



ATLAS OF TRANSBOUNDARY WETLANDS IN THE NILE BASIN 2 0 2 4

« Wetlands are key natural environmental assets providing crucial ecosystem services that support livelihoods and socio-economic development in the basin. Their role in mitigating climate change and supporting climate resilience as well as safeguarding water, food and energy security is currently threatened through their insufficient protection and management » (NBI Wetland Management Strategy, 2022) Copyright @ Nile Basin Initiative (NBI) February 2024

ISBN 978-9970-444-07-6

The Nile Basin Initiative (NBI) is an intergovernmental partnership of ten Nile riparian countries that is seeking to manage and develop the common Nile water resources in a cooperative manner and promote regional peace and security.

No part of this publication may be reproduced or distributed, in any form, for sale or other commercial purposes without prior permission from the NBI. However, the publication may be reproduced in whole or part for educational or non-profit purposes without special permission from the Nile Basin Initiative (NBI), provided acknowledgement of the source is made. The NBI would appreciate receiving a copy of any publication that uses this report as a source.

Nile Basin Initiative Secretariat (NBI)

P.O. Box 192, Enlebbe, Uganda

Tel +256 414 321 424/ +256 417 705 000

Fax + 256 414 320 971 Email nbisec@nilebasin.org Website www.nilebasin.org

Disclaimer

The contents of the atlas are the sole responsibility of the Nile Basin Initiative. The Nile Basin Initiative regrets any errors or omissions that may have been unwittingly made in the report. The designations and presentations in this publication do not imply the expression of any opinion whatsoever on the part of NBI concerning legal status of any country, territory or city, or the delineation of its frontiers or boundaries. Trademark names and symbols are used in an editorial fashion with no intention of infringement on trademark or copyright laws.

Acknowledgement

This Atlas was developed with support from GIZ, on behalf of the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) under the International Climate Initiative (ICI/IKI). The International Climate Initiative is one of the key instruments of the German Federal Government to support international climate action and biodiversity. The IKI supports solution strategies in developing and emerging countries that seek to achieve sustainable change. The first edition of the Atlas was produced under the project "Biodiversity Conservation and Sustainable Utilisation of Ecosystem Services of Wetlands of Transboundary Relevance in the Nile Basin " (PN 14.209.1). An updated edition focusing on peatlands was produced under the project "Stakeholder dialogues for transboundary peatland management in the Nile Basin - Diapol-CE" (12.9230.9).







of the Federal Republic of Germany

MESSAGE FROM THE EXECUTIVE DIRECTOR



Esteemed Reader

I am very happy to share this inaugural Atlas of Transboundary Wetlands in the Nile Basin. This is the frist Atlas on Transboundary Wetlands in Africa. Wetlands and other water-related ecosystems of Nile Basin provide multiple ecosystem services critical for sustaining the Nile river flow, its biodiversity and associated livelihoods and economies.

The objective of the Atlas is to present summarized key information on the transboundary wetlands of the Nile Basin, including spatial distribution, ecological characteristics, major uses, as well as threats and pressures. Therefore, the Nile Basin Wetlands Atlas will be a critical information resource for informing sustainable wetlands utilization and management.

Wetlands of the Nile ocupy 1.1% of the basin and are critical for ecosystem services, fisheries, control of flooding, storage or retention of water, groundwater recharge and a transit route of migratory as well as sanctuary for breeding of birds, sustainance of low flows among others.

The NBI Wetland Management Strategy of 2022 calls for building a knowledge-base of wetlands resources of the Nile Basin for informed interventions. The 10-year Strategy of Nile Basin Initiative under Goal 4 calls for protection, restoration and promotion of sustainable use of water related ecosystems across the basin. In addition, Wetlands are critical for meeting the aspirations set out in Goal 5 of the Strategy for addressing climate change adaptation, mitigation and resilience.

For this purpose, the information presented in this Atlas will facilitate collective decision-making, planning and action under evidence based collaborative integrated water resources management. The Atlas supports joint water related ecosystems I wish you an insightful and informative management and development through provision of factual and impartial knowledge and information.

It is therefore my hope that you, the reader, will find it a very useful document.

I take this opportunity to thank the Staff of Nile Basin Initiative as well as members of the Regional Wetlands Working Group from the Nile Basin countries who have contributed towards the successful preparation of this key technical knowledge product.

Finally, I express my appreciation to Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and International Climate Initiative (IKI) facility of The Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU) for their valuable technical and financial support towards the preparation of this inaugural Nile Basin Wetlands Atlas for the Nile Basin.

DR. FLORENCE GRACE ADONGO

EXECUTIVE DIRECTOR, NILE BASIN INITIATIVE

ACKNOWLEDGMENT

TECHNICAL LEAD

Dr Michael Kizza Deputy Executive Director, NBI

Zeleke Kebebew Earth Observation & Remote Sensing Expert, NBI

NBI TECHNICAL TEAM

Dr Modathir Zaroug Regional Water Resources Modeller, NBI
Sowed Wamala Regional Database Specialist, NBI (Former)
Juliet Nakasagga Knowledge Management Specialist, NBI

Tom Waako Programme Officer, NBI

ADVISORY TEAM

Dr Juan Carlos Sanchez Advisor, Transboundary Wetlands Management in the Nile Basin, GIZ (Former)
Dr Malte Grossman Head of Projects - Support to Transboundary Water Cooperation in the Nile Basin, GIZ

EDITORIAL, DESIGN AND MAP LAYOUT TEAM

Zeleke Kebebew Map layout, Graphic Design and Typesetting, NBI

Dr. Nicholas Azza Editor, Consultant

Vivek Bahukhandi Graphic Design template, India

STEERING COMMITTEE

MEMBERS OF THE NILE TECHNICAL ADVISORY COMMITTEE SUPPORTED BY THE REGIONAL EXPERT WORKING GROUP ON WETLANDS

ACRONYMS

DEM Digital Elevation Model EAC East African Community

ENSAP Eastern Nile Subsidiary Action Program ENTRO Eastern Nile Technical regional Office

ES Ecosystem Services

FAO Food and Agricultural Organization
GIS Geographic Information System

IBAs Important Bird Areas

IUCN International Union for Conservation of Nature and Natural Resources

LVBC Lake Victoria Basin Commission

m a.s.l Meters above sea level m b.s.l. Meters below sea level NBI Nile Basin Initiative

NBSAP National Biodiversity Strategy and Action Plan
NDVI Normalized Difference Vegetation Index

NGO Non-government Organization

NTEAP Nile Transboundary Environmental Assessment

RCMRD Regional Centre for Mapping of Resources for Development

RIS Ramsar Information System

UNEP United Nations Environmental Program Program
USAID United States Agency for International Development

