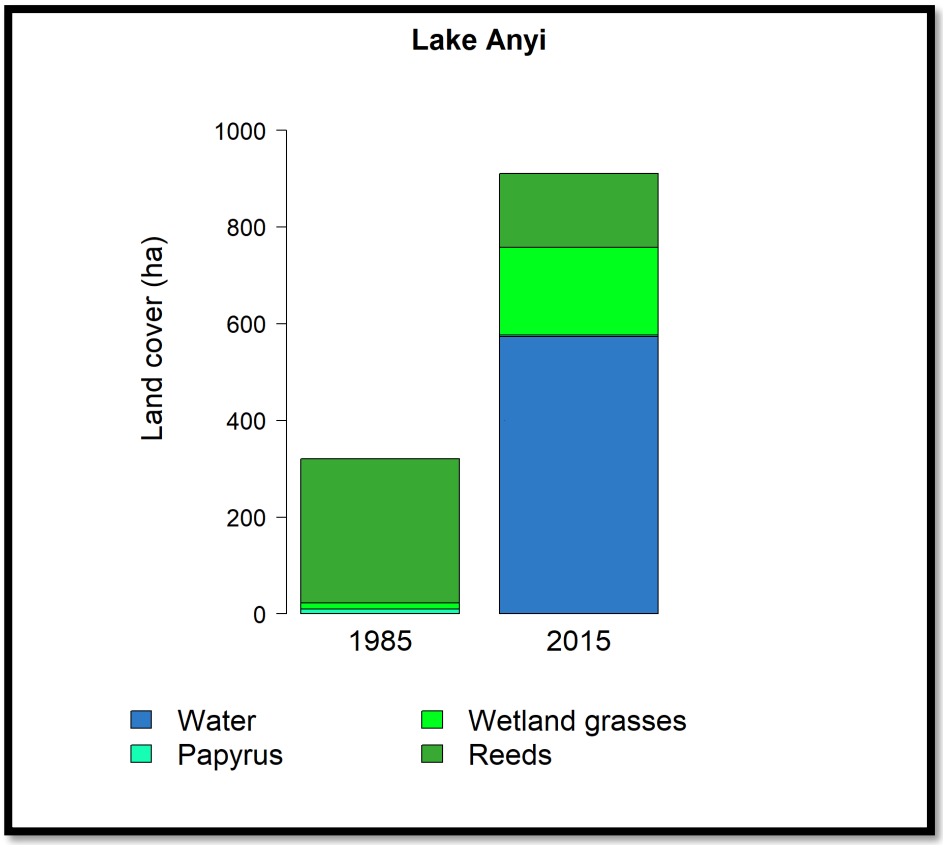

Figure 11: Land conver of Lake Anyi in 1985 and 2015 (NBI, 2020a)

Table 5: Land cover of Lake Anyi in 1985 and 2015 (NBI, 2020a)

Landcover class	1985 (ha)	2015 (ha)	% Change 1985-2015
Water	0	574	N.A.
Papyrus	10	3	-70.0
Wetland grasses	13	181	1292.3
Reeds	298	152	-49.0
Total area*	7319	7319	0.0

*Total area based on all 9 land cover classes

2.3 Geology and Soils

South Sudan consists mostly of granites and gneiss with outcrops in the south-west of the country and its north-eastern edge. The Sudd basin is a depression which has been overlain by continental deposits of Nubian Sandstone and alluvial deposits of the Umm Ruwaba Formation, especially along the major rivers (JICA, 2015).

The Sudd area is defined by heavy clay soils. Sandy soils are only found at depths of approximately 30m (Petersen, 2008b). Soils of the Sudd are seasonal with annual variation. Alkaline loam soils with low organic matter content and a large clay content (15-40%) are found in the highland areas as opposed to more fertile alluvial soils being found in the middle of the wetland. These soils are generally acidic and have an organic matter content that varies from 5 to 45% with variable sand-clay proportions (Ramsar, 2006).

2.4 Hydrology & Climate

Hydrologically the Sudd wetland is regarded as a giant filter that controls and normalises water quality and a giant sponge that stabilises water flow (Ramsar, 2006). The Sudd wetlands have a permanent and seasonal

component, the extent of which varies from year to year following local and regional climatic variation, and the flow regime of the Bahr el Jebel and Sobat Rivers (NBI, 2012). Upstream hydrological and hydrodynamic changes may have a strong transboundary impact downstream. An integrated and cooperative approach is therefore required to manage, protect, maintain and sustain the integrity of the valuable ecosystems and the functions and services that it provides (NBI, 2013).

Effective and sustainable management of floodplains requires an understanding of the fundamental hydrological processes of the floodplain and associated river systems as the hydrology of the system is considered to be one of the most important driving variables in floodplains (Opperman et al, 2017). Monitoring inflow and outflow into and from the Sudd is a challenge, due to its inaccessibility, extent and current political instability. Continuous information on the Sudd wetland hydrology is scarce. In the 1950 to 1970s the wetland was relatively well studied (Sutcliffe & Parks, 1999). During the long civil unrest from 1983 to 2005 few studies have been conducted and continuous monitoring was not possible. For inflowing water, data is available from the gauging station in Mongalla for the period of 1905-1983 and discontinuously after 1997. Missing data can be estimated based on upstream water levels and large-scale spatial rainfall data (Petersen et al., 2008b).

Figure 12: Accessibility to various areas in the Sudd can be problematic. (Photo source: HYDROC)

The Sudd wetland receives its water from the Bahr el Jebel and from direct rainfall. The upstream part of the Bahr el Jebel lies in the tropical wet and dry zone with a winter dry season and two wet seasons, whereas the downstream part is influenced by the subtropical dry, semiarid climate with only one wet season occurring between May and October and its counterpart dry season between November and April (MEF, 2018).

During nine months of the year evapotranspiration exceeds precipitation, hence direct rainfall is a minor contributor to the water balance of the Sudd (Y. A. Mohamed & Savenije, 2014). The wetland hydrology is mainly influenced by climate variations upstream of the Sudd and changing water levels of the Lakes Victoria, Kyoga, Edward and George (Mohamed & Savenije, 2014). An estimated 75 % of inflow water originates from the equatorial lakes and 25 % comes from torrents (seasonal streams) between Lake Albert and Mongalla (Mohamed & Savenije, 2014). At the gauging station in Mongalla, flow in the Bahr el Jebel is fairly constant throughout the year but fluctuates over a longer timescale. Locally generated torrents between Lake Albert and Mongalla differ between seasons as a result of periodic heavy rainfalls (Rebelo et al., 2012).

The monthly rainfall variations are controlled by the movement of the intertropical convergence zone and can be highly seasonal and variable from year to year (Wilusz et al. 2017). Data from five meteorological stations between Juba and Malakal, which recorded rainfall during the 20th century, show that the average rainfall is between 600-1000 mm/year (NBI, 2016).

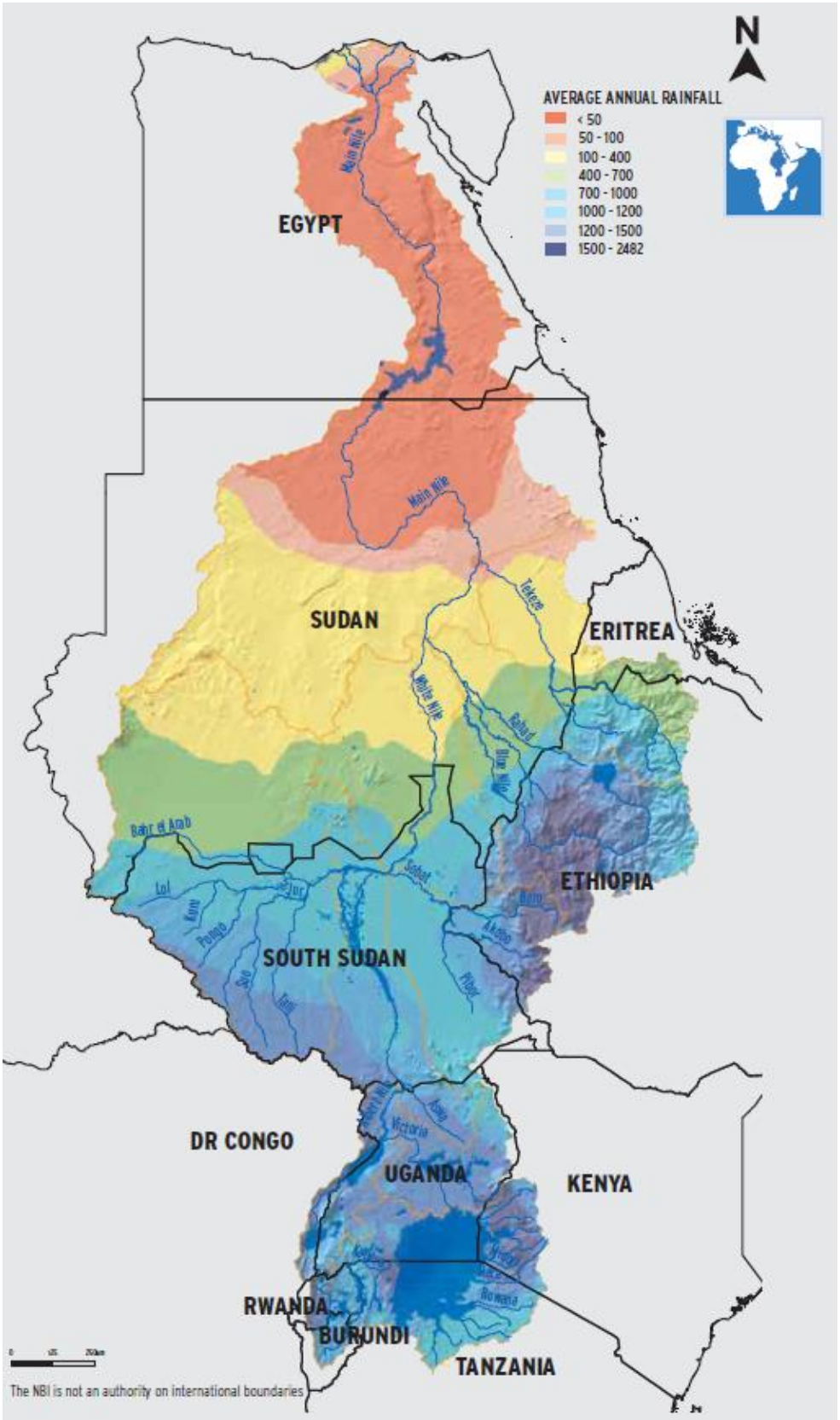

Figure 13: Annual rainfall distribution of the Nile basin (NBI, 2016).
The Sudd being in the 700mm – 1200mm per annum region.

Estimates of rainfall from remote sensing between 2007 and 2011 show similar precipitation quantities (654-904 mm/year), although year to year variation is significant (Wilusz et al., 2017). During periods of high flood and rainfall, the floodplain remains flooded well into the dry season. In contrast, during periods of low flood and rainfall, the floodplain "shrinks" and the permanent swamps dry up (Riak, 2006).

Evapotranspiration varies spatially and seasonally across the Sudd. Seasonal extremes in evapotranspiration as well as in flooding are common in the northwestern region of the Sudd. Annual evapotranspiration can be almost twice as high than the annual precipitation, which ranges between 1200 -1500 mm/year (Rebelo et al., 2012; Wilusz et al., 2017). The peak evapotranspiration usually occurs right after the rainy season, when vegetation growth is favored due to low cloud cover and unlimited water availability (Rebelo et al. 2012).

An analysis of multitemporal and multisensor remote sensing datasets by Rebelo et al. (2012) attempted to investigate and characterise flood pulsing within the Sudd wetland over a 12-month period. The wetland area was mapped five times during the year which indicated that approximately 22% of the wetland area could be considered as a permanent wetland. In terms of evaporation, higher values were obtained in open water than in flooded vegetation. About 50 percent of the 2.9 billion m^3 (BCM) of water that flows into the Sudd wetland is lost through evaporation MEF, 2018).

The hottest months are February and March, and the lowest temperatures occur during July and August. In Juba, temperatures vary between 19 ^oC and 37 ^oC whereas Malakal receives temperatures between 18 ^oC and 40 ^oC. Relative humidity ranges from 55 % in January to 80 % in August and September (NBI, 2016).

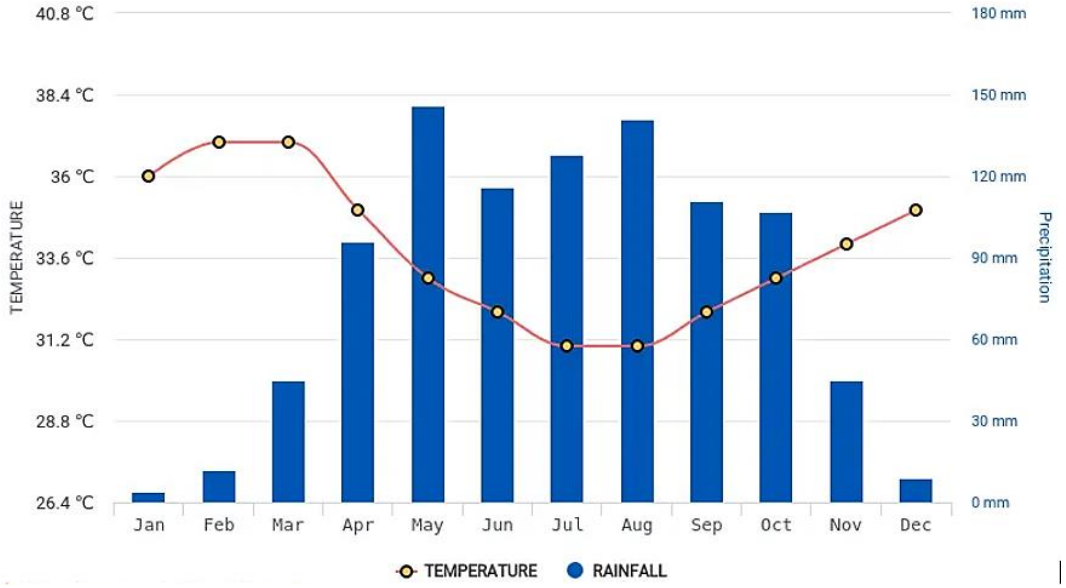

Figure 14: Average monthly rainfall and temperature of South Sudan (Anon, 2021a).

The effect of climate change on the Sudd and its associated biota is still unclear. The historical trend of the rainfall in the Sudd region (1963 – 2012) shows a small (insignificant) increasing rainfall trend. Over the same period, the Sudd wetland region shows the highest increasing trend in temperature (0.4^oC per decade), which is not only the highest in the Nile basin countries, but also the highest among all African countries.

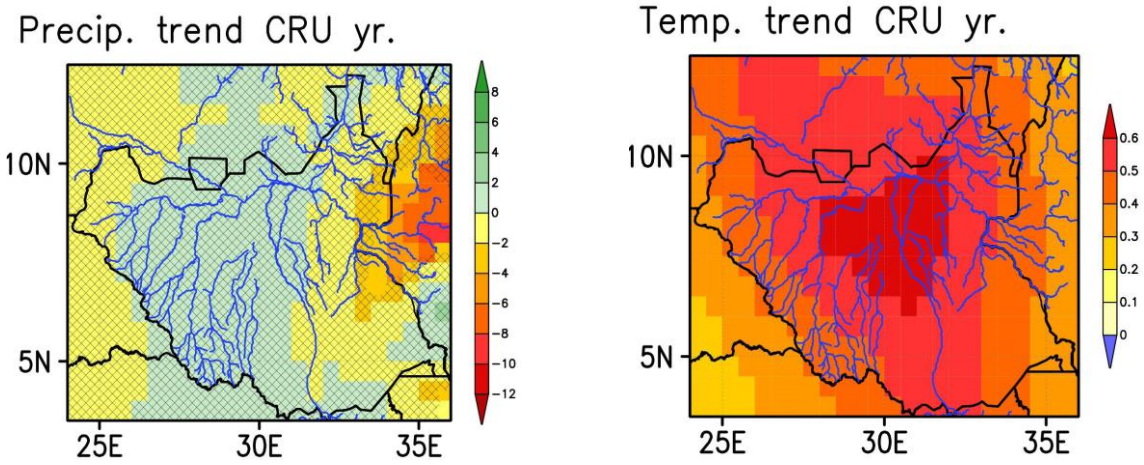

Figure 15: Monotonic slope of precipitation & temperature (1963–2012). (From CRU TS3.22 datasets)

According to a statistical model by Mohamed and Savenije (2014), precipitation and evaporation rates over the Sudd have largely remained the same in the 20th century. Maximum temperature (Tmax) has risen by 0.6 ˚C and minimum temperature (Tmin) by 1.5 ˚C. Relative humidity (RH) has decreased as well as daily sunshine hours (n) by 10 %, respectively. Temperature variations across months increase in the northern part of the Sudd.