TABLE OF CONTENTS

Chapter 1: Introduction

Introduction 75 Chapter 4: Chapter 8 12/ The Nile Basin Wetlands Lake Albert Sub-Basin White Nile sub-basin The Nile Basin and its wetlands 13 14 NBI Wetland Management Policy and 77 Introduction 121 Introduction Institutional Framework 78 Socio-economic context of wetlands in 122 Socio-economic context of wetlands in Lake Albert Sub-basin White Nile sub-basin 15 Methodology 79 Hydrological context of wetlands in Lake 123 Hydrological context of wetlands in Wetlands of the eastern Nile Basin 17 Albert Sub-Basin White Nile sub-basin 18 Wetlands of the Equatorial Lakes Region Wetlands of the Albert Sub-Basin 80 124 The Machar Marshes 19 Wetland distribution by Sub-Basin 81 Rwenzori mountains 126 White Nile Floodplain 20 List of wetlands of transboundary 83 Lake George wetland 128 Gebel Auliya importance 84 Semliki Valley Wetlands List of technical reports on Nile wetlands 21 85 Lake Albert-Murchison Falls-Albert Delta 129 Chapter9 Blue Nile sub-basin Wetlands 23 Chapter 2: Lake Victoria Sub-Basin 87 Chapter 5 131 Introduction Bahr El jebel Sub-Basin 132 Socio-economic context of wetlands in 25 Introduction Blue Nile sub-basin Socio-economic context of wetlands in 26 Hydrological context of wetlands in Blue 89 Introduction 133 Lake Victoria Sub-basin 90 Socio-economic context of wetlands in Nile sub-basin Hydrological context of wetlands in Lake 27 Bahr El jebel sub-basin 134 Dinder Floodplain Victoria Sub-Basin 91 Hydrological context of wetlands in Bahr 136 Lake Tana 28 Sio, Nzoia, Yala and Nyando Wetlands El jebel sub-basin 138 Fincha'a-Chomen Swamp 29 Nyando Wetland 92 The Sudd wetland 139 El Roseires 31 Yala Swamp 96 Lake Yirol 141 Sennar 33 Nzoia River Wetland 97 Lake Anyi 35 Sio Siteko 98 Lake Nyiropo 143 Chapter 10 37 Mara Wetland Tekeze Atbara Sub-Basin 40 The Kagera River and Wetland Systems Chapter 6 42 Ruvubu National Park Wetlands Bahr el Ghazal sub-basin 145 Introduction 44 Wetlands in the Paysage Aquatique 146 Socio-economic context of wetlands in Protégé du Nord Tekeze Atbara sub-basin 46 Akanyaru Swamps 101 Introduction 147 Hydrological context of wetlands in 47 Akanyaru River Swamps 102 Socio-economic context of wetlands in Tekeze Atbara sub-basin 48 Rugezi Marsh Bahr el Ghazal sub-basin 148 Khashm el-Girba 50 Kamiranzovu Swamp 103 Hydrological context of wetlands in Bahr 51 Nyabarongo Wetlands el Ghazal sub-basin 52 Akagera Wetlands Chapter 11 104 The Bahr el Ghazal River Floodplains 54 Lake Mburo-Nakivali System Main Nile Sub-Basin Lake Ambadi 106 56 Sango Bay-Musambwa Islands 57 Lake Victoria Shoreline Wetlands 151 Introduction Chapter 7 58 Lake Wamala 152 Socio-economic context of wetlands in Baro Akobo Sobat Sub-Basin Nabajjuzi Wetland 59 Main Nile sub-basin Lake Nabugabo 61 Hydrological context of wetlands in Main 153 109 Introduction 63 Mabamba Bay Nile sub-basin Socio-economic context of wetlands in 110 65 Lutembe Bay 154 The Lower Nile Valley Baro Akobo Sobat sub-basin Wadi El Rayan Protected Area 155 111 Hydrological context of wetlands in Baro 67 Chapter 3: 157 Lake Qarun Akobo Sobat sub-basin Victoria Nile Sub-Basin 159 The Nile Delta 112 Badigeru Swamps 161 Lake Maryut Kenamuke/ Kobowen Swamp 113 69 Introduction 163 Lake Idku Lotilla River Swamps 114 Socio-economic context of wetlands in 164 Lake Burullus

Veveno/Adiet/Lilebook Swamps

Baro Akobo Wetlands

115

116

Victoria Nile sub-basin

Victoria Nile sub-basin

Lake Opeta

Hydrological context of wetlands in

Kyoga Kwania /Swamp Complex

71

72

73

166 Lake Manzala

CHAPTER 1 INTRODUCTION



Introduction	11
The Nile Basin Wetlands	12
The Nile Basin and its Wetlands	13
NB Wetland Management Policy and Institutional Framework	14
Methodology	15
Wetlands of the eastern Nile Basin	17
Wetlands of the Equatorial Lakes Region	18
Wetland distribution by Sub-Basin	19
List of Wetlands of Transboundary Importance	20
List of technical reports on Nile Wetlands	21



The Nile Basin Initiative

The Nile Basin Initiative (NBI) is an inter-governmental organization formed in year 1999 by the Nile Basin countries to ensure the equitable and sustainable utilization of the water and related resources of the Nile Basin in order to achieve water security and avert conflict. The NBI Member States are Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda while Eritrea is an observer.

SHARED VISION OBJECTIVE: 'to achieve sustainable socio-economic development through equitable utilisation of, and benefit from, the common Nile Basin Water Resources'.

NBI Core Functions

The NBI's core functions, which support the attainment of the shared vision, are the following:

- Basin cooperation: The NBI facilitates, supports and nurture cooperation amongst the Nile Basin countries so as to promote timely and efficient joint actions required for securing benefit from the common Nile Basin water resources.
- Water resource management: The NBI assesses, manages and safeguards the water resource base that supports the peoples of the Nile Basin by applying the principles of knowledge-based integrated water resources management to water development planning and assessment. The Water Resources Management Program has lined up an array of technical interventions aimed at broadening and deepening understanding of the temporal and spatial variations of the Nile Basin water resources and the interaction between country development goals.
- Water resource development: The NBI identifies, prepares and facilitates investment in regional/transboundary water development projects and programs, while avoiding negative impacts on the health of the Nile Basin's resources by applying the principles of integrated water resources management.

NBI 10 Year Strategy

NBI's work towards achieving the NBI Shared Vision is guided by the NBI 10-year Strategy (2017–2027), which defines strategic directions for Nile cooperation, and sets ambition levels for delivery of impact on the ground. The 10-year Strategy is implemented through 5-year programs prepared by the three NBI centres: Nile-SEC, ENTRO and NELSA-CU. The Strategy, prepared in consultation with the member states, identified six strategic priorities.



Goal 1: Water security

Improved availability and sustainable utilization and management of transboundary water resources of the Nile Basin



Goal 2: Energy security

Enhanced hydropower development in the basin and increased interconnectivity of electric grids and power trade.



Goal 3: Food security

Improved efficiency of agricultural water use and promote strengthened linkages between water and food security



Goal 4: Envirnomental sustainablity

Sustainable use of water related ecosystems restored and promoted across the basin



Goal 5: Climate Change adaptation

Improved basin resilience to climate change impacts



Goal 6: Transboundary water governance

Improved governance of transboundary waters in the Nile Basin

THE NILE BASIN WETLANDS

The Wetlands of the Nile Basin

The Nile Basin is endowed with a rich mosaic of wetlands types although they are unevenly distributed in space and represent only 1.1% of the total basin area. Wetland types in the basin include montane bogs, low-land herbaceous swamps, seasonally flooded grasslands, swamp forests, riverine wetlands, and lake-fringe wetlands. The basin wetlands are concentrated in two areas: the Equatorial Lakes region and the Sudd area in South Sudan. The Nile Delta north of Egypt, once an area of lush natural wetlands, has now been almost entirely converted into agricultural land.

The Nile Equatorial Lakes region is characterized by hilly terrain, large swamp-filled valleys, and lakeshore wetlands. The rivers in the region have sections of their courses partially or completely covered by swamp vegetation. Papyrus, reeds, cattails, water lilies, hippo grass, and other aquatic grasses are the dominant herbaceous plants, while palms (mainly Phoenix reclinata and Rafia farranifera), trees of the genus Ficus, Sezygium, Mitragyna, Macaranga, and Acacia are among the dominant woody species in the wetlands. The greatest concentration of wetlands in the basin is found in Uganda, while the most extensive wetland system is the Sudd in South Sudan.

The Nile Valley and Nile Delta in Egypt have scatterings of wetland communities. The common aquatic plants growing along the banks pondweed, curly-leaf pondweed, Egyptian lotus, and the Eurasian watermilfoil. Floating plants include the water fern, water hyacinth, duckweed, and broad-leaf pondweed; and among emergent plants there are the foxtail flatsedge, jointed flatsedge, common reed, Spanish reed, and common cattail. Papyrus, once abundant along the banks of the Nile, and closely intertwined with Egyptian history, is now confined to small clusters in the extreme south of the country, on islands near Cairo, and in the Damietta branch of the delta.

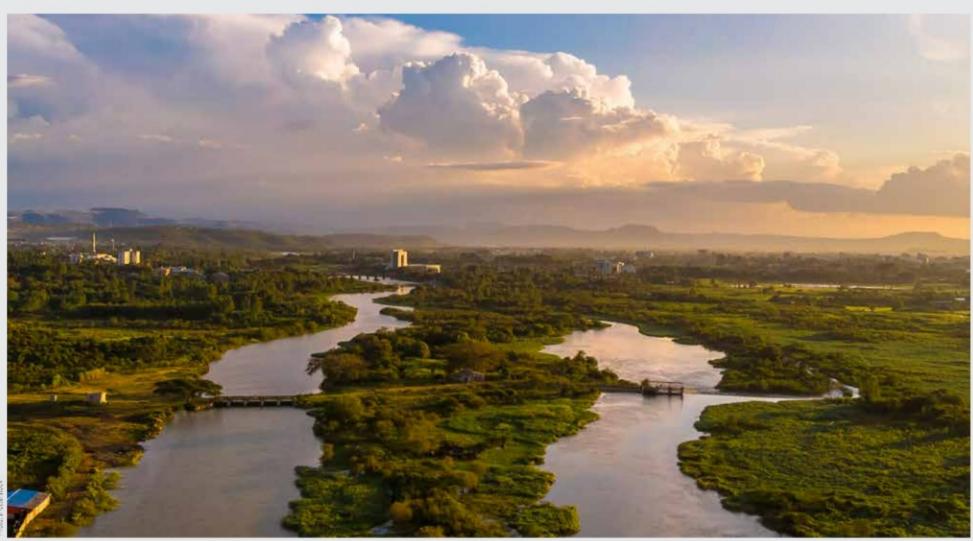
The different reaches of the Nile are endowed to different extents with wetlands. The equatorial lakes region hosts extensive growths of wetlands along the shores of the great lakes, and in the broad valleys that characterize this region. There are also profuse growths of herbaceous vegetation and swamp forests lining the courses of the Victoria and Albert Niles, and other tributaries of the Nile such as the Kagera, Katonga, Semliki, Yala and Mpologoma rivers. The system of lush riverine wetlands continues all the way to the Ugandan-Sudanese border at Nimule.

Further downstream of this point, the Nile, now called the Bahr el Jebel, crosses a mountainous region before spreading into the massive Sudd wetland area that measures approximately 60,000 km² in size. In the north western part of the Sudd is the adjoining Bahr el Ghazal River with its extensive system of Bahr el Ghazal swamps. The Bahr el Ghazal and Bahr el Jebel rivers join at Lake No to form a single river – the White Nile, which has thinner belts of wetland vegetation along its course.

The Sobat River, which drains the large Baro-Sobat-Pibor catchment and carries a significant flow, joins the White Nile downstream of Lake No near the town of Malakal. The lower reaches of this river system feature the extensive Baro-Akobo-Sobat wetlands, and the Machar Marshes. The damming of the Nile at Aulia in Sudan has caused the ponding back of the White Nile in its natural channel for a distance extending upstream of over 500 km, reaching all the way to the northern parts of South Sudan. This has allowed for fringe vegetation to develop along this stretch of the White Nile.

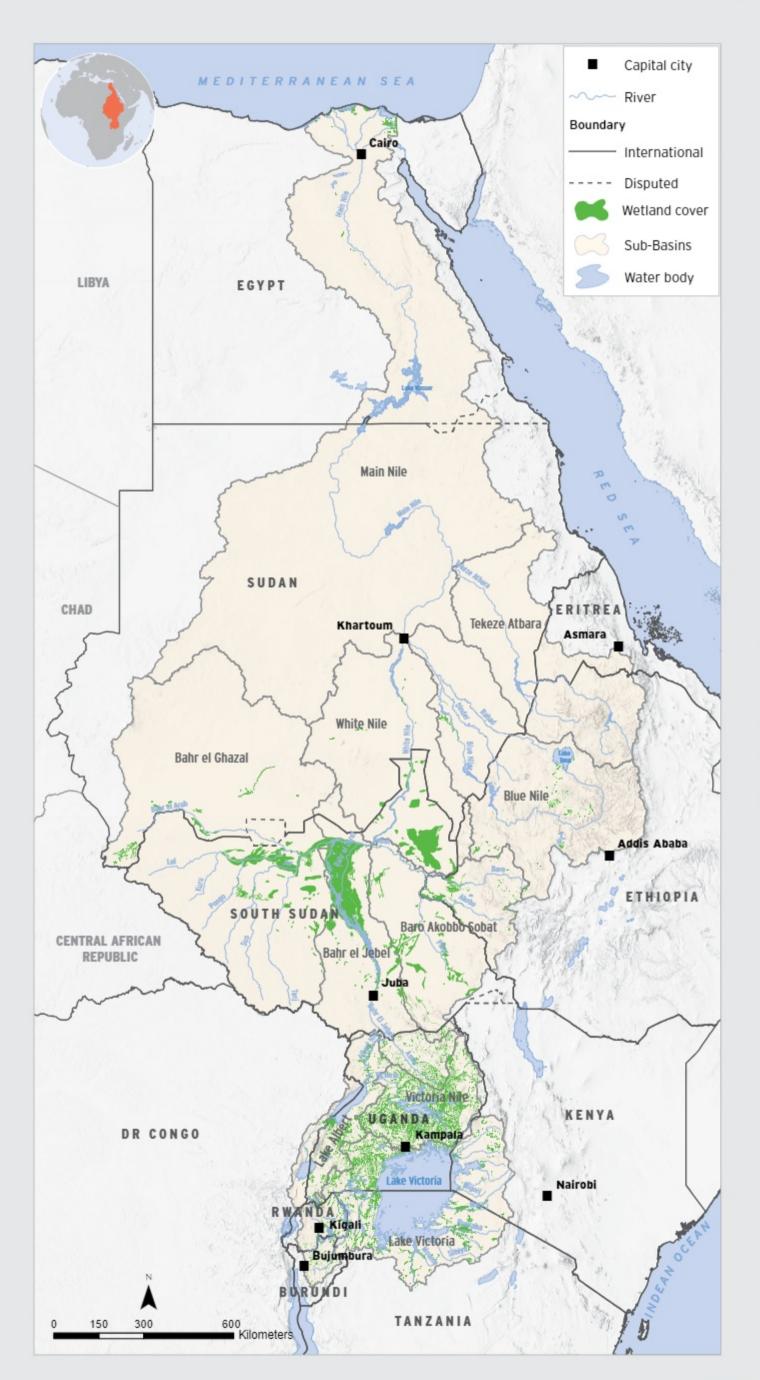
At Lake Tana in the Ethiopia Highlands, the second major tributary of the Nile – the Blue Nile – starts its journey. Lake Tana hosts a variety of wetlands along its shore that have a significant biodiversity. Downstream of Lake Tana, other wetlands are found along the course of the Blue Nile as well as along its tributaries. Notable among the Blue Nile wetlands is the Dinder wetlands in the Dinder National park. This wetland system supports sizable populations or large game and migratory waterfowl. Rising from the high mountains east of Lake Tana is the Atbara River which traverses a landscape similar to that crossed by the Blue Nile. Wetlands in this sub-basin are confined to the course of the river as it traverses the incised landscape.