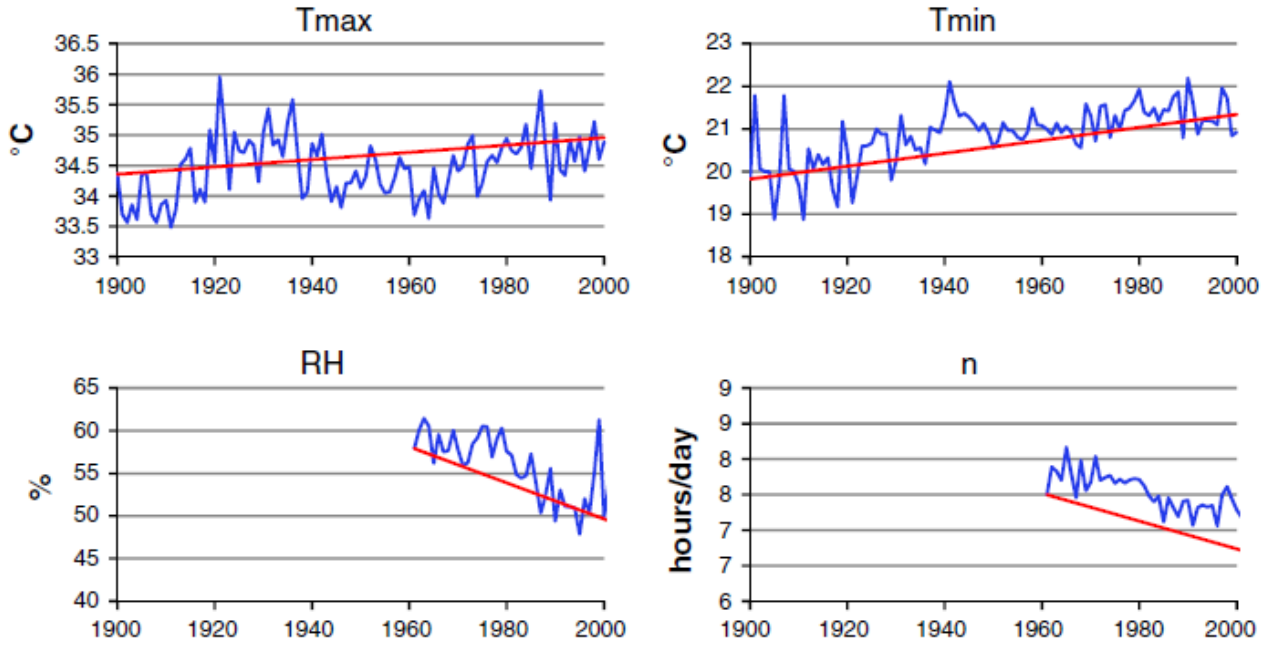

Figure 16: Time series and trends of the key climate parameters (Mohamed and Savenije, 2014)

There are fluctuations of periods (often over several years) with higher or lower rainfall and respectively Sudd inflow and Sudd size. Climate variability exacerbates the already existing pressure on South Sudan's ecosystems (MEF, 2018). Rising temperatures and erratic rainfall have led to floods and droughts in the region, which negatively impact natural ecosystems, especially the ecologically sensitive zones such as the Sudd wetland (MEF, 2021). A recent increase in rainfall in the region has led to increased inflow and the subsequent expansion of the Sudd. These changes can be seen in the Sudd wetland landcover.

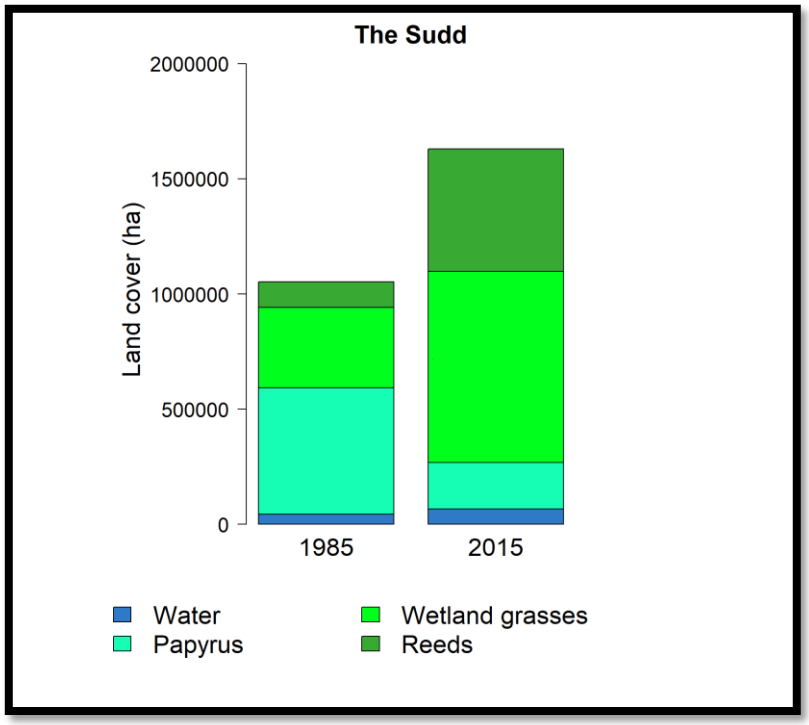

Figure 17: Land cover change of the Sudd from 1985 to 2015 (NBI, 2020a)

The figure above clearly shows a major expansion of the Sudd over a 30-year period from 1985 to 2015.

Table 6: Land cover change of the Sudd from 1985 to 2015 (NBI, 2020a)

Landcover class	1985 (ha)	2015 (ha)	% Change 1985-2015
Water	43589	66203	51.9
Papyrus	550021	203171	-63.1
Wetland grasses	348482	829792	138.1
Reeds	110340	529912	380.3
Total area*	2390265	2390265	0.0

The table above shows that the expansion is mostly related to the increase in grasses and reeds. There is however a sharp decline in papyrus, which is concerning, as it is a valuable peatland vegetation that performs the function of carbon storage and sequestration.

Future rainfall projections (to the year 2039) show that there will be a reduction in rainfall by over 150 millimeters between June and September in some parts of the country, which will only put more pressure on communities' whose livelihoods depend on sectors that are sensitive to changes in climate such as agriculture and fishing (MEF, 2021).

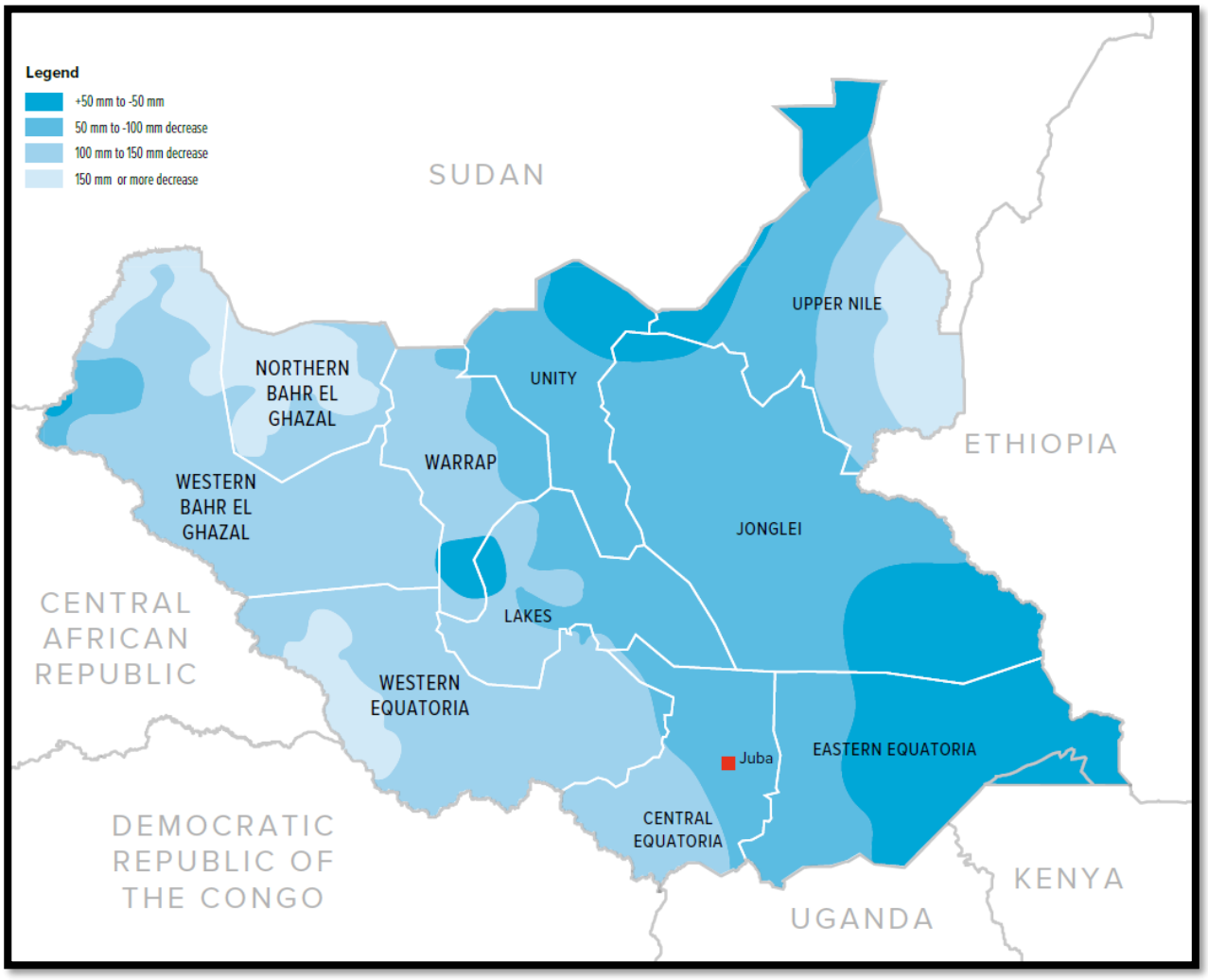

Figure 18: Projected change in precipitation in South Sudan, 1960-2039 (MEF, 2021)

Future temperature projections indicate that temperatures may increase by 0.6–1.7°C by 2030 and by 1.1–3.1°C by 2060, which will serve to intensify the impacts of droughts and reducing the available water through increased evaporation (MEF, 2021).

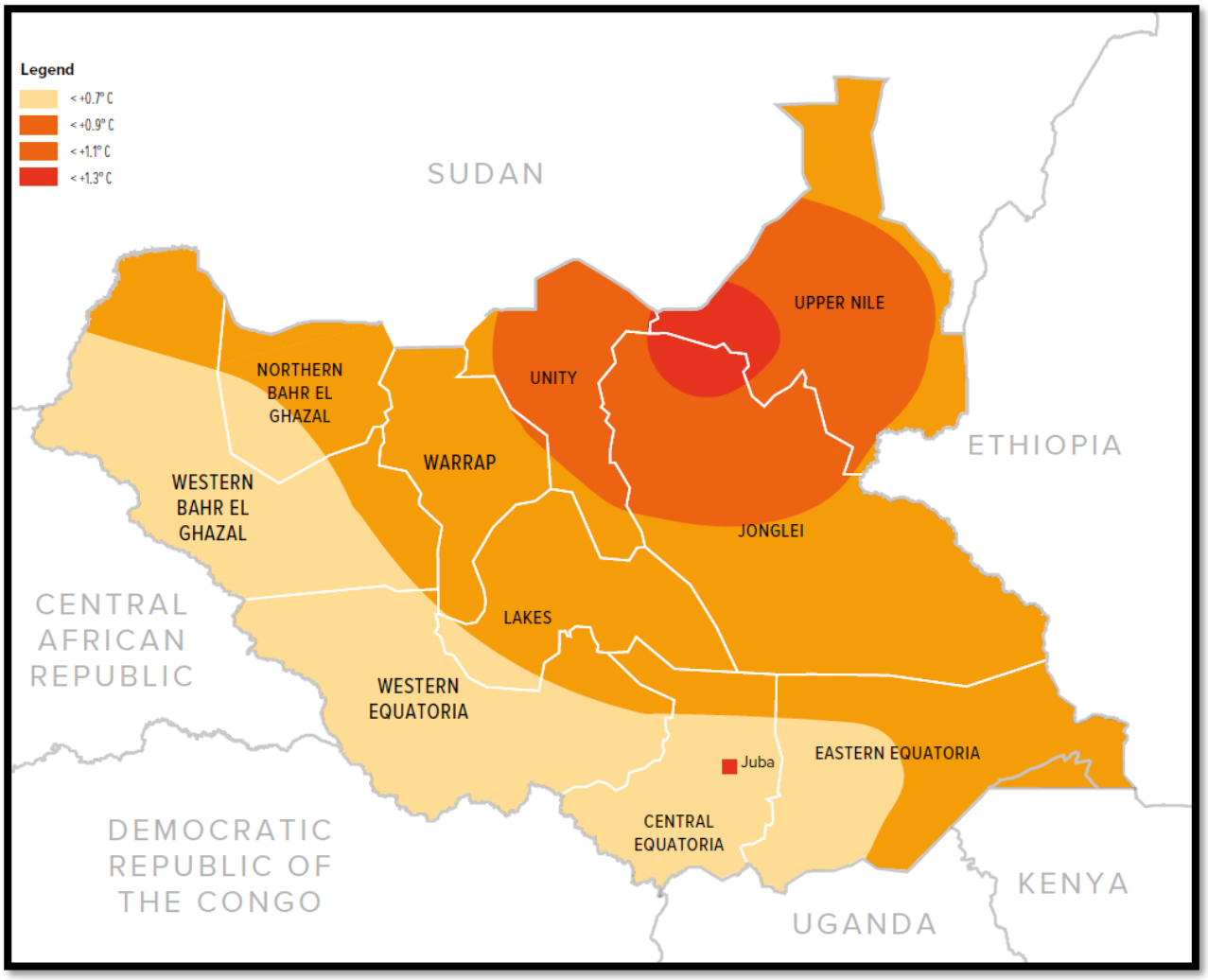

Figure 19: Projected change in temperature in South Sudan, 1960-2039 (MEF, 2021)

2.5 Peatlands and Climate Change

With a global focus on climate change, the role of wetlands in carbon storage and sequestration has received increasing attention. Although the Nile basin is not considered to be a major emitter of greenhouse gases from commercial and industrial energy uses, emission contributions come in the form of deforestation and land use cover change.

The recently updated and revised Nationally Determined Contribution (NDC) by the Ministry of Environment and Forestry (2021) found that greenhouse gas (GHG) emissions are gradually increasing by more than 1% per annum, as the population is growing and economic development is taking place. This comes as a result of economic growth being highly dependent on natural resources. Biomass and fossil fuel were found to be the most consumed resources in South Sudan, which is associated with intensified carbon emissions. Fourteen sectors were identified that need to be prioritised where mitigation and adaptation strategies are to be implemented. Sustainable wetland management makes out one of these prioritised sectors. Wetlands thus have an important role to play in mitigating the effects of climate change.

Wetlands in general, but particularly peatlands, store substantially large quantities of carbon when compared with other terrestrial ecosystems. Tropical peatlands are known to be the most space-efficient terrestrial carbon stock pool, with their carbon stock per hectare 10-15 times higher than a tropical rain forest.

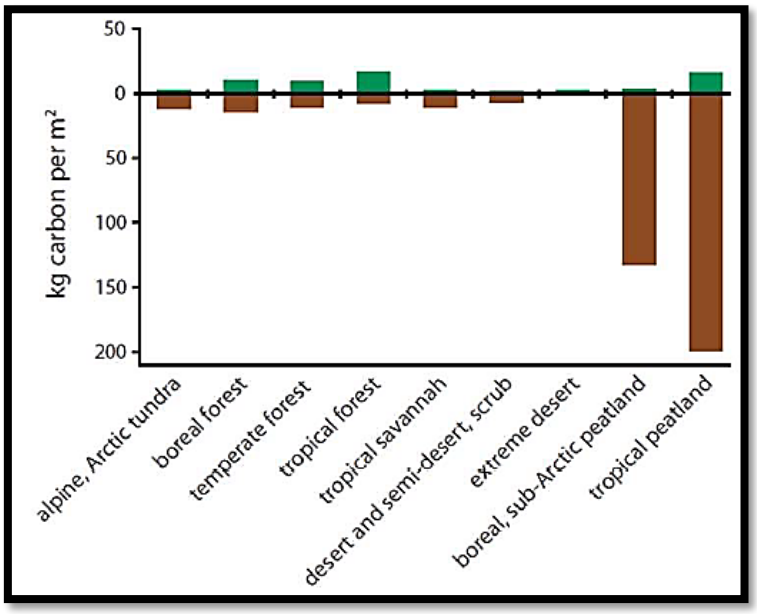

Figure 20: Carbon stocks of terrestrial ecosystem (NBI, 2019)

Accelerated land use change has led to an increasing area of peatlands being impacted directly through burning and clearing for agriculture and peat extraction for energy or indirectly (drainage for infrastructure, surrounding plantations causing groundwater drawdown). The impact depends on the duration and intensity of use. Other threats to peatlands include changing rainfall patterns and fire hazards. The consequences are increased GHG emissions and the loss of carbon stocks and productive land.

A recent study on peatlands, has provided some findings on peatland extent, carbon stock, land-use threats and practical strategies for their sustainable use and management (NBI, 2019). The study found that the most important concentration of peatlands in the Nile basin lies in the Sudd wetlands, where the estimate area of peatlands (organic soils) is ~15,780 km², which represents about 50 % of the total peatland area and 37 % of the total carbon stock of the entire Nile basin, translating to 1.5 - 3.6 GtC carbon stock (Peters, 2021).

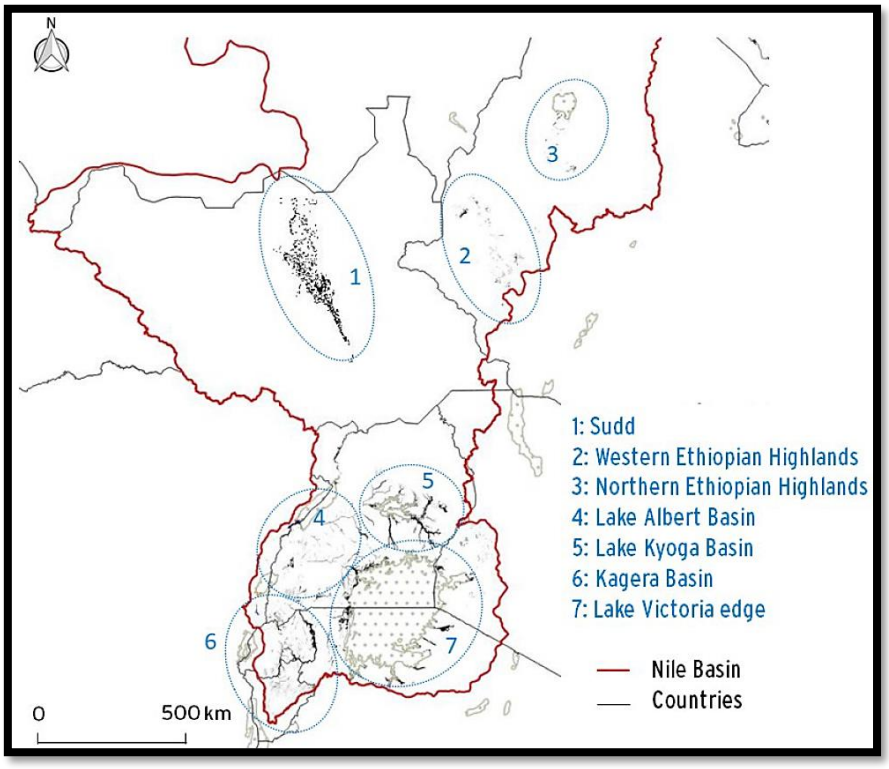

Figure 21: Peatland areas in the Nile basin (NBI, 2019)

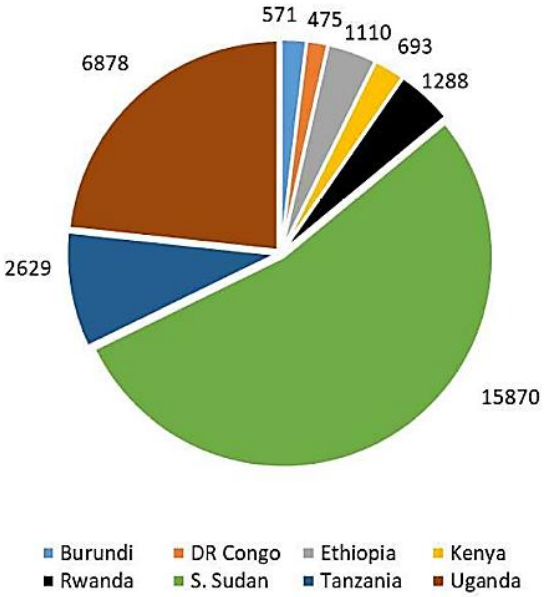

Figure 22: Proportional distribution of peatlands in the Nile basin in km² (NBI, 2019)

Most peatlands are characterised by papyrus (Cyperus papyrus L.), but Raphia palms, other sedges (e.g., Cyperus latifolia) and tall grasses are also common, and partly grow in patches together with papyrus. Papyrus alone covers an area of 5,879 km² in the Sudd of which 1,893 km² overlay the permanent wetlands. Papyrus and permanent wetlands largely lack overlap from Shambe northwards where the Sudd widens, which may be due to spectrally different vegetation classes compared to the Bor area in the south. The areas to the north of the Sudd have not been described or verified due to lacking access and ground information.

Figure 23: Typical papyrus peatlands (NBI, 2019)

The result from this study provides the opportunity to recognise the existence of peatlands and the carbon stock that is associated with these peatlands. The information can be used to promote further soil organic

carbon research with the possibility of utilizing this as carbon offsetting and trading. This can drive actions towards climate change mitigation and adaptation by effectively managing and maintaining peat stocks.

Controlling emissions emanating from the wetlands due to anthropogenic activities and protecting biodiversity and natural ecosystems are key priority areas for South Sudan (MEF, 2021). In 2016, the Ministry of Environment from South Sudan developed a National Adaptation Programme of Action (NAPA) which has emerged from the multilateral discussions on adaptation measures within the UN Framework Convention on Climate Change (UNFCCC) and aims to identify and communicate priority activities to address urgent and immediate adaptation needs. Five thematic areas were identified which include environment, water resources, agriculture, disaster risk reduction and the policy and institutional framework. Wetlands have a direct impact on all of these themes but are also directly impacted upon by decisions made related to these themes.

The following mitigation and adaptation strategies have yet to be implemented for biodiversity, ecosystem and sustainable wetland management (MEF, 2021):

Table 7: Mitigation and adaptation strategies for biodiversity, ecosystem and sustainable wetland

Strategies	Activities under consideration
Conservation and sustainable use of wetlands for improved carbon sequestration. South Sudan will collaborate with international research institutes and agencies to conduct ground research on the release of methane emissions from the Sudd wetland and develop measures to sustainably manage and mitigate high emissions coming from the country's wetlands.	• Build the capacity of government and research institutions on wetland processes and associated GHG emissions. • Identify and classify wetlands and assess their biodiversity. • Bring wetlands under protection for sustainable management.
Monitor wetland inventory and biodiversity hotspots. Similar to forest cover monitoring, South Sudan will monitor and develop an inventory of its wetland and biodiversity hotspots through ground surveys or by using other technologies such as geographic information systems and satellite imagery.	• Identify and classify wetlands. • Assess threats to wetlands by conducting a vulnerability assessment.
Establish buffer zones around wetlands. Establish buffer zones around wetlands to limit human activities that negatively impact the value of natural resources. The buffer zones will allow government to cost-effectively manage ecosystems and maintain water quality while protecting human habitat from flood-related damages.	• Assess wetland services. • Assess wetland areas of use.
Reclaim wetlands. The government will also focus on restoring degraded wetlands in South Sudan with the aim of reducing their emissions by increasing carbon sequestration and building long-term carbon stock.	• Identify degraded wetlands in the country. • Improve wetland resource use. • Develop integrated Management Strategys for wetlands. • Educated and create awareness amongst the general public for the sustainable management of wetlands.
Conduct a biodiversity mapping study. South Sudan will focus on understanding native and endangered species in various regions in the country through a biodiversity mapping study and/or a census. This will enable South Sudan to direct and prioritise conservation resources in a structured manner.	• Utilise the capacity of existing research institutions and universities in the country to conduct a biodiversity mapping study throughout the country.
Reduce the rate of deforestation by promoting alternative sources of energy. The government will develop suitable regulations and measures for reducing the deforestation rate by increasing access to electricity, introducing alternative	• Assess available energy sources. • Select suitable energy sources that can be sustainably used by communities that are currently dependent on fuel wood. • Develop a roadmap and implementation plan for introducing alternative energy sources.

sources of energy and strengthening land-use management policies and planning.	• Monitor and evaluate project performance.
Develop waste management policies. South Sudan will develop regulations in line with proposed waste management policies to reduce the disposal of solid wastes and/or untreated wastewater into water bodies or onto open land.	• Develop and implement a waste management policy.
Promote agroforestry. South Sudan will promote agroforestry for diversifying land production systems and also to promote alternative livelihood options.	• Assessment of available production systems and the tree and crop species involved. • Utilise indigenous and scientific knowledge to identify combinations of tree species that could provide improved livelihood opportunities to people, while also acting as a carbon sink.
Promote afforestation of degraded landscapes. South Sudan will promote afforestation of degraded landscapes and of watersheds using multi-purpose tree species to increase community safety nets and to diversify livelihoods.	**Planning phase:** • Identify degraded sites for afforestation. • Organise a tender to carry out afforestation works. **Implementation phase:** • Develop baselines. • Select tree species and design planting protocols. • Establish forest nursery for seedling production. • Prepare soil. • Implement planting and tending activities. **Monitoring phase:** • Monitor overall project performance. • Monitor carbon levels in trees and soil. • Create project database. • Build capacity and raise awareness of various levels of involved stakeholders.
Develop a Management Strategy to protect watersheds. The government will develop forest reserves and Management Strategys to protect natural watersheds to maintain water availability and quality.	• Study the existing literature and information available for the country. • Conduct field studies and stakeholder consultations to gather insight on forest reserves and watershed management practices. • Outline the country's biodiversity targets. • Carry out monitoring and evaluation. • Draft Management Strategys for forest reserves and watershed protection.
Introduce wildfire Management Strategys. South Sudan will introduce fire Management Strategys to prevent and control the spread of wildfires during dry periods and to reduce damage to forest resources and wildlife.	• Plan, implement and monitor. • Research. • Build capacity. • Raise awareness.
Establish wildlife conservancies and protected areas. South Sudan will establish wildlife conservancies, protected areas and national parks to prevent degradation of forest areas and conserve wildlife.	• Engage with key government stakeholders and communities living adjacent to forestlands to gather their views and consent on changes to protected areas. • Assess the status of existing protected areas and national parks, and determine their sizes. • Draw an implementation plan to bring forestlands under conservation.
Establish water points for wildlife. The government will establish water holes for wildlife in protected areas to ensure that water is available	• Identify and select sites for creation of water holes in protected areas.

during dry seasons, thus reducing negative impacts on animals.	
Introduce integrated natural resources management. Government will promote an integrated natural resources management approach whereby coordination between different stakeholders and development efforts are integrated to address human and institutional factors affecting the conservation of natural resources, as well as affecting livelihoods.	• Identify and select different natural resource management approaches that best fit the context in South Sudan. • Implement, monitor and evaluate the performance of identified management approaches.
Promote ecotourism services. South Sudan will promote sustainable community-based ecotourism services (for example, in the Southern National Park), including wildlife tourism, to provide improved or alternative livelihood opportunities to rural communities while also protecting biodiversity.	• Engage with communities living near protected areas to increase awareness on the environmental and economic benefits associated with ecotourism.
Improve national parks and protected areas. The government will focus on improving the current conditions and landscapes of protected areas to conserve wildlife.	• Engage with communities and seek consent from communities for any changes to the sizes of protected areas.
Increase awareness and build the capacity of key stakeholders. South Sudan will focus on building capacity of institutions for conducting baseline surveys to record and monitor changes in environmental pollution, biodiversity loss and natural resources management. In addition, increasing awareness and knowledge among communities regarding climate change and environmental concerns will also be a key focus area.	• Organise interactive and informative talks on radio and television. • Organise talks at clubs and schools to spread awareness among youth.
Strengthen institutional and governance frameworks for implementation of environmental regulations. The government will focus on strengthening and improving governance mechanisms and institutional frameworks for efficient enforcement of environmental regulations in the country.	• Review the existing environmental regulations to identify areas for improvement. • Identify the drivers of law enforcement.

2.6 Flora and Fauna

The Sudd flood plains are a rich habitat for flora and fauna such as fish, mammals, birds, reptiles, amphibians and other rare species. Hydrological and ecological functions of these wetlands such as water quality improvement and food provision both contribute to ensuring ecological and sociocultural stability in the region. In addition, the inaccessibility of the Sudd provide protection for several species of wildlife (ME, 2015).

Flora

The Sudd has over 350 plant species and is composed of a maze of wetland ecosystems (MEF, 2018). Vegetation ranges from open water and submerged vegetation to floating fringe vegetation, seasonally inundated woodlands, rain-fed and river-fed grasslands, and floodplain scrubland (Ramsar, 2006):

- Open water vegetation: This ecotype is dominated by free-floating-leaved plants like Eichhornia crassipes, Lemna gibba, Azolla nilotica and Nymphaea lotus as well as submerged vegetation e.g., Potamogeton, Trapa and Ceratophyllum spp in both flowing waters and lakes. Microphytes are prevalent in lakes but less so in the flowing turbid waters of the main channel. The diatom Aulacosiera granulata dominates the phytoplankton during the dry season but is replaced by the cyanobacterium Lyngbya limnetica during the wet season when the river velocity and turbidity are high.

- Permanent swamps: These occur on land that is flooded throughout the year. The most prevalent types of plants are the floating and fringe vegetation, dominated along the banks of the river by massive stands of Cyperus papyrus, Vossia cuspidate, Phragmites karka and Typha domingensis. Associates of the Cyperus swamp are climbers and ferns

- River flooded grassland, locally called Toich: These grasslands are seasonally flooded to varying extent and depth by the river. During the rainy season, the plains of this belt are often swampy and completely covered with luxuriant growth of tall grasses. Species composition and biomass is closely linked to soil type and degree of inundation. The tall grasses are dominated by Phragmites, Sorghum, Hyparrhenia and Setaria spp as well as Oryza and Echinochloa. Two grassland types are recognised. These are wild rice grassland dominated by Oryza longistaminata and Echinochloa grassland dominated by Echinochloa pyramidalis. Sedges, herbs and other grasses such as Sporobolus pyramidalis associate with the Oryza grassland. It is the most productive grassland type in terms of year-round grazing for livestock and wildlife because of the high protein content of dead materials of wild rice grass. The Echinochloa grassland associates with Oryza and legumes like Desmodium hirtum. Within the Toich there are many small seasonally flooded pools that support a variety of plants at different times of the year. They are dominated by grasses and herbs during the dry season, semi-woody herbs (Sesbania rostrata) in the early wet season, and floating and submerged aquatic plants during the remaining part of the rainy season. When the rivers flood, the pools are colonised by green algae (desmids and filamentous) and Cyanobacteria which themselves are replaced by euglenophytes and dinoflagellates following evaporative concentration and nutrient enrichment from cattle and bird feeding. These pools are sources of water for domestic, livestock and wildlife use as well as fish and pasture during the dry season.

- Rain-flooded grasslands: These are seasonally inundated grassland or rainfed wetlands (Toich). They occur on seasonally waterlogged clay soil which in part is heavily used by livestock. It is made up of a comparatively well drained portion dominated by Echinochloa haploclada, heavily grazed grassland dominated by Sporobolus pyramidalis, Phragmites, Sorghum and a high biomass but nutrient poor Hyparrhenia ruffa grassland in areas that are inundated by rainwater and sheet flow. These grasslands act as a source of string and grass for thatching.