The Blue and White Nile merge at Khartoum to form the Main Nile. Further downstream along the main Nile, throughout northern Sudan and in Egypt, wetlands occur in relatively small and discontinuous patches along the river. This riverscape is only interrupted by relatively larger wetlands in shallow parts of the Merowe and Aswan reservoirs. Towards the Mediterranean Sea, the river forms the Nile Delta, which is a last significant area of wetlands, most of which has been converted to agricultural land.



The headwaters of the Blue Nile as it leaves Lake Tana - Bahir Dar, Ethiopia

THE NILE BASIN AND ITS WETLANDS



River Length: 6,695 km

Area of the Nile Basin: 3,176,541 km2

No of Sub-Basins: 10

Mean annual rainfall: 650mm

Population: 272 million

NB WETLAND MANAGEMENT POLICY AND INSTITUTIONAL FRAMEWORK

Policy and Institutional Framework

The Nile Basin Wetlands Atlas (2024) was prepared under the guidance of the NBI Wetlands Management Strategy (2013) whose goal is to attain the sustainable management and utilization of the wetlands of the Nile Basin. Five objectives were defined under the strategy to support the attainment of the above goal over the duration of the strategy. The first of the five objectives was to strengthen the knowledgebase on wetlands of transboundary importance in the Nile Basin so as to support their conservation, management, planning and restoration. A key output defined under the strategy to contribute to realization of objective 1 was Output 1 under which the NBI was to create and regularly update an inventory and regional database on wetlands of transboundary significance. The wetlands in the database were to be categorized according to agreed criteria relating to their importance to basin hydrology, and transboundary dimensions. This output further provided for regular publications (every three years) of the Nile Wetlands Atlas to provide information on the status of wetlands, and performance and effectiveness of wetlands polices and management interventions. The Nile Basin Wetlands Atlas (2024) was prepared to fulfil this output of the Strategy.

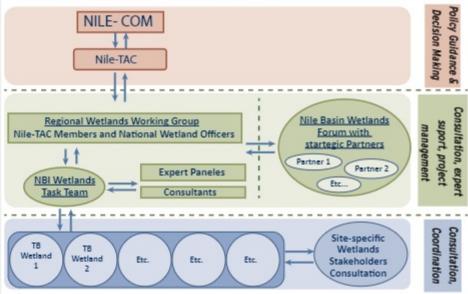
The NBI Wetlands Management Strategy (2013) has been replaced by a new strategy – the Wetlands Management Strategy (2022). The new strategy is a tool for continuation, expanding and consolidating achievements in transboundary wetlands management made under the Wetlands Management Strategy (2013). Strategic Action 1 of the new strategy has provision for multiple activities that support the continuation of work on the atlas. These include the development of a wetland portal using the NBI wetlands inventory and database; adding the wetland portal to NBI's Integrated Knowledge Platform (IKP); regular update of the information on the wetland portal; extracting information from the wetlands portal to support the preparation of regular State of Basin reports; and publishing updates of the Nile Basin Wetlands Atlas every 10 years.

Other important policy and legal instruments of the NBI with a role in wetlands management are the following:

- Agreement on the Nile River Basin Cooperative Framework (2010). The Agreement on the Nile River Basin Cooperative Framework, or the Cooperative Framework Agreement (CFA) as it is commonly known, is intended to be the new agreement on the Nile that replaces old agreements and sets a new era of Nile cooperation based on principle of equitable and reasonable utilization. The agreement is not yet in force as the required number of ratification instruments (six) and deposition in the African Union has not yet been realized. The CFA under Article 6 provides for protection and conservation of terrestrial and aquatic ecosystems of the Nile Basin, including wetlands. Under Article 9, the CFA provides for environmental impact assessments and environmental audits, which are important tools for the protection of wetlands from pollution and degradation.
- Environmental and Social Policy (2013). The Environmental and Social Policy (ESP) seeks to provide coherence for the NBI's activities by covering the environmental and social dimensions of sustainable development in line with international best practice. Its overarching goal is to ensure social and environmental sustainability of NBI program outcomes. The policy specifically identifies wetlands as important ecosystems to be protected from degradation. The policy provides for Environmental and Social Impact Assessments (ESIA) and Strategic Social and Environmental Assessments (SSEA), for assessment and management of environmental and social risks and impacts associated with NBI projects and programmes.
- Strategy for the management of environmental flows in the Nile
 Basin (2016). Environmental flows describe the quantity, timing and
 quality of water flows required to sustain freshwater and estuarine
 ecosystems and the human livelihoods and well-being that depend
 upon these ecosystems. The overarching goal of the strategy is "to
 facilitate and develop a culture of incorporation of collaborative, best
 practice e-flow management into the water resource planning, management and policies of the countries who share the Nile Basin (short

term) to ultimately result in the establishment of an integrated, basin scale e-flow management system (long term)". Nile Basin wetlands inventory and database/portal are an important knowledge resource and are expected to support e-flow assessments in the Basin. One of the objectives of the e-flows strategy it to develop a regional e-flow knowledge management, quality assurance and support function at NBI. The strategic actions to create this system include carrying out classification of aquatic ecosystems based on ecosystem types and flow responses, so as to facilitate meta-data capturing and analysis of e-flow assessments. Thus, activities related to building the wetlands knowledgebase are critical to the e-flows assessment framework development.