- Floodplain scrubland (woodland): It is quite distinct from the grass plains being higher in level. It is the well-drained areas around the floodplains. This rain fed belt is an open mixed Acacia forest supporting several species of trees and shrubs and a luxuriant growth of grasses. The tree vegetation is dominated by Acacia seyal, Acacia sieberiana and Balanites aegyptiaca. The tree vegetation is an important source of firewood and building poles. Balanites has additional food and medicinal values. It is the most utilised ecotype for settlement, crop production and wet season grazing

There are three swamp types: *Vossia cuspidate* swamps (which cover 250 km²), *Cyperus papyrus* swamps (3,900 km²) and *Typha domingensis* swamps (13,600 km²). Grassland can be divided into seasonally river-flooded grassland (16,200 km²) and seasonally rain-flooded grassland (20,000 km²). There are areas of single-species woodland mainly of *Acacia seyal* (5,400 km²) or *Balanites aegyptiaca* (5,300 km²). Mixed woodland is characterised by *Ziziphus mauritiana*, *Combretum fragrans*, *Acacia seyal* and *Balanites aegyptiaca*. In the permanent swamps, the channels have a band of *Vossia*, backed by *Cyperus papyrus*, usually forming a floating mat, which is backed by *Typhia domingensis*. Since 1950, *Eichhornia crassipes* has started to replace *Pistia stratiotes*, the Nile Cabbage. The native free floating water cabbage has been pushed out and had become confined to temporary pools and small Khors (local depressions connected to the main swamps). The tall plants provide a framework for climbers such as *Luffa cylindrical* and *Vigna luteola*. In some areas the papyrus is replaced by *Phragmites karka*, which does not form a floating platform. Further away from the main channels there are swamps dominated by *Typha domingensis* (MEF, 2018; BirdLife International, 2019; Green & El-Moghraby, 2009).

At times *Eichhornia crassipes* (Nile hyacinth) causes blockages along the White Nile from the Sudd to Jebel Aulia Dam (Green & El-Moghraby, 2009). Seasonal flooding enables the growth of grasses such as *Sorghum sudanica, Echinochloa spp.* And *Oryza longistaminata,* wild rice-grass. This grassland is known as the 'Toich'.

Where the water is deeper the *Oryza longistaminata* is dominant but needs several months (mostly up to 3) of surface water in order to flower. *Echinochloa pyramidalis* is the dominant grass with *Sporobolus pyramidalis*, *Digitaria debilis* and *Desmodium hirtum* where the flood water is shallower. The pools formed by seasonal flooding have their own separate vegetation with *Echinochloa stagnina, Glinus lotoides, Sesbania rostrate* and *Aeschynomene indica.* It is the most productive grassland type in terms of year-round grazing for livestock and wildlife due to the high protein content of dead materials of wild rice grass. Within the toich there are many small seasonally flooded pools that are sources of water for domestic, livestock, and wildlife use as well as fish. Further from the channels, where rain is the main source of water, *Hyparrhenia rufa* is the main grass or *Sporobolus pyramidalis. Echinochloa haploclada* occurs where the soil is better drained and is heavily grazed by livestock. The grasslands merge into open floodplain woodland with *Acacia seyal, A. sieberiana* and *Balanites aegyptiacus* (MEF, 2018; Green & El-Moghraby, 2009; Rebelo & El-Moghraby, 2018).

A recent biodiversity baseline assessment conducted by NBI (2020b) calculated meaningful ratios of proportional habitat structure and compositional changes over the past 30 years:

- Woody: Non-woody – this is a ratio of all woody vegetation (shrubland & forest) to non-woody vegetation (papyrus, reeds & wetland grassland), an important relationship which can often highlight a drying out of wetlands when flows are markedly reduced or highly regulated.
- Papyrus: Reeds – this is a ratio of ecologically valuable but different habitat types that are directly dependent on both wet and dry season flows (both high and low), but in different ways. A changing ratio could thus indicate a direct response to altered hydrology.
- Fringe: Grassland – this is a ratio of vegetation (fringe vegetation – papyrus & reeds) that is dependent on all aspects of the flow regime to vegetation (wetland grassland) that is mainly dependent on the flooding component of the flow regime. A change in this ratio is likely to indicate an altered flooding regime but may also indicate severely reduced or regulated base flows.

Table 8: Ratios of select habitats in the Sudd over time

	Woody: Non-woody			Papyrus: Reed			Fringe: Grassland		
Wetland	1985	2005	2018	1985	2005	2018	1985	2005	2018
Sudd	1.3	0.6	0.5	5.0	3.5	0.4	1.9	1.1	0.9

The numbers indicate a sharp decline in wetland habitat, which should raise serious concerns over the sustainable use of these resources.

Aquatic macrophytes provide shelter, food, hatching and nesting sites for other organisms. They play an important role in the gaseous balance in both the atmosphere and hydrosphere. *Suddia sagitifolia*, is the single higher plant presumed endemic to the Sudd. It is rhizomatous, with nodal rooting, reaches a height of 2.5 m and grows within papyrus swamp. Its enormous, 12 cm wide leaves are well adapted to function in the shade of reed swamps (Osman, 2009).

Fauna

The Sudd has fifteen keystone and umbrella species. There are also thirty-two species that can be considered as flagship species. The most important of these include the African Openbill, African Pygmy Goose, Basra Reed Warbler, Black Crowned Crane, Nile Lechwe, Nile Shoftshell Turtle, Pel's Fishing Owl, Sahelian Flapshell Turtle, Shoebill, Sitatunga, Vundu Catfish and White-eared Kob. Forty-seven of the species found in the Sudd have an IUCN threat status of interest. Several endangered animal species are found in the Sudd namely, A*cinonyx jubatus* (cheetah), *Addax nasomaculatus* (White addax), *Equus grevyi* (Grévy's zebra), various gazelles (*Gazella dama*, *G. dorcas*, *G. leptoceros*, *G. rufifrons*, *G. soemmerringii*), *Kobus megaceros* (Nile lechwe), and *Lycaon pictus* (African wild dog). The figure below indicates the proportion of threatened taxa found in the Sudd (NBI, 2020b).

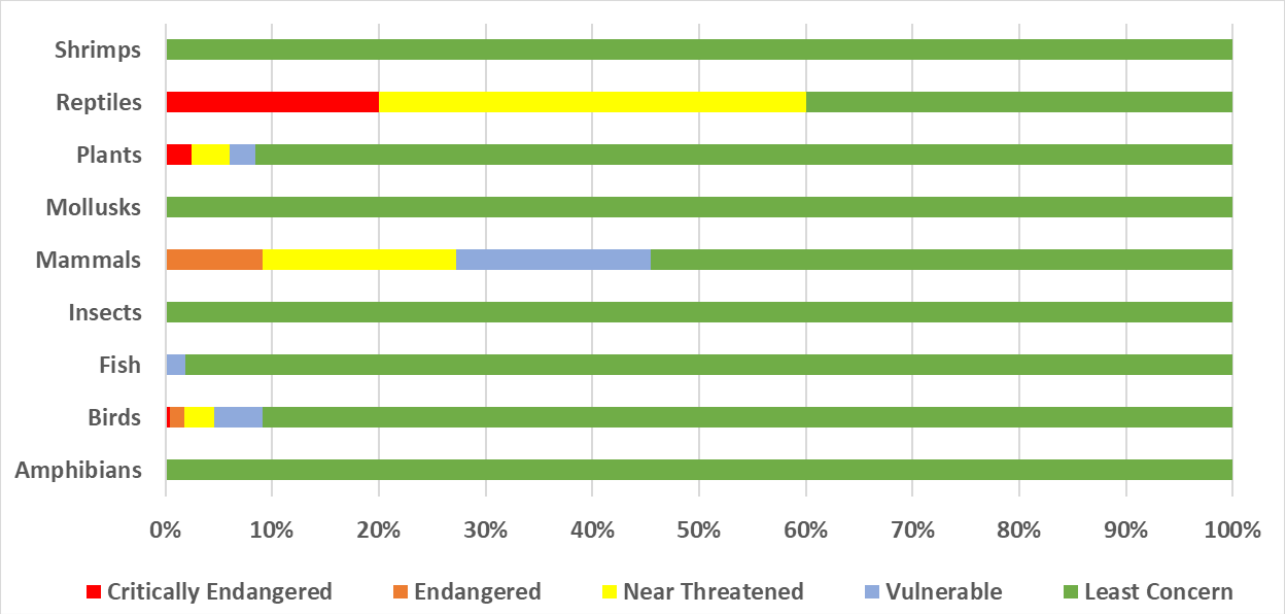

Figure 24: Proportion of threatened taxa for the Sudd wetlands (NBI, 2021b)

Other swamp dwelling mammals include *Hippopotamus amphibius* (hippopotamus), *Tragelaphus spekeii* (Sitatunga), *Atilax paludinosus* (Marsh Mongoose). *Kobus megaceros* (Nile lechwe) is endemic to the Sudd and its movements are related to the flood cycle. It does not live in the swamp but follows the waterline of the river flooded grasslands. *Kobus kob leucotis* (white-eared Kob) make large migrations in the seasonal grasslands, they feed in the grasslands mainly on *Hyparrhenia* and associated grasses. *Loxodonta africana* (elephant) make local movements in the wetlands as the water recedes and giraffes have been seen wading in the water. Migratory mammals depend on the wetland for their dry season grazing (BirdLife International, 2019; Green & El-Moghraby, 2009; Rebelo & El-Moghraby, 2018).

The Sudd is listed as an Important Bird Area by Birdlife International with over 470 documented species (MEF, 2018). Located on the eastern flyway between Africa and Europe/Asia, the Sudd is one of the most important wintering grounds in Africa for Palaearctic migrants, providing essential habitats for millions of migrating birds such as *Pelecanus onocrotalus, Balearica pavonina, Ciconia ciconia* and *Chlidonias nigra*. Balaeniceps rex (shoebill) is considered as an icon of the Sudd. The site is believed to hold over 80% of the world's population of the shoebill stork (Balaeniceps rex) and is probably also important for the ferruginous duck (Aythya nyroca) and passing lesser kestrel (Falco naumanni) (BirdLife International, 2019; Green & El Moghraby, 2009; Rebelo & El-Moghraby, 2018).

Figure 25: Shoebill stork (left) and Saddle-billed stork (right) (NBI, 2012)

Figure 26: Migratory bird flyways (NBI, 2012)

The white-eared Kob and Tiang migration across Boma and Badingilo, and Sudd and Bandingilo savannah ecosystems is a wildlife spectacle and superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance, in which hundreds of thousands of animals migrate in mega-herds across a wide expanse of intact grassland savannah ecosystem (WEF, 2018; Team Africa Geographic, 2021).

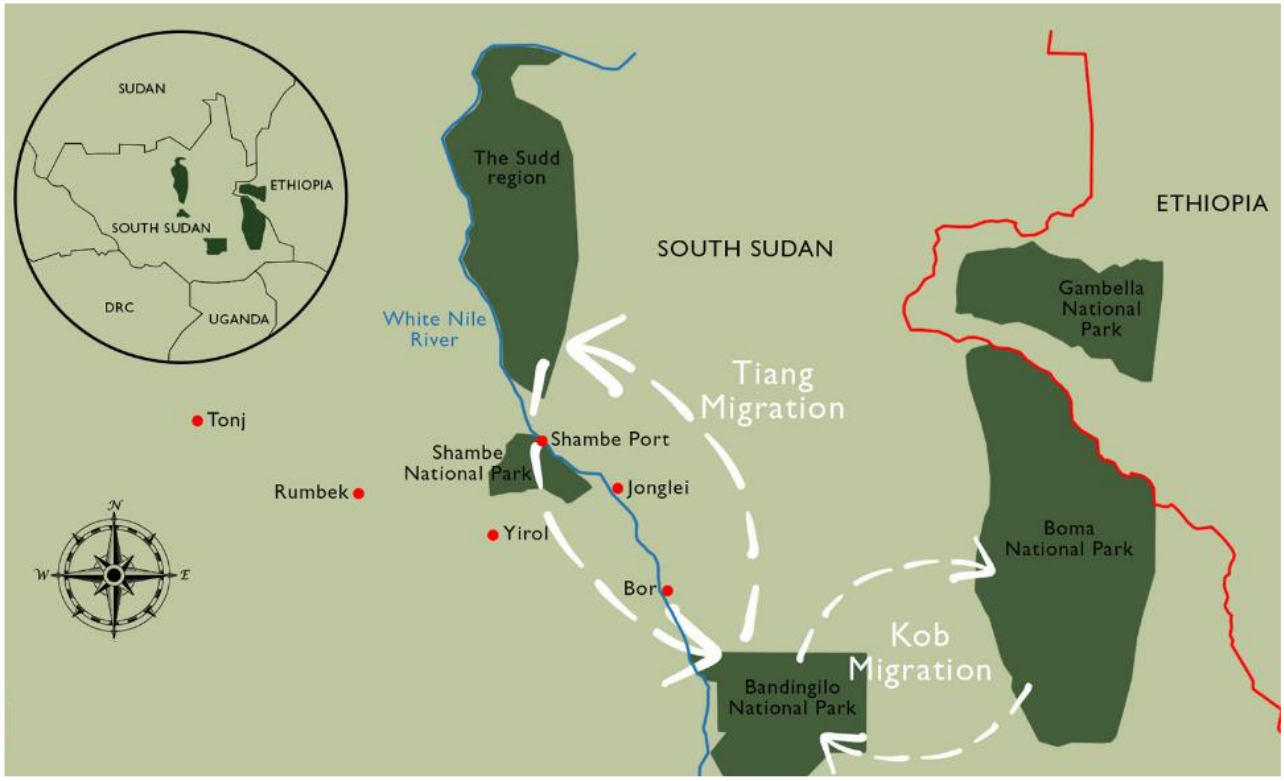

Figure 27: Migration routes of the White-eared Kob and Tiang (Team Africa Geographic, 2021).

This antelope migration represents one the world's few long distances and wide rang seasonal movements of terrestrial mammal species on earth similar to that of Serengeti ecosystem. During the 20 years of the civil war which ravaged South Sudan, the kob and tiang populations were thought to be severely hunted for food by both the combatants and local people to the extent that their populations may have drastically fallen to levels that put the migrations in danger. However, recent aerial transect surveys suggest that the white-eared kob population may still exceed 800,000, and while tiang may have been reduced from almost 500,000 to 160,000 (Malik, 2014). In some instances, the displacement of populations by civil insecurity helps to protect plants and animals from human exploitation. This has been the case for the Sudd.

Figure 28: White-eared Kob (NBI, 2012)

Figure 29: Migrating herd of Tiang (NBI, 2012)

The permanent and seasonal aquatic systems of the Sudd wetland play important roles in the life cycles of many fish species found in the Sudd. The different habitat types ranging from open water, riverine, lacustrine to palustrine provide for the complete life cycle of the fish (Ramsar, 2006). About 100 species of fish have been recorded from the Sudd; 31 siluroids, 16 characoids, 14 cyprinoids, 11 mormyrids, 8 cichlids and 7 cyprinodontids (MEF, 2018). Important fish species from the seasonal floodplain habitat are facultative air breathers e.g., *Protopterus aethiopicus, Polypterus senegalus, Heterotis niloticus, Xenomystis nigri, Clarias gariepinus, Ctenopoma murie*i, and *Parachanna obscura*. The important species in the lakes and channels of the perennial wetland are *Synodontis schall, S. frontosus* and *Auchenoglanis biscutatis, Alestes dentex* and *Heterotis niloticus* (Witte et al., 2009).

Many fish species migrate from the surrounding rivers to the nutrient-rich floodplains to feed and breed during the seasonal floods and therefore play an important role in the life cycles of many fish species identified in the wetland. Fish diversity in the Sudd is impressive and appears to be a response to the favorable environmental conditions offered by the mosaic of habitat types. Some fish species have life cycles that start and end in the wetland. There is very limited data available regarding the status of fisheries in South Sudan, but over 100 species of fish of which Distichodus spp., Gymnachus spp., Hetrotis spp., Citharinus spp., Clarias spp., Lates niloticus, tilapias and catfishes are some of the main species, have been reported to form the bulk of the catches in the Sudd area. There are also eight dwarf fish species of the Nile that are endemic to the Sudd wetland. Frogs are abundant and there are several snake species in the swamps (MEF, 2018).

2.7 Socio-Environmental Context

It is estimated that one million people are inhabiting the Sudd wetland region (UNESCO, 2017). The area supports different tribes (Dinka, Nuer and Shilluk tribes) that live in the Sudd and its surroundings (Rebelo & McCartney 2012), who temporarily migrate with the wet-dry season as the Sudd floods to make use of the products and services this ecosystem provides (Riak 2006; Gowdy & Lang 2016).

The socio-economic and cultural activities of these Nilotes are entirely dependent on the Sudd wetland and on its annual floods and rains to regenerate floodplain grasses to feed their cattle. They move from their permanent settlements on the highlands to dry season grazing in the intermediate lands (Toich) at the beginning of the dry season and return to the highlands in May-June when the rainy season starts (Ramsar, 2006).