To guide the implementation of the wetlands strategies, NBI established the Wetlands Regional Expert Working Group under the guidance of NBI's Technical Advisory Committee (TAC). The REWG brings together those responsible for water resources planning and those for wetland management in NBI member states. The REWG reviewed technical products relating to the Wetlands Strategy, which were subsequently approved by Nile-TAC and Nile-COM. The institutional framework for management of activities related to implementation of the Wetlands Strategy are summarized in the figure below.



Regional Wetlands Working Group

Wetlands of Transboundary Importance

An important tool for management of natural resources is data and information on the physical and ecological characteristics of the natural resources. To commence the building of a knowledgebase on wetlands of the Nile Basin to support their sustainable management, an inventory of the wetlands of the basin was carried out under Nile Basin Transboundary Wetlands Project from 2015 to 2021. The project mapped and described the overall wetland situation in the Nile basin using remote sensing technology and supplementing this information with data obtained through field campaigns, literature review and stakeholder consultations. A key objective of the inventory project was to create a list of wetlands in the Nile Basin that are of transboundary significance. Using criteria that are developed under the study and validated by riparian states through the Nile Basin Regional Wetlands Working Group, the project came up with a list of 68 wetlands as the wetlands of transboundary importance in the basin. This list includes 15 wetlands that physically span the boundaries of two Nile riparian countries, and 20 that are international Ramsar sites. The 68 wetlands were clustered into 13 groups on a basis of hydrological systems and their geographical location.

The final Nile Basin wetlands inventory was reviewed by the Nile Basin Regional Wetlands Working Group before its approval by the Nile Technical Advisory Committee (Nile-TAC) and the Nile Council of Water Ministers (Nile-COM). The wetlands inventory has provided the technical basis for the preparation of this wetland atlas. The atlas does not cover all of the wetlands of the Nile Basin but only the few selected wetlands of transboundary importance (The list excluding small lakes without fringing wetland vegetation).

METHODOLOGY

The development of this Atlas followed the process of collecting field data and literature review, data screening, data analysis and interpratation of results. Below is a summary of data sources and methods that were employed.

DATA SOURCES

The NBI Wetland Inventory with Wetland information sheets

Detailed information on each of the Nile Basin wetlands have been captured in the NBI's Wetland Inventory (NBI 2021). This inventory brought together and summarized information on the wetlands of transboundary significance from various sources.

The methodology for developing the Nile Basin wetland inventory is largely based on Ramsar Handbook 15 on how to develop a wetland inventory. Data was collected by reviewing existing inventories and scientific literature, as well as remote sensing. The main sources of information for each individual wetland were Hughes and Hughes (1992), information provided by Ramsar in the form of Ramsar Information Sheets (RIS) and countrywide wetland baseline studies previously conducted by NBI. This inventory brought together and summarized all available information on 68 wetlands from previous inventories, country reports and scientific publications and complemented this with land use and land cover information from 1985 and 2015 surveys. The structure of the inventory follows the geography of the Nile Basin from upstream to downstream. Therefore, the results chapter is structured in ten sections and each section describes the wetlands for each sub-basin. NBI has further grouped wetlands into twelve main wetland groups of transboundary significance, which were agreed on during stakeholder consultation. Each individual wetland is part of one of these wetland groups where possible. Some wetlands of transboundary significance cannot be clearly assigned to a single wetland group, therefore they are described separately.

The data is stored in a database which is available at NBI's Secretariat. The Inventory was reviewed and validated by the Nile Basin REWG Wetlands.

The NBI Inventory Wetland landscape boundary map with classification of wetlands of transboundary significance.

Based on the land cover, topographical maps and the digital elevation model, a map of the outline of wetland landscapes was developed. This map is based on the definitions of transboundary wetlands. In this process, 68 wetlands in the Nile Basin have been considered by the Nile Basin countries to be of transboundary importance. Of these 15 are part of cross-border wetland landscapes shared by at least two countries. 20 are also designated as "Ramsar wetlands of international importance", providing wintering grounds for migratory birds and important biodiversity hot spots. In their aggregation, however also many smaller wetlands not captured are important for the Nile Basin's catchments and hydrology.

The identified wetlands have been further clustered into 12 main wetland groups. 1. ND = Nile Delta; 2. DW = Dinder wetlands; 3. LTW = Lake Tana wetlands; 4. BASW = Baro Akobo Sobat wetlands; 5. Sudd; 6. BeG = Bahr el Ghazal wetlands; 7. LKW = Lake Kyoga wetlands; 8. SW = Semliki wetlands; 9. LVW = Lake Victoria wetlands; 10. KW = Kagera wetlands; 11. MW = Mara wetlands; 12. SNYN = Sio Nzoia Yala Nyando wetlands.

Table 2 lists the NBI Inventory Wetlands and how they have been classified within the sub-basin, the wetlands group and the country(ies).

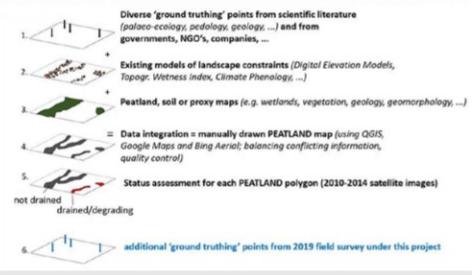
NBI Inventory Remote Sensing Landcover Mapping

The inventory was complemented with a land use and land cover analysis from 1985 and 2015 survey based on remote sensing data. The wetlands within the Nile basin were mapped based on various Earth Observation (EO) satellites. The images cover the Earth surface regularly since the 1980's. In particular the optical data provides very rich information on plant species, above ground biomass and land cover. Microwave data,

on the other hand, is very receptive regarding surface water. Using all EO data conjointly guarantees optimum outputs in terms of thematic and geometric accuracy. The available ground truth information covers the eleven classes of interest in the final map product: water, papyrus, wetland grasses, reed, grassland, forest, agriculture, desert/bare soil, and settlements. These land cover categories were subsequently used for classification of land cover. The details of the method and resulting maps are captured in the NBI Wetlands of Transboundary Significance Remote Sensing Technical Report (NBI 2022). For purpose of defining wetland land cover in the atlas, the following three categories where merged into one aggregated category of wetlands: papyrus, wetland grasses and reeds.

NBI Peatlands data

The peatlands mapping approach concentrated on the merging of already existing, often national geospatial soil and proxy information and the use of recent satellite and aerial imagery. A first assessment of the drainage and degradation intensity of organic soils was made. It should be noted that the estimates do not account for the total area of peatland in each country, but only for the areas within the respective Nile Basin boundaries. The study area was divided into two sub-systems according to the general Nile Basin division: 1) The Equatorial Nile sub-system, which includes the Nile Equatorial Lakes region (NEL, including the sub-basins of Lake Victoria, Lake Albert and Victoria Nile) and the Sudd wetlands in South Sudan and 2) The Blue Nile subsystem (Ethiopia). Egypt and Sudan are not covered specifically, because these countries have very little peat, but the available literature on peatlands and other organic soils in these countries is included in the NBI Technical Report: Assessment of Carbon (CO2) Emissions Avoidance Potential from the Nile Basin Peatlands' (NBI 2019). A variety of methodologies and information sources to identificanceible neetland accumences were used and aummented in the