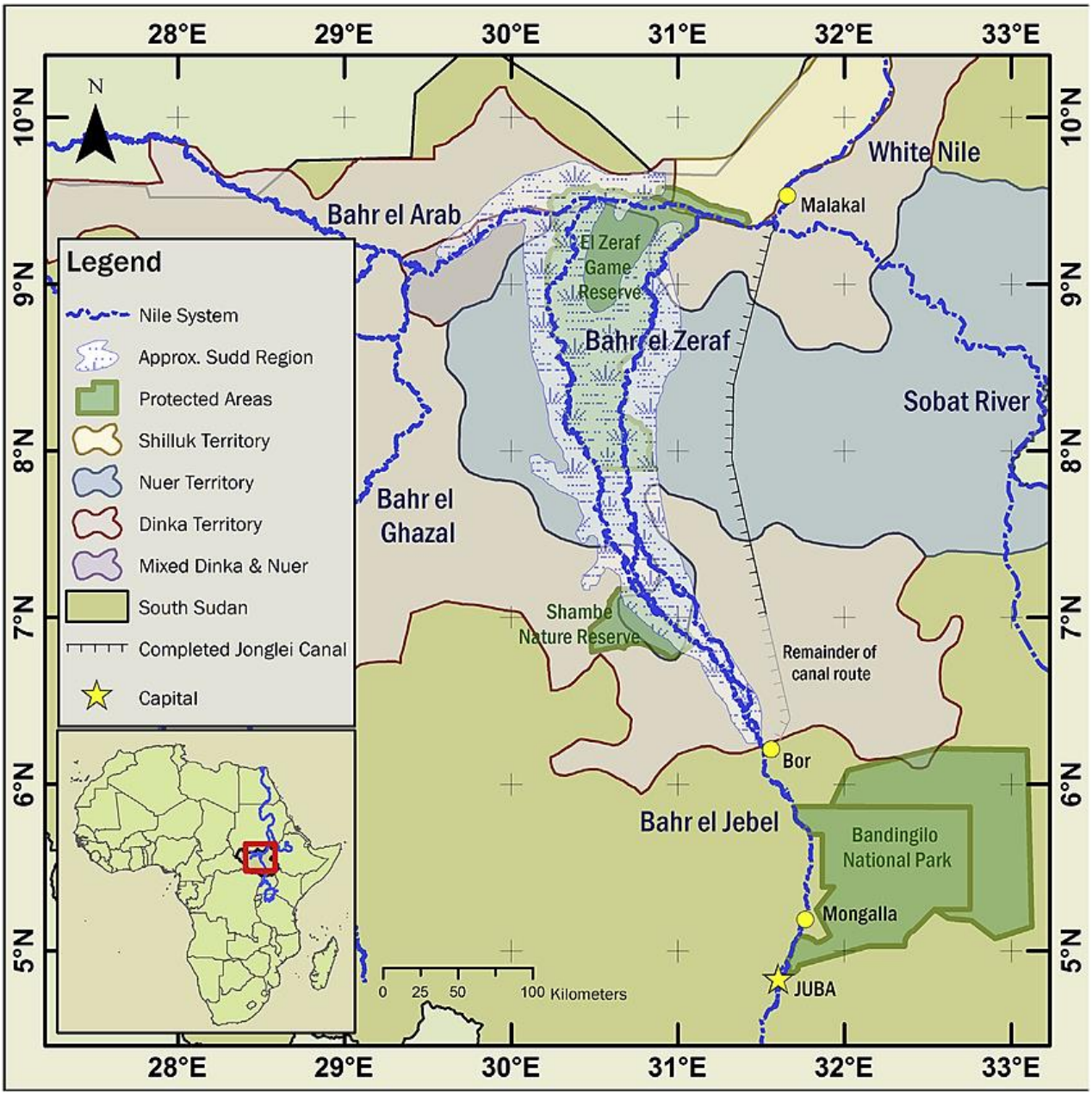

Figure 30: Tribal distribution in the Sudd (Sosnowski et al, 2016)

The influx of refugees and internally displaced people since 2005 have however been an important driver of inappropriate land use and overexploitation of natural resources. The increase in numbers has put more pressure on the already scarce environmental resources.

Latest available information from the World Bank shows that over a period of 10 years, from 2009 to 2019, there has been an increase in human population of almost 21% from 9.142 million people to 11.06 million people.

According to current projections, South Sudan's population is expected to grow throughout the rest of the 21st century. At 11.19 million people as of 2020, the population is expected to grow to 19.96 million people by 2050 and 31.74 million by 2100 (Anon, 2021b).

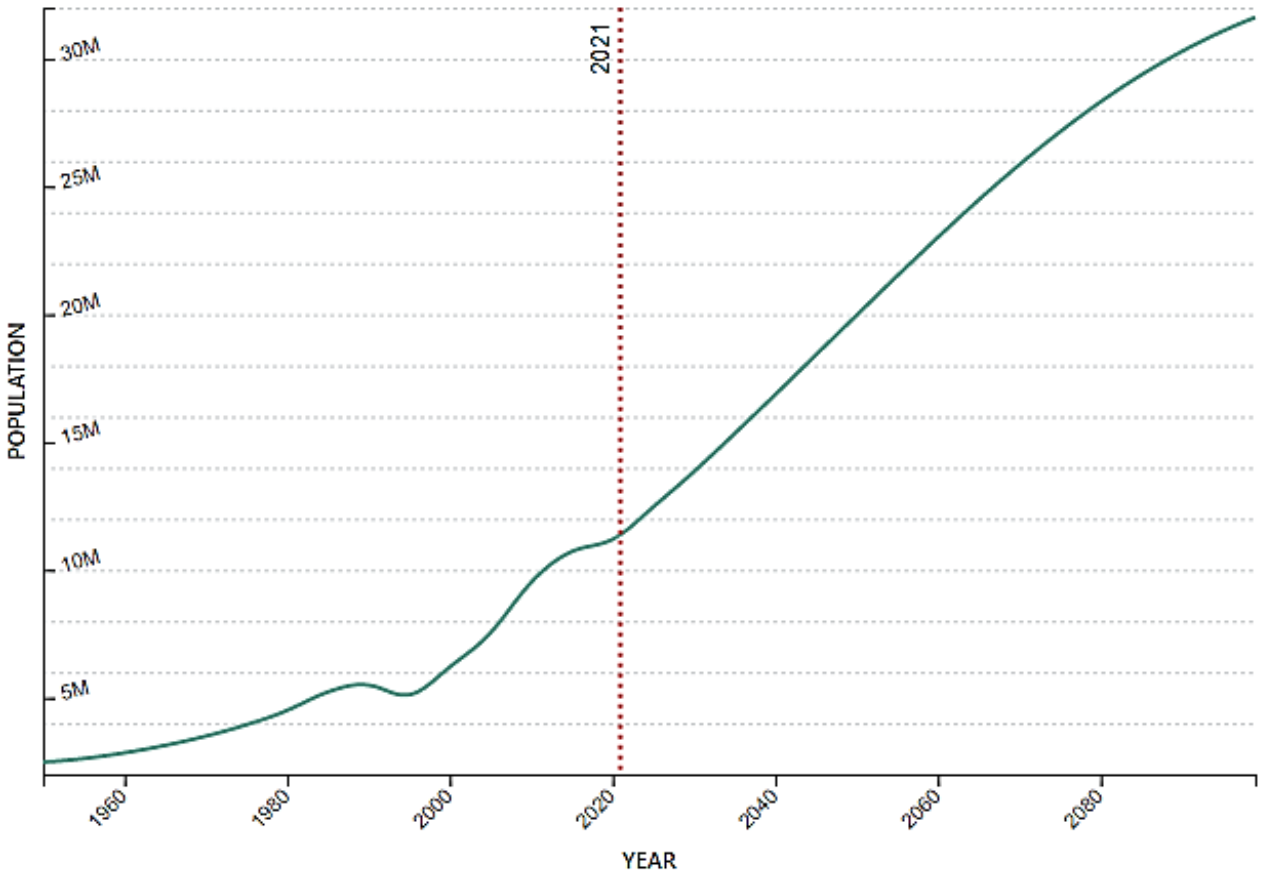

Figure 31: South Sudan population projection (Anon, 2021b)

This is concerning as it can lead to serious losses of wetland area and services as a result of increased demand when not controlled in a sustainable manner. According to Moghraby et al. (2006), the Sudd wetland serves a number of important functions that sustain the livelihoods its people, the most notable ones being:

Agriculture, livestock grazing and fishing

Around 90 percent of the South Sudanese population depend on agriculture and livestock production to sustain their livelihoods. Agriculture and livestock production is mostly practiced for subsistence and almost entirely rain-fed with subsequent low outputs. Livestock which is typically raised in pastoral systems represents a significant proportion of agricultural sector activity, with an estimated population of 10 million heads of cattle, 20 million heads of sheep and goats and undetermined numbers of other livestock (ALTF, 2011). Crop production is not as significant although some subsistence agriculture is carried out in the highland areas during the wet season (Rebelo & El-Moghraby 2018).

Livestock grazing is a major land use practice that is being supported by the Sudd wetland. Seasonal floods sustain vast grazing lands, which are essential to pastoral communities of the Sudd (MEF, 2016). In the 1980s, the floodplain area of the Sudd wetland used for livestock grazing during the dry season was already estimated to be around 700,000ha (Howell et al, 1985). Current land policy dictates common rights to grazing land, the right-of-way to water and grazing land, the right to grass on agricultural land unless the occupier cut and stacked it, and the right to crop residues unless similarly treated. This open access approach to grazing lands leaves little control over or incentive for protection against overgrazing, loss of soil cover, or erosion (Baecher, 2000).

Figure 32: Livestock grazing along the banks of the Sudd (Sosnowski et al, 2016)

During the rainy season, crop cultivation is practiced on a small scale by the Nilotes of the Sudd wetland on the higher grounds surrounding the floodplain. Major crops grown include sorghum (Sorghum spp), maize (Zea mays), cowpeas (Vigna unguiculata), groundnuts (Arachis hypogaea), sesame (Sesamum indicum), pumpkin (Cucurbita maxima), okra (Hibiscus esculentus) and tobacco (Nicotiana tabacum). Although crop production does not depend on the wetland, hundreds of thousands of seed eating birds especially Quelea quelea that breed in the wetland are a major threat to agricultural development and their control a major threat to nontargeted species.

Fishing is an important seasonal activity and source of food as fish migrate to the nutrient-rich floodplains. It is the second most important practice of the Nilotes of the Sudd region as those who have no cattle or lost them during the floods of the 1960s depend on fishing for their livelihood. Traditionally it is an important occupation of the Shiluk and Nuer. It is typically conducted seasonally alternating with crop production and livestock-rearing (Rebelo & McCartney, 2012). The Dinka also fish during the dry season. Commercial fishing has also progressively become an important economic activity of the wetland. The potential sustainable fisheries production from the River Nile, the Sudd, the Bahr el Ghazel, the Sobat Rivers and their floodplains has been estimated at 100,000 – 300,000 tons per annum (MEF, 2016).

Fisheries are inherently closely linked to the use and management of water, as well as land-based or industrial activities which impact water quality, including agriculture (through pesticides and fertilizer run-off), livestock, and petroleum and mining developments. Environmental measures that safeguard water quality are critical to sustainable fisheries development, including the safety and quality of fish in a given body of water (ME, 2015).

Hunting and protected areas

In South Sudan wildlife migrations extend mostly across large areas with relatively low human population densities, but it does also include community dominated zones, which makes conservation particularly important. As with wildlife, local people also move around to find seasonal grazing and to hunt. Subsistence hunting has always been important to the Nilotes of the Sudd catchment (Rebelo & El-Moghraby 2018). Recent wars have provided easy access to guns. Poaching has therefore been accelerated with the use of automatic rifles. This has led to a decrease in the number of wildlife in the area.

In terms of safeguarding the natural environment, the Ministry of Environment and Forestry is responsible for the development of policies and regulatory frameworks with priority work programs for wetlands and biodiversity management. The Ministry of Wildlife Conservation and Tourism is responsible for maintaining the protected areas in South Sudan. However, the remnants of war have made it difficult for initiatives such as rehabilitation, research and other management activities that will enable the extension of currently protected areas and the proclamation of new protected areas. (MEF, 2018).

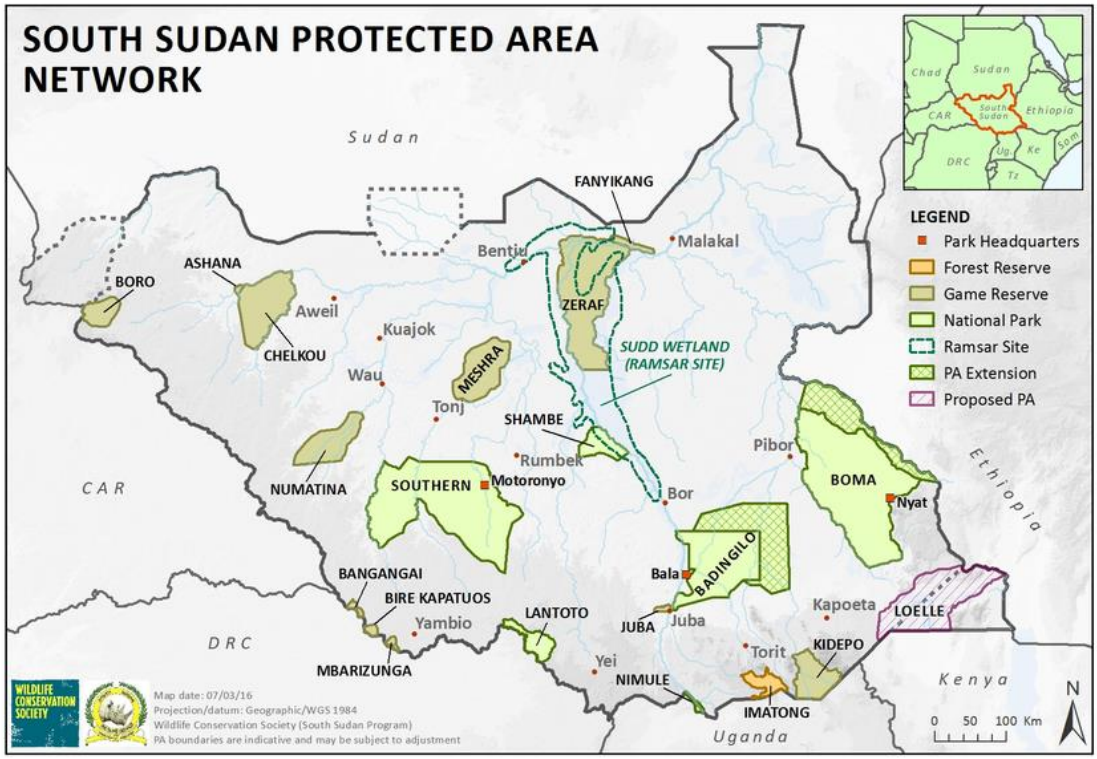

Figure 33: The protected areas network of South Sudan (WCS, 2016)

Table 9: Status and size of Protected Areas in South Sudan (taken from MEF, 2018)

Name and year protected	Area (km²)	Type*	Habitat
Ashana (1939)	900	Game Reserve (VI)	Woodland and tree savanna
Badingilo (1986)	16 500	National Park (II)	Grassland and woodland savanna
Bengangai (1939)	170	Game Reserve (VI)	Lowland forest, woodland and open glades
Boma (1977)	22 800	National Park (II)	Woodland and tree savanna
Chelkou (1939)	5 500	Game reserve (VI)	Woodland and tree savanna
Zeraf (1939)	80 00	Game reserve (VI)	Wetlands, toich grassland, wooded savanna and floodplains
Juba (1939)	200	Game Reserve (VI)	Woodland & wooded savanna
Kidepo (1975)	1 200	Game Reserve (VI)	Woodland & wooded savanna
Lantoto (1986)	760	National Park (II)	Woodland, forest and open glades
Meshra	4 500	Game Reserve (VI)	Woodland & wooded savanna
Mbarizunga (1939)	10	Game Reserve (VI)	Lowland forest, woodland and open glades
Mongalla (1939)	75	Game Reserve (VI)	Woodland savanna, grassland and floodplains
Nimule (1954)	200	National Park (II)	Wooded savanna, Nile River
Numatina (1939)	2 100	Game Reserve (VI)	Woodland & wooded savanna
Shambe (1985)	620	National Park (II)	Woodland & wooded savanna, grassland and floodplains
Southern (1939)	22 000	National Park (II)	Woodland and wooded savanna, bush land, small grasslands, riverine woodland, inselbergs
Bire Kapatuos (1939)	5	Game Reserve (IV)	Lowland forest, woodland and open glades
Badingaru (1939)	805	Game Reserve (VI)	Grassland, woodland & wooded savanna
Boro	1500	Game Reserve (VI)	Woodland and tree savanna

The number in brackets in Table 8 above refers to the IUCN management categories: Strict Nature Reserve (Ib), Wilderness area (Ib), National Park (II), Natural monument or feature (III), Habitat/species management area (IV), Protected landscape (V), Protected area with sustainable use of natural resources (VI).

The primary function of protected areas has been to conserve populations of wildlife and big game, but it also has a major value in preserving ecosystems and ecological functions. The protected areas in Table 8 above, listed under IUCN Category VI, aims to protect habitats through the sustainable usage of its natural resources. The protected areas with national park status falls under category II, which aims to protect natural ecological processes and species on which other cultural, spiritual, educational scientific of tourism activities are based. Only one protected area falls under category IV, which aims to specifically protect the Bongo antelope and the lowland forest habitats.

Current threats that hinder the conservation and sustainable management of these protected areas, include (MEF, 2018):

- Continued civil unrest
- Alternative income options for displaced people and refugees
- Sale of endangered species
- Unsustainable hunting practices
- Livestock grazing pressure
- Unsustainable agricultural practices
- Encroachment
- Lack of data for planning and management
- Lack of capacity (technical, financial and administrative)
- Limited integration of conservation into natural resource management
- Transboundary insecurity

Forestry

Woodlands are a source of significant income for people, communities, state governments, and the central government. As a result, the diversity of ecosystems and species in the country are under constant threat from human pressures. Ecosystems are being further degraded through the expansion of urban areas and increasing developmental and industrial activities, which also involve land conversion. This has a direct impact on the biodiversity of the region. The contribution of woodland resources remains undetermined as the various services that woodlands provide have not been valued and woodland products are traded informally (MEF, 2018). This presents various challenges to develop and sustainably manage the forestry sector.

Deforestation and degradation, through uncontrolled fires, overgrazing and over harvesting, is one of the biggest issues that South Sudan faces, given that these ecosystems are extremely fragile. Historically, it is estimated that South Sudan has lost 2% of its forests annually between 1973 and 2006. Fires are unfortunately also used to clear land for cultivation, hunting and rejuvenating grazing land, which further accelerates the deforestation process. Forest fires also originate from lightning, smokers, and honey collectors. Communities also deliberately set forest fires out of discontent with policies and regulations. Prevention and control of bush fires therefore requires full engagement of local communities (ME, 2015).

On a local level, tree vegetation is an important source of firewood and building poles and is also used in brick making (Riak, 2006). Fuel wood and charcoal make up 80% of the country's energy supply due to a lack of other alternative energy sources. This is leading to the major depletion of woodland resources (ME, 2015).

During war periods, no forest governance could be applied and although there have been efforts to improve forest governance to prevent illegal exploitation, it is still a common practice. The prevent these practices from further occurring, administration and management of the forestry sector require better coordination with the policies, laws, and the institutions that are governing land. (ME, 2015).

Navigation

River transport on the Bahr el Jebel in South Sudan has a long history of successful operation while in the last decades having strongly declined due to the challenging security situation in the country. Considering the seasonal conditions challenging land transport in the rainy season and especially in the Sudd, the river is an economic lifeline for the riparian people.

The Bahr el Jebel is navigable throughout the Sudd between Juba and Malakal. From Juba, the river is first maintained by riverbanks, but from Juba onwards being constricted only by large papyrus and reed fields as well as the seasonally flood floodplain areas. The river is following a strongly meandering course, partly broken up by large lagoons. Further to the north, the river leaves the Sudd at the confluence with the Sibat close to Malakal where it is maintained by clear riverbanks again.

The slope of the river as well as its flow velocities are gentle, ranging between 0.5-4.5 m/s, which is mostly within the navigability threshold (4 m/s) (UNOPS, 2018). Water depth between Juba and Bor is currently insufficient for navigation of larger barges during the dry season, while north of Bor water depth suffices at all times. River width is often limited by vegetation, including floating vegetation blockages and narrow curvature of meanders.

Main ports in and adjacent to the Sudd include Juba, Mangalla, Terakeka, Mingkaman, Bor, Shambe, Adok, Bentiu, and Malakal. All ports have limited facilities and lack basic infrastructure which is often nonexistent or deteriorated. Investments have been made over the last years at ports in, e.g., Juba, Mangalla, Bor, Mingkamen, and Malakal to improve their handling ability and capacity, while other ports seem to be little used. Especially Bentiu Port is completely overgrown. A major factor affecting barge navigation is the current security situation characterised by prevalence of acts of armed conflict and banditry, causing various incidents.

Considering historic peak barge transport numbers of approximately 140,000 tons per year in 1981-1982, and current transport numbers of about 10,000 tons, there is an immense potential for the river transportation sector. UNOPS (2018) calculated that under competitive market conditions barge transport should cost only around 25-50% as compared to road transport. Barge transport is possible year-round, while road transport is challenging and partly impossible in the rainy season.
The long-term economic benefit associated to a river transport system with its lower transport costs is clearly seen in long-term development benefits, i.e., making available large-scale supplies of goods that are currently expensive due to high transport costs. By the same token South Sudan's goods currently stand limited chance in export markets.

The currently available operational fleet is sufficient to manage additional cargo capacities, although much of the fleet needs improvement if barge transport is to be improved. To reach Juba by barge, dredging between Juba and Bor is required. Further, ports need upgrading to reduce port time. This can be achieved with partly reasonable efforts, while e.g., for the case of Bentiu significant dredging and port rehabilitation works are necessary. Which are unlikely to be compelling from an economic perspective. Dredging work is already taking place in some canals and in inflow areas to the Sudd from the west to clear the way for transportation. This is however taking place without proper environmental controls being in place, which could leave lasting damage to the Sudd ecosystem. An overarching requirement for increasing barge transport and a growing economy is also the improvement of the security situation.

Further, environmental aspects are an important consideration in developing river transportation in the Sudd. The Sudd is a pristine wetland area and Ramsar site that has so far been relatively undisturbed by human activities. This international status obligates the Government of South Sudan to protect and manage the Sudd effectively, yet this requires capacities for the monitoring and enforcement of environmental regulations. Social and environmental impact assessments will be required before any works are being carried out.

It is important to identify a proper balance between the improved navigation sector to support human development as well as environmental controls that secure sustainability of the White Nile River and the Sudd ecosystems.

Figure 34: Cattle being transported by boat (Photo source: HYDROC)

2.8 Ecosystem Services and Valuation

The Sudd wetland is an ecosystem of worldwide importance (Riak 2006; Rebelo & McCartney 2012; Rebelo & El-Moghraby 2018; Gowdy & Lang 2016). The IUCN identified the Sudd as part of a key unrepresented ecological system globally. It is a vast social-ecological and hydrological system driven by the dynamics of the Nile basin's water regime, supporting a diverse array of wildlife and various cultural traditions of its Indigenous communities (UNESCO, 20217).

The Sudd supports a diverse range of habitats (e.g., open water, swamps, seasonally flooded grasslands, floodplain woodlands) which are highly dependent on the annual flood pulse (Rebelo & McCartney 2012). The Sudd resources have enormous ecological, cultural, and economic value that emanate from the interactions between the water, physical structures and biological processes of the wetland ecosystem services. These services include sediment and nutrient reduction, carbon sequestration, groundwater recharge, fisheries, recreation and support for biodiversity (Opperman et al, 2017).

The Sudd contributes provisioning ecosystem services in the form of food (fish, game and fruits), freshwater, building materials, and medicinal products. Particularly important are the diversity of vegetation communities that are heavily used for grazing, especially the seasonally river-flooded grasslands, which are the most productive for year-round grazing caused due to high protein content of the dead grass. Further the flooded areas are an important freshwater source for livestock during the dry season. The Sudd as a water source is also important for other wildlife during the dry season (Riak, 2006).

Besides these products and supporting biodiversity, the Sudd also provides regulating ecosystem services such as the regulation of water flow, nutrient retention, purification of water, and providing climatic and natural hazard regulation. The socio-economic benefits of the wetland to the communities living in its catchment are considered as immense. Ultimately, the Sudd has very important cultural values for the local tribes, from sacred wildlife species (e.g., Nile lechwe (Kobus megaceros), the shoebill (Balaeniceps rex), and

the crowned crane (Balearica pavonina) to important ritual places, used for the initiation of relationships and dancing leading to courtship and marriage (Rebelo & El-Moghraby 2018). According to Gowdy & Lang (2016), if effectively managed, the Sudd wetland can greatly contribute to the sustainable economic development of South Sudan.

Table 10: Present Ecosystem Services (ES) identified for the Sudd wetlands (From NBI, 2020c)

0 = not applicable; 1 = ES in Bahr El Jebel sub-basin (according to literature); 2= ES potentially available in Bahr El Jebel sub-basin (based on Table 3 - expert judgement); 3 = Not Known

Ecosystem Services Category	Ecosystem Services	Open water (1)	Permanent Swamps - Papyrus (2)	Reeds (3)	Grassland (4)	Woodland/Forest (5)	Agriculture (6)	Other/Not Specified (0)
Provisioning ES	food - wild fish	1	1	1	0	0	0	2
	food - insects	2	2	2	2	2	3	3
	food - wild game	2	1	1	1	1	2	2
	food - fruits	0	2	2	2	1	2	2
	food - vegetables	0	2	2	2	2	2	2
	food - grains	0	2	2	2	2	2	2
	food - fodder and pasture (for livestock)	2	1	1	1	1	2	2
	food - farmland (for crop cultivation)	3	1	1	1	1	2	2
	fresh water	1	1	1	2	2	0	2
	fuel/ fiber/ raw materials	3	2	1	2	1	2	2
	medicinal products	3	2	2	2	1	3	2
	genetic materials	2	2	2	2	2	3	2
	Transport Infrastructure	1	0	0	2	2	0	2
Regulating ES	waterflow regulation	2	1	1	1	1	0	2
	water purification/waste treatment	2	1	1	1	1	0	2
	erosion regulation	2	2	2	2	2	0	2
	maintenance of soil fertility	2	2	2	2	2	0	2
	natural hazard regulation	2	1	1	1	1	3	2
	climate regulation	1	1	1	1	1	3	2
	pollination	0	2	2	2	2	2	2
	biological control	2	2	2	2	2	0	2
Supporting ES	soil formation	2	2	3	2	2	0	2
	nutrient cycling	2	2	2	2	2	0	2
	maintenance of genetic diversity	2	2	2	2	2	0	2

A recent TEEB analysis on the Sudd wetland (NBI, 2020d) had the objective to conduct an economic valuation of biodiversity and ecosystem services of the Sudd wetland which would inform green infrastructure planning and development.

For this study, the current total value is estimated based on the LULCC data for the year 2015. The total economic value (TEV) of the wetland for 2015 is estimated at about $3.3 billion. The result shows that the wetland has major contribution for the community as it provides more than $253 million worth of provisioning services per annum while it also contributes about $148 thousand worth of water transportation services. The wetland also provides regulating and biodiversity services worth of about $1.8 billion and $1.2 billion, respectively in the form of microclimate regulation, flood control, and water regulation.

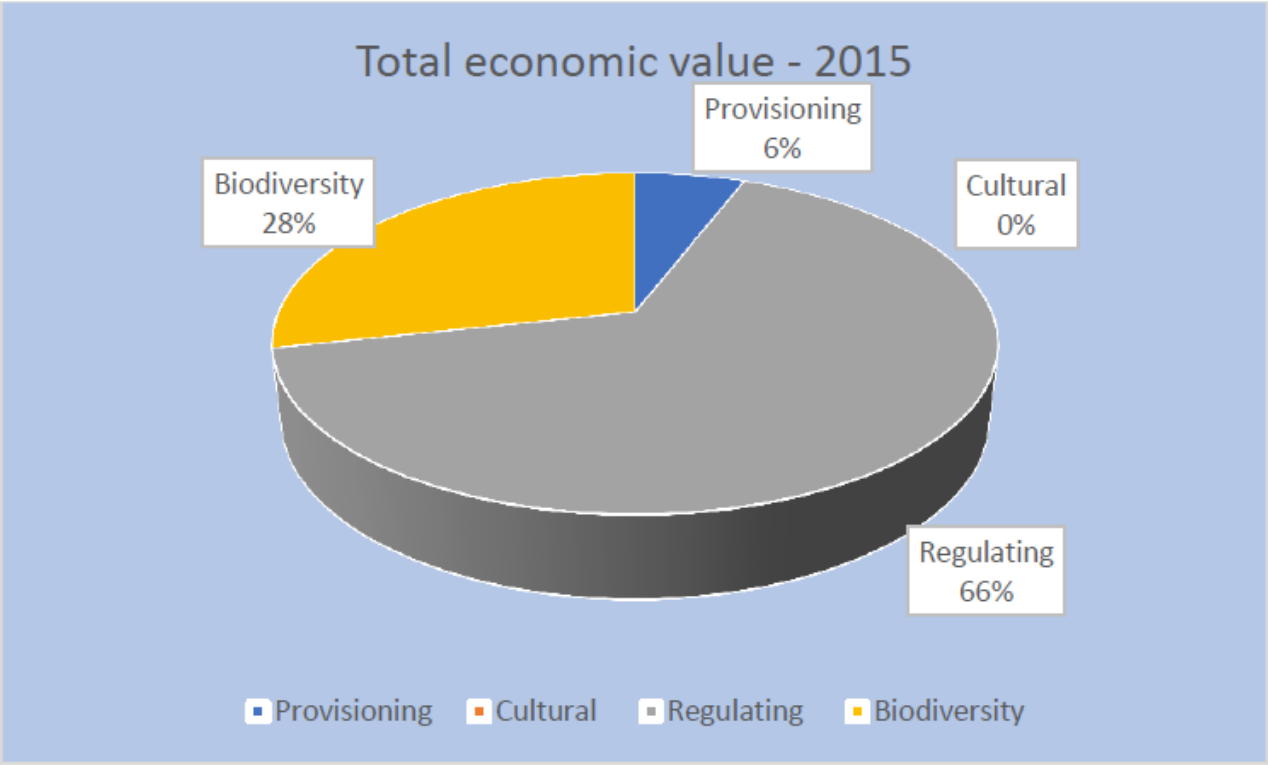

Figure 35: Total Economic value of the Sudd Wetland (NBI, 2020d)

Comparing the total economic value across time for the different LULCC, reveals that the total economic value of the wetland declines from year 2015 to 2025 and then to 2035. However, this decline did not occur for all the ecosystem services computed in this study. The provisioning ecosystem services increased from 2015 to 2025 and then to 2035 mainly due to the increase in cropland and grasslands. The remaining ecosystem services: that is, the cultural, regulating and biodiversity services declined through time as a result of the decline in the vegetation cover. The findings clearly highlight that the current land use pattern is not sustainable and hence a viable option needs to be considered.

2.9 Development Potential

Oil Extraction

The Sudd is of significant interest for oil exploitation as it contains South Sudan's largest oil reserves (UNESCO, 2019). Crude oil accounts for the largest portion (98%) of the total revenue generated by South Sudan. Estimated oil reserves total 428.2 million tons. Production per day totaled 140,000 barrels per day in 2019 and is predicted to be increased to 350,000 barrels per day by 2022 (MEF, 2021).

Unfortunately, most of these oil and gas reserves are located in or near important biodiversity areas. This fact makes it difficult for decision makers to find a balance between conservation and economic progression (World Bank, 2018). Several blocks have already been allocated to oil companies and exploration drilling is underway in the permanent swamps. An oil field investigation in the Upper Nile of the Sudd region have revealed that soils from oil drilled land as well as from cultivated locations 5km away from oil wells are highly contaminated with petroleum hydrocarbons concentrations that exceed the Sudanese threshold value of 5,000 $mgkg^{-1}$ soil for petroleum hydrocarbons (NBI, 2020e)

Many further studies reported a high salt content in the water, dying of livestock, reduction in vegetation cover and uncommon diseases among the local communities around the oil extraction sites. Without proper management, land use conversion from natural to oil drilling, will reduce soil fertility and agricultural productivity. Wetland biodiversity would suffer by these activities, especially fish species, which are a critical resource for the communities living in the area (NBI, 2019). Consequently, population of the surrounding wetland will suffer losses in their food security.