For the Nile Equatorial Lakes region and the Blue Nile sub-system, legacy soil maps, dispersed notes of peat occurrences (e.g. from palaeo-ecological studies) and spatially explicit peatland proxy data (e.g. on bedrock, relief, landforms, wetlands, vegetation, land use) were gathered from open access online archives including ISRIC (World Soil Information), JRC (Joint Research Centre), FAO Corporated Document Repository, SPHAERA (Base de données Sphaera du service Cartographie), WOSSAC (World Soil Survey Archive and Catalogue), the Perry Castanea Library of Austin University, and the Peatland and Nature Conservation International Library (PeNCIL1). Using the freely available program QuantumGIS, these data were overlain with free satellite (Google Maps) and aerial imagery (Bing Aerial), and with the Topographical Wetness Index of the African Soil Information Service. On the basis of this integrated information, the peatland extent was mapped manually using a detailed decision key to arrive at a high resolution (1:25,000) map of 'confirmed', 'probable' and 'possible' ocurrences of organic soil. The broad IPCC definition % and a minimum depth of the organic layer of 10 cm was used. The resulting GIS database includes for every peatland polygon information on key references

Within the permanent wetland boundaries, the technical team determined by remote sensing the distribution of Cyperus papyrus L., Phragmites mauritianus Kunth. and hippo grass (Vossia cuspidata Grift.)

These species require water saturated conditions throughout (almost) the entire year and were considered as indicators for the occurrence of peat. The distribution of papyrus and reeds was derived through 'Random Forest Classification' using Sentinel-2 scenes from mid-January 2018. Sentinel-2 provides images of a location every 5 days and with 10 spectral bands of which the green (Band 3), red (band 4), near-infrared (8) and short-wave infrared band (11) were combined to scenes of 10 m resolution. This resolution generates generally higher accuracy compared to Landsat or MODIS imagery with 30m and 500m resolution, respectively.

Wetlands Land Cover from FAO MADE data

The Multipurpose Africover Database for the Environmental Resources (MADE) was used for the purposes of this Atlas. The database covers all NBI Countries except Ethiopia.

The main source in addition to the internal NBI resources described above was the FAOs AfriCover land cover data.

The Africover data was developed in response to national requests for assistance in the development of reliable and georeferenced information on natural resources. These data were needed for: early warning, food security, agri-culture, disaster prevention and management, forest and rangeland monitoring, environmental planning, watershed catchments management, natural resources, biodiversity studies and climate change modelling. The data is based on an innovative land cover classification and mapping methodology, which enabled global harmonization of land cover classes. This methodology, based on the Land Cover Classification System (LCCS) developed by FAO, is used as a standard by a growing number of land cover mapping projects. Africover greatly reinforced national and subregional capacities for the establishment, update and use of land cover maps and spatial data bases.

Table 1: list of data used in the Atlas of Transboundary Wetlands in the Nile Basin

Protected Area category data

For developing the Protected Area Category Maps, the World Database on Protected Areas (WDPA) was used. WDPA is referred to as the most comprehensive global database on terrestrial and marine protected areas

It is based on the IUCN protected area categories, or IUCN protected area management categories; categories used to classify protected areas in a system developed by the International Union for Conservation of Nature (IUCN). The enlisting of such areas is part of a strategy being used toward the conservation of the world's natural environment and biodiversity. The IUCN has developed the protected area management categories system to define, record and classify the wide variety of specific aims and concerns when categorizing protected areas and their objectives.

This categorization method is recognized on a global scale by national governments and international bodies such as the United Nations and the Convention on Biological Diversity.

The Categories are as follows:

Category Ia - strict nature reserve

Category Ib - wilderness area

Category II - national park

Category III - natural monument or feature

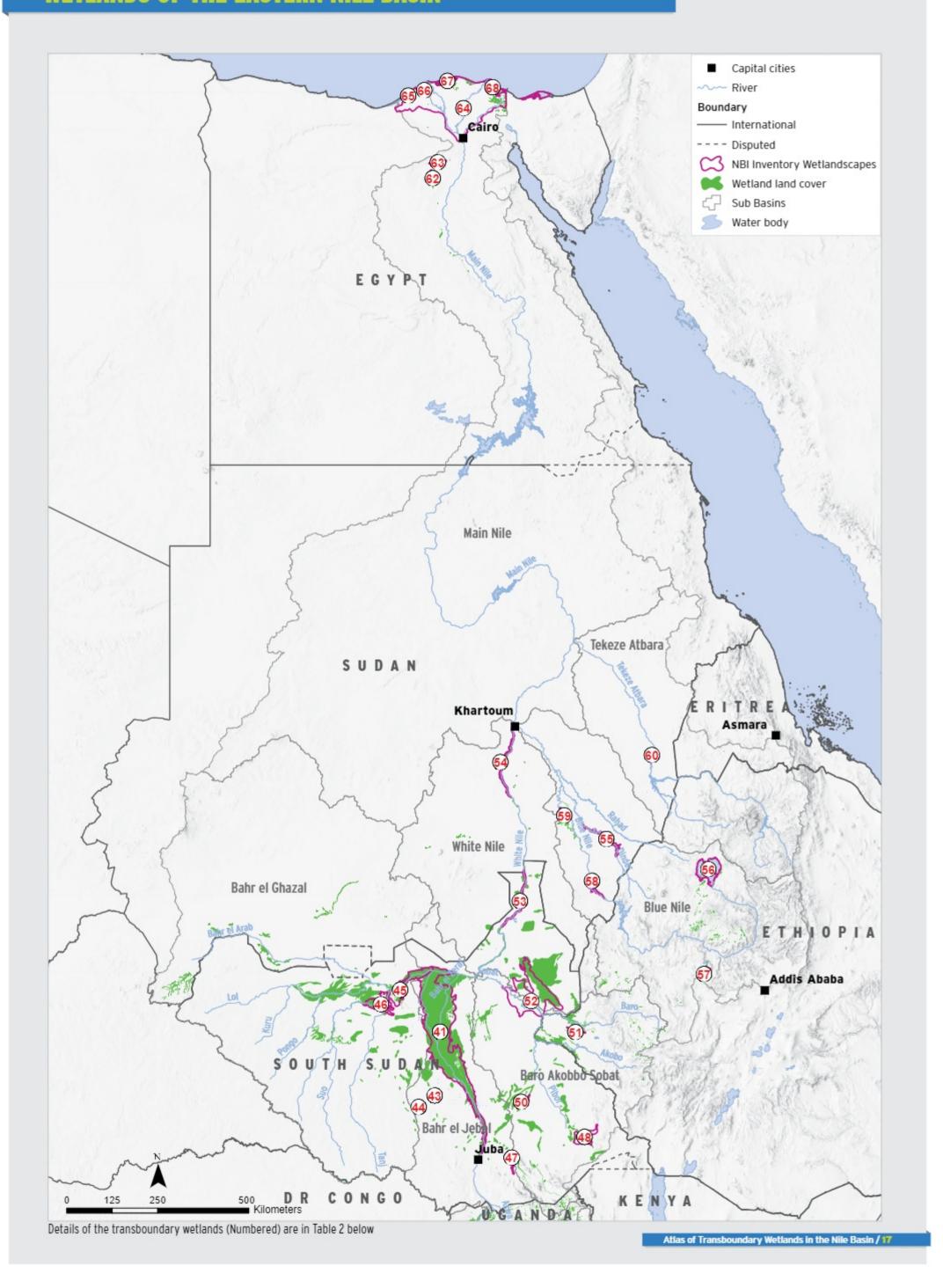
Category IV - habitat or species management area