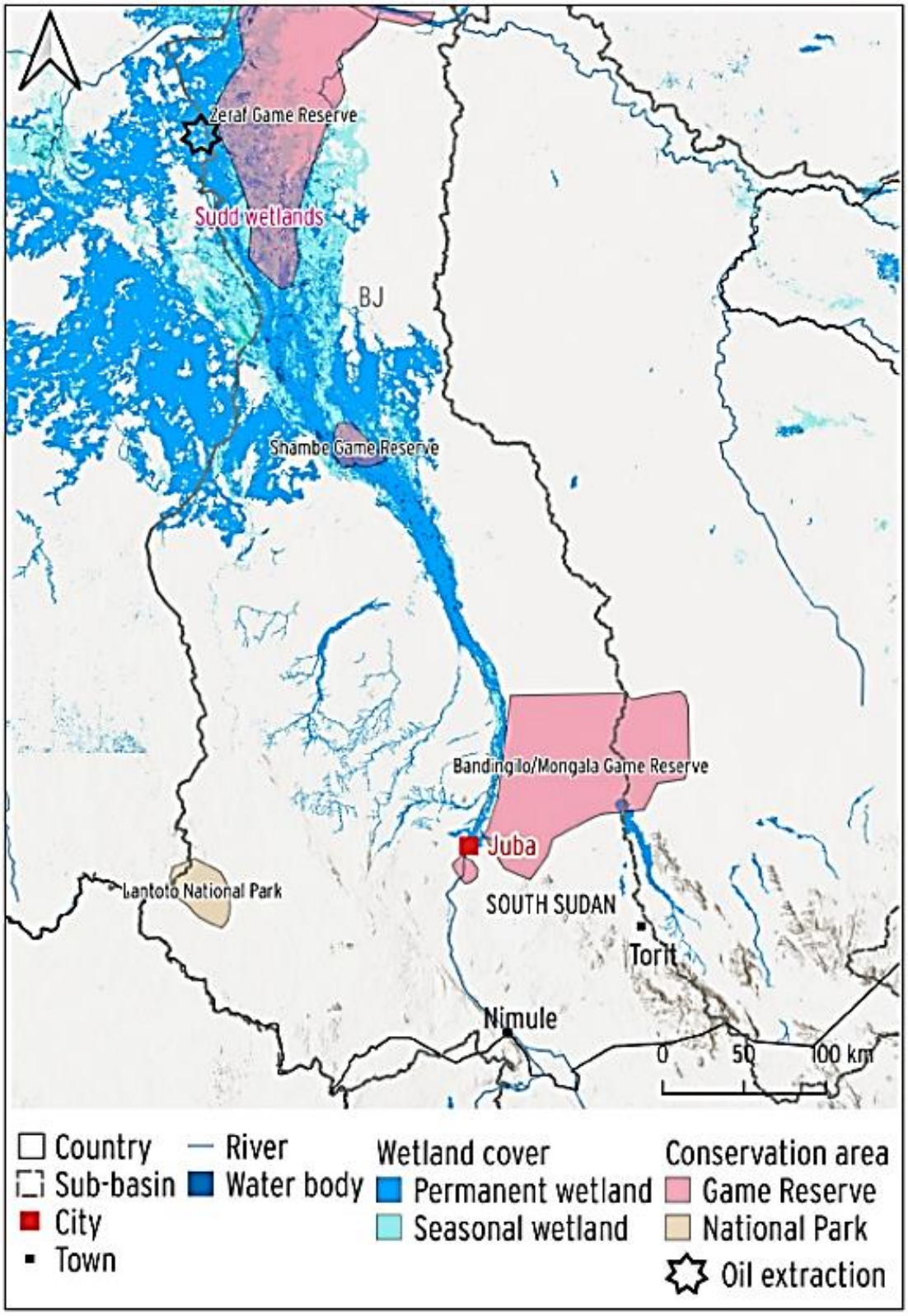

Figure 36: Oil Extraction in the Upper Nile, South Sudan (NBI, 2020e)

Dams for Hydropower Generation

South Sudan has considerable hydropower potential, with the greatest lying on the Nile River between Nimule and Juba. Along with this, mini-hydropower projects may be feasible in many other parts of the country.

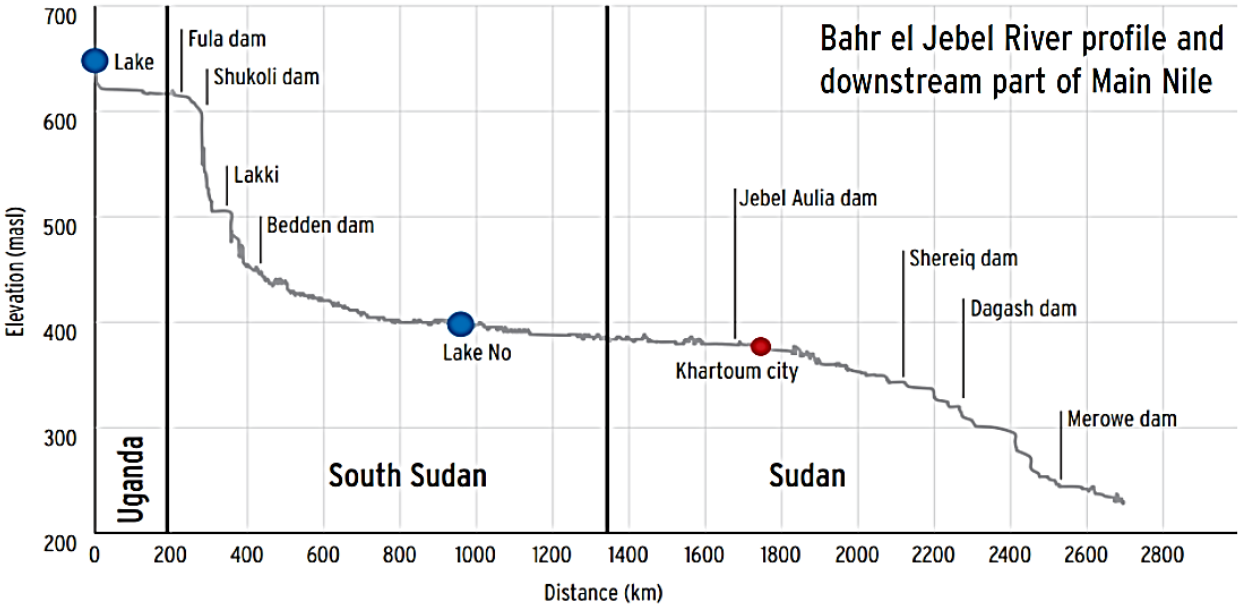

Figure 37: Bahr el Jebel profile (NBI, 2020e)

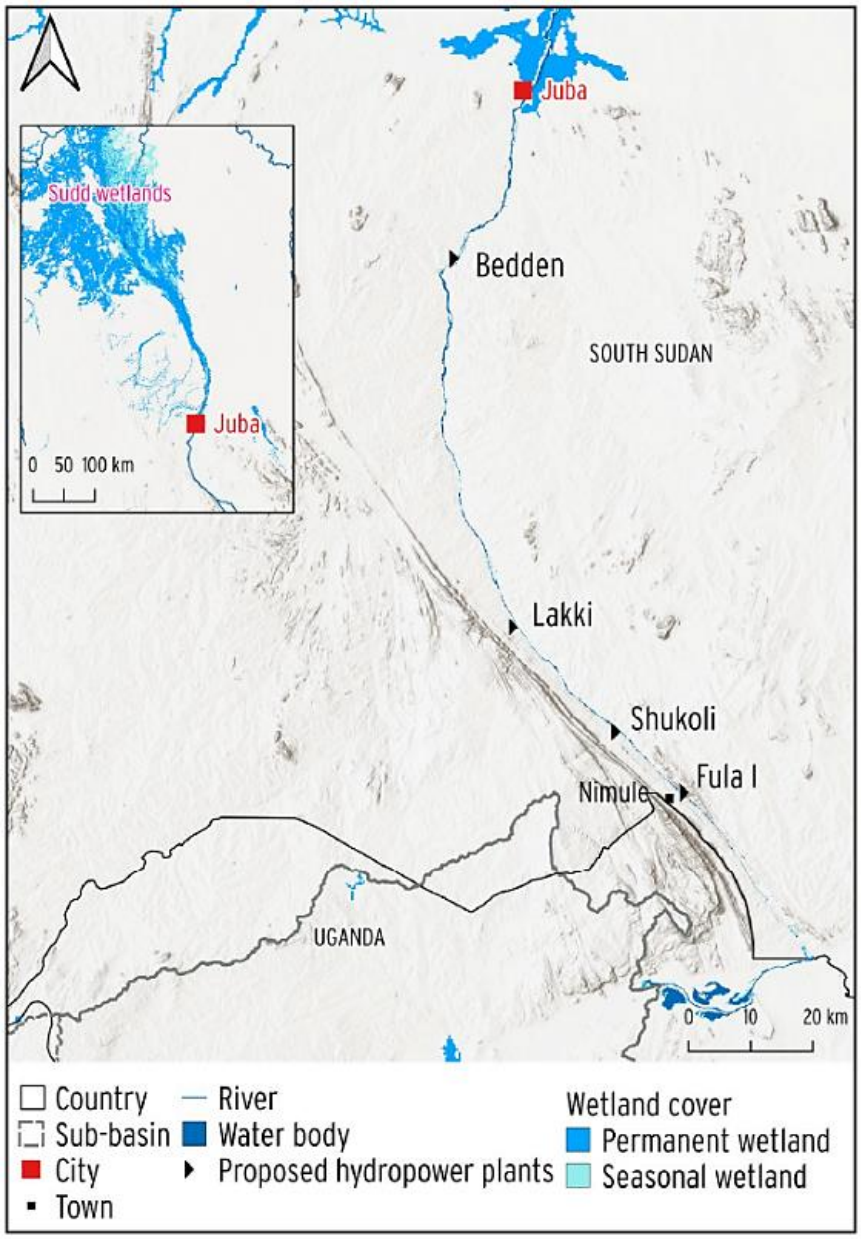

Figure 38: Possible dam locations in Bahr el Jebel (NBI, 2020e)

The potential for hydropower planning in the Bahr el Jebel sub-basin is quite substantial. From the outlet of Lake Albert in Uganda to the inlet of Lake No, in South Sudan, the river stretches 1,000km with a decrease in elevation of 250m (NBI,2016). Several potential hydropower sites are planned e.g., the Fula dam in Nimule (completion in 2025) and the Bedden dam south of Juba (2028).

As the economy modernises, energy production will also have to be ramped up gradually from the current 22 MW of installed capacity, which will require in the short term the establishment of a basic institutional framework and in the medium term the implementation of a diverse mix of generation resources with special attention to large-scale hydropower development. The exact hydropower potential (in terms of total MW exploitable) has not yet been fully studied at feasibility level. A potentially attractive cascade of hydroelectric power development options is available to South Sudan on the Bahr el Jebel River. Some prospective sites were studied at prefeasibility level in 1983 and again in 2009. The prospective sites include Fula (890 MW), Bedden (570 MW), Shukoli (235 MW), and Lakki (410 MW) (Fernando & Garvey, 2013).

Beyond the technical issues of carrying out feasibility studies and preparing designs, there are major strategic, institutional, and capacity issues in developing the hydropower resources. These are new challenges for the country and the concerned ministries. They include (Fernando & Garvey, 2013):

- Analyzing and understanding potential transboundary water allocation and management issues and possible solutions;
- Assessing the optimum sequencing of dam cascade development and implications on future benefits that might be forgone with such development;
- Understanding impacts on downstream environmental integrity, hydrology of the Sudd and wetlands, and communities and livelihoods of people depending on wetlands and Nile waters;
- Implementing and monitoring of plans to mitigate environmental and social impacts arising from dam construction and operation to internationally accepted standards;
- Developing institutional capacity for administration of complex procurements, monitoring large multiple contracts, and dealing with contractual disputes;
- Developing in-country capacity for dealing with transboundary water issues;
- Developing capacity and a program for dam safety monitoring and management;
- Enhancing stream gauging and river flow monitoring of the Bahr el Jebel.
- Heavy silt inflows from upper catchment areas from poor land use might be a major issue for future dams, and upstream watershed management programs will have to be continued to reduce soil erosion and sediment flows in the Nile.

The effect of the further dam projects and other related development schemes like construction of the Jonglei Canal or dikes along the River Nile may have enormous impact on the Sudd wetland and downstream countries Sudan and Egypt.

Jonglei Canal

The Jonglei Canal project was proposed to reduce the water losses in the Sudd region. The aim of the project was to bypass water next to the Bahr el Jebel by diverting 20-25 million m^3 per day of its water directly northwards through a side canal from Bor to near Malakal in order to by–pass the Sudd (Ramsar, 2006).

This would create a navigable canal and more importantly would prevent approximately 100 m^3 of water from evaporating in the Sudd, which in turn would be available for downstream use. On top of this, 100,000 ha of land for agricultural purposes were planned to be gained by draining the wetland. The canal was expected to reduce the water level of the swamp by 10% during flood season and by 20% during the dry season, greatly reducing the area of the toich.

Construction started in 1978, however, the Sudanese civil war in 1983 put the project on halt, after 240km of 360 km (66%) were already completed. With the signing of the Comprehensive Peace Agreement in 2005 and the end of the civil war, a major threat to the wetland was the potential completion of the Jonglei Canal (Sutcliffe, 2009).

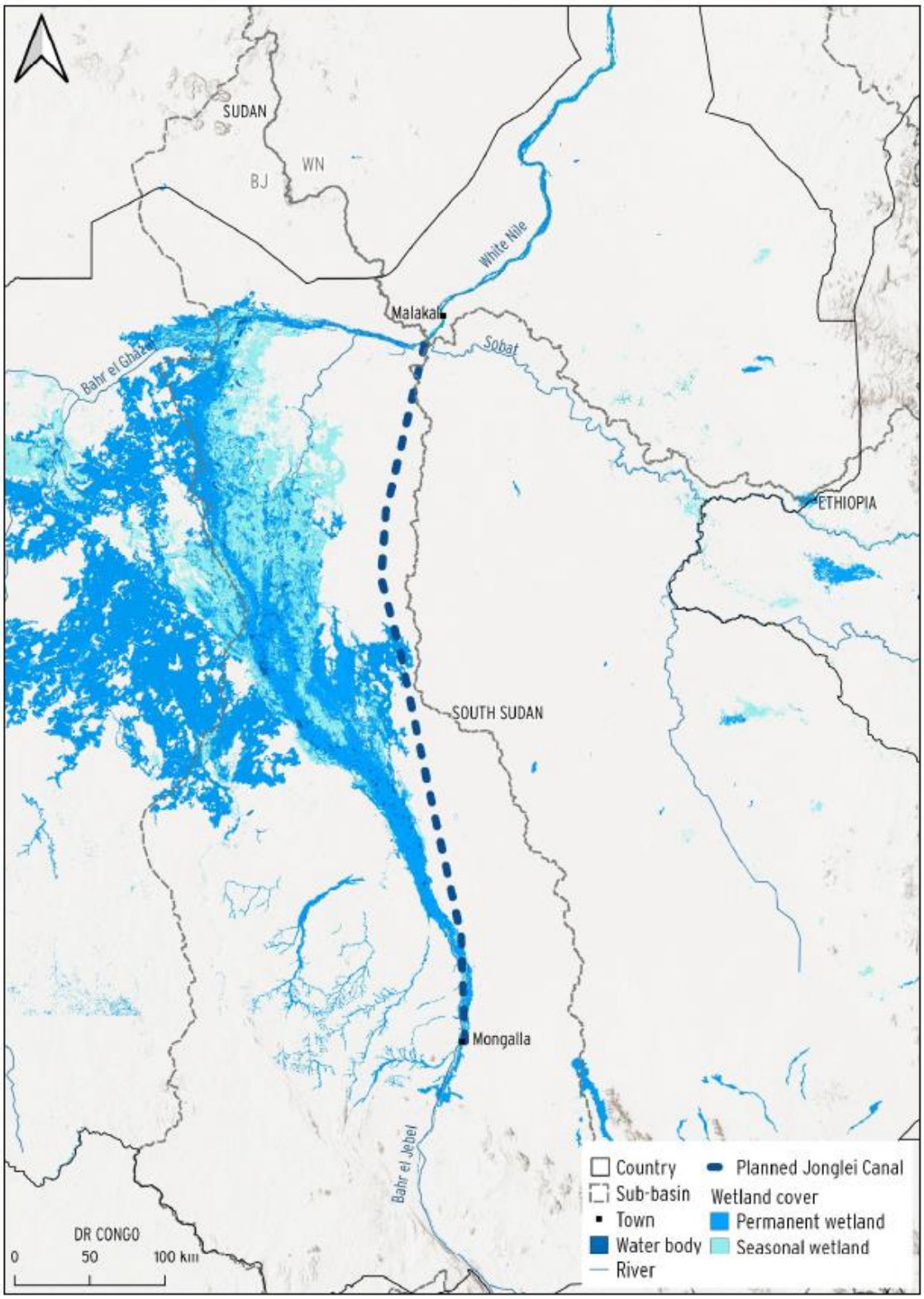

Figure 39: Location of the Jonglei Canal (NBI, 2020e)

The completion of the canal would significantly impact climate, groundwater recharge, sedimentation, and water quality. If only 20 % of the peatland area in the Sudd are drained by such a project, this would lead to annual emissions of about 5.8 Mt CO2 (Peters, 2021). These impacts will most likely result in the loss of biodiversity, fish habitats, and important grazing areas. The canal will interfere with the seasonal migration patterns of both cattle and wildlife, all of which will have an effect on the livelihoods of the local populations (MEF, 2018). The expected environmental, social and economic consequences of the canal are well reviewed by Howell et al. (1985). The effects of the canal on the economic activities of the inhabitants of the Sudd

region though variable can be viewed under the following headings according to their importance:

- Pasturalism: Although the construction of the canal is supposed to increase the area of rangeland, the canal interferes with the seasonal migration pattern of the nomads and their cattle.