Category V - protected landscape or seascape

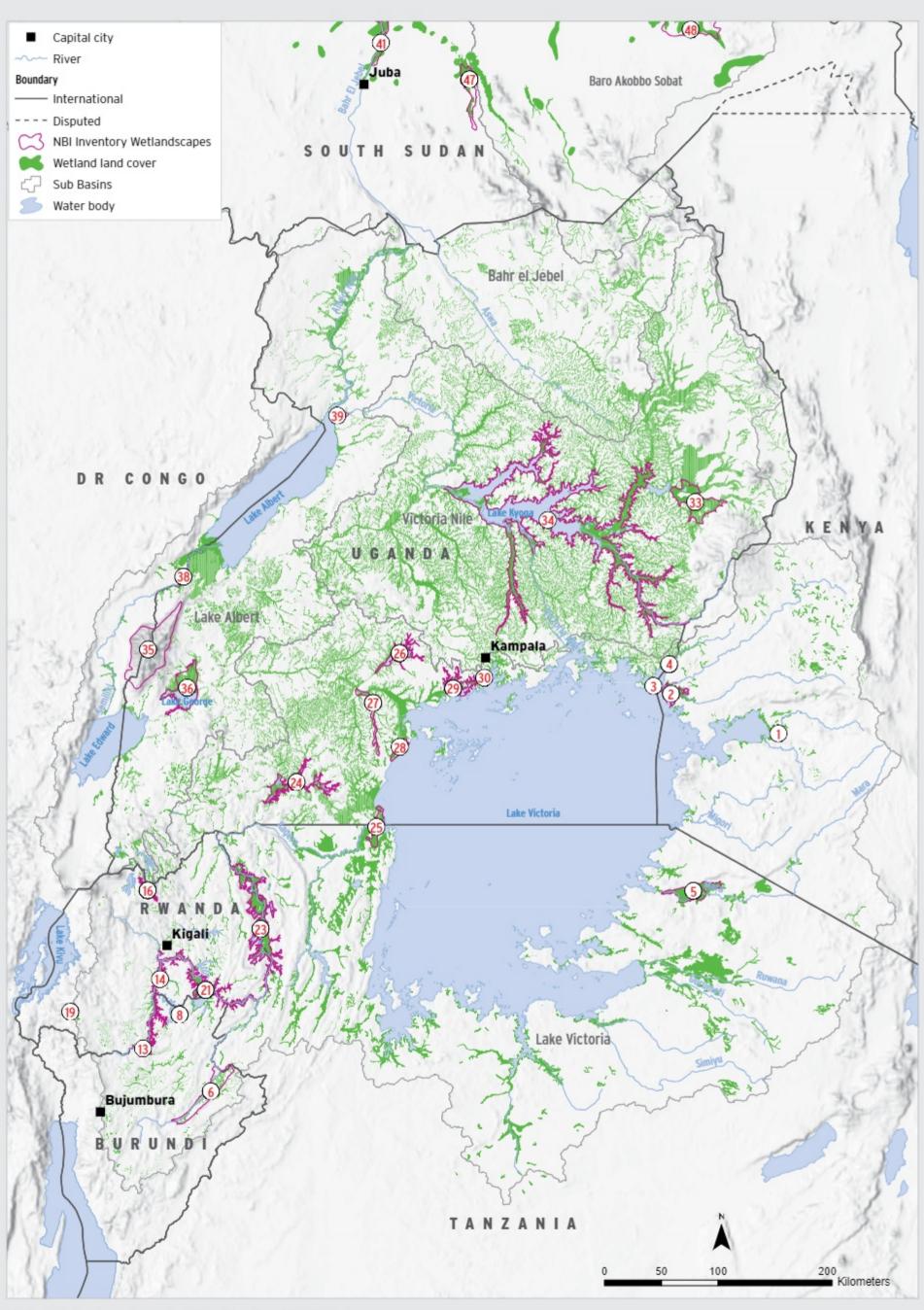
Category VI - protected area with sustainable use of natural resources

DATASETS	SOURCES
NBI Wetland landscapes	NBI
Wetland land cover	Multipurpose Africover Database for the Environmental Resources (MADE), FAO ; Uganda Wetland Atlas data; woodybiomass data
Cities/towns	NBI, OpenStreetMap (OSM) : https://download.geofabrik.de/africa.html
Road and settlement	OpenStreetMap (OSM) : https://download.geofabrik.de/africa.html
Administrative boundary	FAO database: https://rb.gy/5xf9qv
Population Density	NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H49C6VHW.
Protected Areas	World Database on Protected Areas (WDPA): https://www.protectedplanet.net/en
Lakes/reservoirs)/ rivers	NBI, OpenStreetMap (OSM) : https://download.geofabrik.de/africa.html
Basin/Sub-Basin	NBI
Dam Locations	NBI
Hydro-meteorological stations	NBI
Hillshade	Developed from SRTM DEM

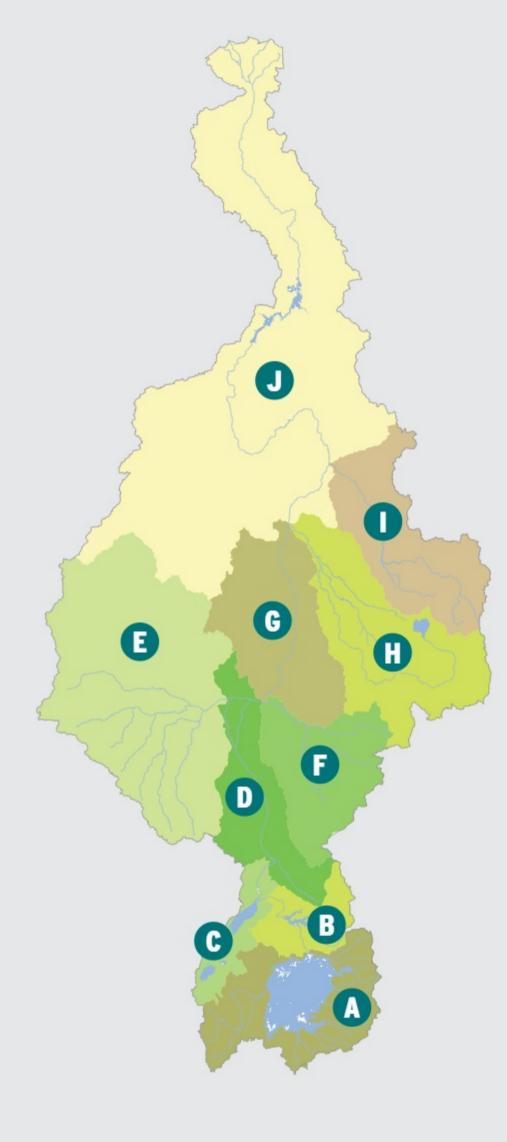
WETLANDS OF THE EASTERN NILE BASIN



WETLANDS OF THE EQUATORIAL LAKES REGION



WETLAND DISTRIBUTION BY SUB-BASIN



A Lake Victoria Sub-basin

- 1 Nyando
- 2 Yala Swamp
- 3 Nzoia River
- 4 Sio-Siteko
- 5 Mara Wetland
- 6 Ruvubu National Park
- 8 Paysage Aquatique Protégé du Nord
- 13 Akanyaru Swamps
- 14 Akanyaru River Swamps
- 16 Rugezi Marsh
- 19 Kamiranzovu Swamp
- 22 Lake Mugesera
- 23 KageraSwamps
- 24 Lake Mburo NakivaliSystem
- 25 Sango Bay-Musambwa Islands -Kagera Wetland System
- 26 Lake Wamala
- 27 Nabajjuzi Wetland
- 28 Lake Nabugabo
- 29 Mabamba Bay
- 30 Lutembe Bay