- Fisheries: Enlargement of the Sudd floodplains during the last four decades brought many positive changes to the fisheries of the Sudd region. The mosaic of open water, riverine, palustrine and lacustrine environments created by the high floods improved recruitment and survival chances for most fish species in the area. Some biologists speculate that this healthy state will be reversed if the effect of the canal is combined with a return of the flooding regime to its pre 1961 period. Low river discharges into the swamp will create blockages of channels thereby impairing river transport and lateral fish migration, reduction in permanent and seasonal swamp areas causing decline of fisheries resources and their possibility of expansion.

- Wildlife: Change in habitat due to reduced river discharge, blockage of mammalian migratory routes for species like tiang, reedbuck, giraffe and zebra among others, and increased poaching, due to improvement in communication, are the major effects of the canal on wildlife. Habitat loss will affect recruitment and survival of the Shoebill stork as well as toich dependent and resident mammalian species. It will also create competition between wildlife and livestock for the shrinking toich grassland. The canal will also expose animals to other forms of mortality at the canal edge.

- Agriculture: Large scale crop production has never been an important occupation of the nomadic tribes of the Sudd region due to the effects of climate, soil fertility, pests, weeds and diseases. The assumed benefits of the canal to the agriculture sector have been found to be minimal. The use of avicides for the control of pest birds like Quelea quelea will disrupt the ecosystem function if non-target species are affected.

In 2008, discussions to continue the work were resumed. However, since the independence of South Sudan in 2011, there has not been any further discussions or agreements made to resume the project (Dumont, 2009). Plans for the future of the canal do however remain unclear (Lunt et al., 2019; Rebelo & El Moghraby, 2018).

Figure 40: The Jonglei Canal (Photo credit: HYDROC)

(Photo source: HYDROC)

3. POLICY, LEGAL, INSTITUTIONAL AND STAKEHOLDER CONTEXT

The utilisation of the various functions of wetlands and the resources that it provides are interlinked with various stakeholders at various levels and therefore also needs to incorporate regulatory frameworks such as legislation, policies and institutions that share in the management of these wetland resources.

Table 11: Roles of stakeholders that share the management & use of wetlands (From NBI, 2020d)

Ecosystem service	Functions	Stakeholders	Roles and interest
Provisioning	Fuelwood, agricultural crops, domestic water consumption, livestock watering, communal grazing, fish, medicine, papyrus, papyrus crafts	Local communities	Consumption Generate income (livelihood) Conservation
		States	Consumption Generate income (tax) Policy formulation Project design & approval Budget allocation
		South Sudan as a nation	Generate income (tax) Policy formulation Project design & approval Budget allocation
		Neighbouring countries	Consumption Generate income
Regulation	Microclimate regulation, water regulation, flood control	Local	Microclimate regulation Consumption (water and soil) Conservation
		Regional	Regional climate regulation Water flow regulation
		Global	Climate change reduction
Cultural	Transport	Local communities	Transportation Generate income
		States	Transport Generate income Policies and regulations Project design and approval
		National	Policies and regulations Project design and approval Budget allocation and follow-up
Biodiversity	Different flora and fauna, biodiversity hub, different reserved areas	Local	Generate income Conservation
		Regional	Financing of biodiversity projects Research Capacity building
		Global	Financing of biodiversity projects Capacity building Database and research

Different stakeholders can be identified with direct and indirect contribution and concern on wetland. Involvement differs in level and scope. At a local level, stakeholders are usually mostly involved with consumption, generating income and localised conservation practices. At a national level, stakeholders are engaged in broader contexts and mainly focus on formulating policies and regulations for wetlands and other resources; allocate budget; negotiate and approve global and regional treaties; monitor the implementation of policies and regulations; prioritise budgeting for different activities; attract funding from donors; and design and approve projects related to wetlands among others (NBI, 2020d). At regional and global level stakeholders are concerned with research, funding and capacity building initiatives.

In South Sudan the Ministry of Environment and Forestry is in charge of the protection and conservation of the environment and the sustainable utilization of environmental resources which includes wetlands. The

Directorate of Wetland and Biodiversity under the Ministry is also tasked with drawing up policy and strategies which helps to apply not only domestically but also transboundary conventions signed by the government to conserve the wetlands. With regard to conventions, while the Ministry of Foreign Affairs and International Relations is the political body for different agreements, the Ministry of Environment and Forestry is the technical body which drafts the agreements. The different Universities and institutions, while building the capacity of the bureaucracy through different formal and informal trainings, are also sources of knowledge base and research on the potential, degradation, challenges, and alternative interventions of the wetland (NBI, 2020d).

The external stakeholders also play a vital role in providing guidance and funding for the protection and conservation of different natural and environmental resources, capacity building initiatives, and conducting different studies among others. (NBI, 2020d). There are thus several aspects that guide the management and conservation of wetlands in South Sudan. The most relevant of these are highlighted in this section.

Multilateral environmental agreements (MEA)

Table 12: Multilateral environmental agreements that are in place in South Sudan

MEA	RELEVANCE
Ramsar Convention on Wetlands of International Importance, 1971	This is the most relevant international agreement to the Sudd wetland. The Convention was ratified by South Sudan in 2013. It provides guidelines for sustainable use, management and governance of wetlands and a framework for international action and cooperation for the conservation and wise use of these areas and their resources. Most relevant to this plan is the call for international cooperation between contracting parties and individual countries to formulate national policies on wetlands.
United Nations Framework Convention on Climate Change (UNFCCC), 1994	The UNFCCC entered into force on 21 March 1994. Today, it has near-universal membership. The 197 countries, which includes South Sudan, which have ratified the Convention are called Parties to the Convention. The ultimate aim of the UNFCCC is to preventing human interference with the climate system.
Paris Climate Accords, 2015	In 2016 South Sudan agreed to an ambitious programme of climate change mitigation and adaptation under the UN Framework Convention on Climate Change. The agreement calls on states to develop Nationally Determined Contributions (NDCs) to address climate change, with nature-based solutions as a key component, including from wetlands. These have a critical role in both adaptation and mitigation through carbon storage and sequestration, particularly in peatlands. Through this plan, South Sudan is encouraged to prioritise inclusion of the Sudd wetland conservation and management in their NDCs. However, in spite of the increased recognition on safeguarding wetlands as key natural climate buffers in landscapes, very few climate initiatives have identified the need to protect, restore and sustainably manage these ecosystems.
Convention on Biological Diversity (CBD), 1992	The CBD prioritises the protection of ecosystems such as wetlands, which are species-rich and are important for endemic and threatened species and obligates states to develop national strategies, plans or programs for conservation and sustainable use of biological diversity and to integrate them into sectoral or cross-sectoral plans, programs and policies. This makes the CBD relevant and justifies the rationale for the development of this Plan for sustainable management of biodiversity within the Sudd wetland ecosystem. South Sudan ratified the CBD in 2014.
East African Community (EAC) Treaty, 2000	Obligates parties to cooperate in matters of environment and natural resource management in their countries as well as those that are transboundary. It's Protocol on Environment and Natural Resources Management, 2006, obligates parties to harmonise, adopt and domesticate common policies, laws and frameworks to ensure that there is sustainable management and use of the wetlands resources within their borders and also ensure the same for the transboundary resources.

Policy, legal and regulatory framework for wetland management in South Sudan

South Sudan does not have a specific policy for wetlands management. Wetland management falls under the ambit of various other policies and regulation related to the management of water resources in general. South Sudan has experienced various challenges with the implementation of wetland management as a result of management conflicts that arise from overlapping institutional mandates where different departments have authority over the same resource. It is critical therefore that the distinct roles of government institutions

are clearly understood and harmonised. Table 12 below provides a detailed overview of the legal framework that exists within the governance structures of South Sudan that can be related to wetland management.

Table 13: Current policies and plans relevant to the Sudd wetlands

No.	Policy/plan	Date	Responsible institution	Topical coverage
1	National Environmental Policy	2015	• Ministry of Environment and Forestry	- Management of wetlands, rivers, lakes and other water resources - Principle wetlands of South Sudan - Climate change - Wastes management and pollution - Biodiversity and natural heritage
2	National Biodiversity Strategy and Action Plan (NBSAP)	2018	• Ministry of Environment and Forestry • Directorate of Wetlands and Biodiversity	- Biodiversity and ecosystems of South Sudan and hotspots and forest reserves - Protected areas within Sudd wetlands - Sudd and other permanent swamps
4	Forestry Policy	2013	• Ministry of Environment and Forestry	- South Sudan forest reserves
5	South Sudan Environmental Protection and Management Bill	2012	• Ministry of Environment and Forestry	- Guidelines on lakes, wetlands and rivers - Outlines environmental protection regimes
7	Ministry Strategic Plan	2015	• Ministry of Environment and Forestry	- Outlines policy issues and strategic directions for environment and forest sectors
9	National Adaptation Programme of Action to Climate Change (NAPA)	2016	• Ministry of Environment and Forestry	- Details adaptation strategic interventions
10	National Adaptation Plan of Action (NAPA)	2015	• Ministry of Environment and Forestry • Directorate of Climate Change and Meteorology	- Climate change profile - Adaptation interventions - Thematic areas; environment, water resources, agriculture, disaster risk reduction, policy and institutional framework - Specific interventions for wetlands e.g. Sudd
11	Water Policy	2012	• Ministry of water Resources and Irrigation	- Sectoral status and policy actions
12	Water Bill	2013	• Ministry of water Resources and Irrigation	- Regulations and institutions on water resources of South Sudan
13	Irrigation Development Master Plan (IDMP)	2015	• Ministry of water Resources and Irrigation	- National irrigation development in South Sudan with Ministry of Agriculture
14	WASH Strategic Framework	2012	• Ministry of water Resources and Irrigation	- Road map for WASH in South Sudan
15	Wildlife Management Act	2008	• Ministry of Wildlife Conservation and Tourism	- South Sudan wildlife heritage and management regimes
16	Wildlife Conservation and Protected Areas Bill	2021 Reviewed	• Ministry of Wildlife Conservation and Tourism	- Details wildlife conservation regimes
17	Agriculture Policy	2012	• Ministry of Agriculture and Food Security	- Outline agricultural sector priorities and policy directions
18	Comprehensive Agriculture Master Plan (CAMP)	2016	• Ministry of Agriculture and Food Security	- Details agricultural sector development strategic interventions
19	Fisheries Policy	2012	• Ministry of Animal Resources and Fisheries	- Outline fisheries sub-sector priorities and policy directions
20	Livestock Policy		• Ministry of Animal Resources and Fisheries	- Outline livestock sub-sector priorities and policy directions
21	Food Security Policy	2016	• Ministry of Animal Resources and Fisheries	- Details food security policy areas and strategic directions

22	Land Act	2009	• Ministry of Lands, Housing and Physical Infrastructure	- Land administration regimes
23	Petroleum Act	2012	• Ministry of Petroleum	- Exploration of oil in wetlands
24	National Policy for Culture and Heritage	2020	• Ministry of Culture, Museums and National Heritage	- Outline national culture and heritage sub-sector priorities and policy directions - Sudd wetlands as world heritage site
26	Animal Resources and Fisheries Policy Framework and Strategic Plan	2012	• Ministry of Animal Resources and Fisheries	- Potential wetlands, lakes and rivers for fish production and Animal grazing areas
27	Aquaculture Development Bill	2019	• Ministry of Livestock and Fisheries	- Details aquaculture development regimes
28	Capture Fisheries and Aquatic Environment Bill	Under development	• Ministry of Livestock and Fisheries	- Supported by EU
29	Investment Plans for Urban and Rural Water		• Ministry of Water Resources and Irrigation	- Investment areas and strategic interventions
31	Petroleum Policy	Draft	• Ministry of Petroleum	- Details petroleum policy issues and strategic interventions
32	National Land Policy	2014 Draft	• Ministry of Lands, Housing and Urban Development	- Details land administration policy areas and strategic directions

Non-governmental stakeholders related to the sustainable management of the Sudd wetlands

It is important to know which stakeholders participate in the management of the Sudd wetland and ensure that there are clear cut mandates and roles in place to prevent confusion and overlapping authority.

Table 14: Non-governmental stakeholders and their roles

No.	Stakeholder name	Mandate	Actual role
1	Wildlife Conservation Society - INGO/Working with ministry of Wildlife	• Wildlife conservation and management	- Boma-Jonglei equatorial landscape including Sudd Wetlands
2	University of Juba - College of Natural Resources and Environmental Studies	• Training and research	- Studies and research on wetlands including e.g., Lake Jor - Vegetation and restoration of wetlands
3	Dr John Garang University of Science and Technology	• Training and research	- In Bor working on fisheries
4	Upper Nile University	• Training and research	- In Malakal working on fisheries and natural resources
5	Sudd Institute	• Research	- Impact of petroleum/oil exploration and flooding on Sudd areas
6	Community Empowerment and Progress Organization	• Community and conservation projects	- Fisheries training and inputs, conservation awareness/anti-poaching programme, sensitization on deforestation, tree planting like mangoes…Badinglo National Park, Mangala, Gemeiza
7	Wetlands International	• Wetlands conservation, research and capacity building	- Wetland conservation - Kineti River/Wetlands in Eastern Equatorial
8	Niras International	• WASH projects	- Watershed management
9	Nile Basin Initiative	• River Nile and its wetlands	- Wetlands mapping, valuation and action planning and Sudd and Machar dedicated studies
10	Ramsar Secretariat	• Wetlands conservation	- Designation of Sudd wetlands as Ramsar Site
11	UNESCO South Sudan Office	• National cultural and heritage conservation	- Designation of Sudd wetlands as World Heritage Site - Designation of Sudd wetlands as biosphere reserve in South Sudan and Man and Biosphere Programme - Capacity building for programming,

			- Community radio /awareness/ radio stations
12	South Sudan Nature Conservation Organization	• Wildlife conservation and management	- Restoration of landscapes, smart agriculture, clean energy and baseline surveys - Boma National Park in Jonglei State, Bandigilo National Park in Central Equatoria State, Kidepo Game Reserve and Loelle (in process of gazettment in Eastern Equatoria
13	Sudd Institute		- Think tank research
14	Nile Basin Discourse Forum		- Advocacy/awareness on Nile River
15	Community Initiative for Sustainable Peace Organization (CISPO)		- Peace and natural resources conservation
16	South Sudan Women Entrepreneurship Organization		- Businesses on agro-processing,
17	Horn of Africa Regional Environmental Network		- Natural resources management/ managing transboundary /parks
18	UNEP		- Feasibility studies and capacity development for environmental policy formulation
19	UNDP		- Support government in developing policies, capacity building -
20	GEF		- Mobilise resources for government projects
21	World Bank		- Support government projects on disaster management
22	GIZ		- Support the Ministry of WRI in transboundary WRM, capacity building and policy development
23	African Development Bank		- Support government developmental projects
24	UNIDO		- Working on industrial development/value chain addition/ Terkeka/ focal centre for fisheries/ crops/livestock e.g milk
25	Local Communities		- Mobilise communities in flood management, awareness, support projects, give land for development, provide manpower
26	IUCN		- In Nimule National Park in Eastern Equatorial working on illegal wildlife trade on border between Uganda and South Sudan
27	Flora and Fauna International (FFI)		- Working in Western Equatorial; Southern National Park; conservation and management of wildlife in the park
28	University of Bahr El Ghazal		-
29	Rumbek University		-
30	Jonglei, Upper Nile, Unity, Lakes, Central Equitoria , Ruweng Administrative Area (Lake No) State Governments		-

(Photo source: HYDROC)

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