B Victoria Nile Sub-basin

- 33 Lake Opeta
- 34 Kyoga Kwania Swamp Complex

Lake Albert Sub-basin

- 35 Rwenzori Mountains Ramsar Site
- 36 Lake George
- 38 Semliki Valley Wetlands
- 39 Murchison Falls Lake Albert Delta

D Bahr el Jebel Sub-basin

- 41 The Sudd
- 42 Lake Yirol
- 43 Lake Anyi
- 44 Lake Nyiropo

E Bahr el Ghazal Sub-basin

- 45 Bahr el Ghazal Floodplain
- 46 Lake Ambadi

F Baro Akobbo Sobat Sub-basin

- 47 BadigeruSwamp
- 48 Kenamuke/ Kobowen Swamp
- 49 Lotilla River Swamps
- 50 Veveno/ Adiet/ Lilebook Swamps
- 51 Baro-Akobo-Sobat Wetlands
- 52 Machar Marshes

G White Nile Sub-basin

- 53 White Nile Floodplain
- 54 Gebel Auliya

H Blue Nile Sub-basin

- 55 Dinder Floodplain
- 56 Lake Tana
- 57 Fincha-Chomen
- 58 El Roseires
- 59 Sennar

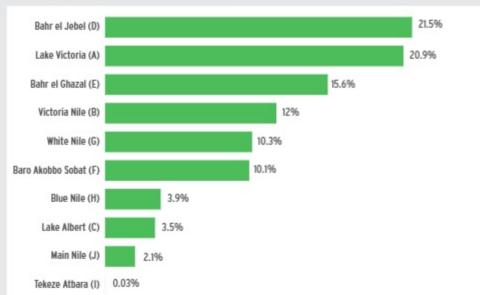
I Tekeze Atbara Sub-basin

60 Khashmel Girba

J Main Nile Sub-basin

- 62 Wadi El Rayan Protected Area
- 63 Lake Qarun
- 64 The Nile Delta
- 65 Lake Maryut
- 66 Lake Idku
- 67 Lake Burullus
- 68 Lake Manzala

Area of Wetland by sub-basin (in %)



LIST OF WETLANDS OF TRANSBOUNDARY IMPORTANCE

Table 2: Wetlands of transboundary importance as per the wetlands inventory for the Nile Basin

Nr H	ydrological Sub-basin	Wetland Name	Country (incl. Cross Border if shared by two countries)	River / Lake	Ramsar Site
1 La	ake Victoria	Nyando	Kenya	Nyando River	
2 La	ake Victoria	Yala Swamp	Kenya	Yala River	
3 La	ake Victoria	Nzoia River	Kenya	Nzoia River	
4 La	ake Victoria	Sio Siteko	Kenya, Uganda	Sio/ Siteko	
5 La	ake Victoria	Mara Wetland	Tanzania	Lake Victoria	
6 La	ake Victoria	Ruvubu National Park	Burundi	Ruvubu River	
8 La	ake Victoria	Paysage Aquatique Protégé du Nord	Burundi	Akanyaru	
13 La	ake Victoria	Akanyaru Swamps	Burundi	Akanyaru	
14 La	ake Victoria	Akanyaru River Swamps	Burundi, Rwanda	Akanyaru	
16 La	ake Victoria	Rugezi Marsh	Rwanda	Rwangabavu	YES
19 La	ake Victoria	Kamiranzovu Swamp	Rwanda	Lukarara /Kamiranzovu	
21 La	ake Victoria	Nyabarongo Wetlands	Rwanda	Nyabarongo	
23 La	ake Victoria	Kagera Swamps	Rwanda, Tanzania	Kagera River	
24 Lä	ake Victoria	Lake Mburo Nakivali System	Uganda	Ruizi River, Kibali River	YES
25 La	ake Victoria	Sango Bay-Musambwa Islands -Kagera Wetland System	Uganda, Tanzania	Katonga, Bukola, Lake Victoria	YES
26 La	ake Victoria	Lake Wamala	Uganda	Akanyaru	
27 La	ake Victoria	Nabajjuzi Wetland	Uganda	Nabajjuzi	YES
28 La	ake Victoria	Lake Nabugabo	Uganda	Lake Victoria	YES
29 La	ake Victoria	Mabamba Bay	Uganda	Lake Victoria	YES
30 La	ake Victoria	Lutembe Bay	Uganda	Lake Victoria	YES
33 Vi	ictoria Nile	Lake Opeta	Uganda	Lake Kyoga	YES
34 Vi	ictoria Nile	Kyoga Kwania Swamp Complex	Uganda	Lake Kyoga, Victoria Nile	
35 La	ake Albert	Rwenzori Mountains Ramsar Site	Uganda, DRC	George, Edward, Albert, Semliki	YES
36 La	ake Albert	Lake George	Uganda	Lake Edward	YES
38 La	ake Albert	Semliki Valley Wetlands	Uganda, DRC	Semliki	
39 La	ake Albert	Lake Albert Delta	Uganda	Semliki River, VN, AN	YES
41 Ba	ahr el Jebe	Sudd	South Sudan	Bahr el Jebel	YES
42 Ba	ahr el Jebe	Lake Yirol	South Sudan	Yei River	
43 Ba	ahr el Jebe	Lake Anyi	South Sudan	Yei River	
44 Ba	ahr el Jebe	Lake Nyiropo	South Sudan	Lau River	
45 Ba	ahr el Ghazal	Bahr el Ghazal Floodplain	South Sudan	B. el Ghazal	
46 Ba	ahr el Ghazal	Lake Ambadi	South Sudan	B. el Ghazal	
47 Ba	aro Akobbo Soba	Badigeru Swamp	South Sudan	Kinyeti River	
48 Ba	aro Akobbo Soba	Kenamuke/ Kobowen Swamp	South Sudan	Kangen River, Sobat River	
49 Ba	aro Akobbo Soba	Lotilla River Swamps	South Sudan	Lotilla River	
50 Ba	aro Akobbo Soba	Veveno/Adiet/Lilebook Swamps	South Sudan	Lotilla River	
51 Ba	aro Akobbo Soba	Baro-Akobo-Sobat Wetlands	Ethiopia	Alwero	
52 Ba	aro Akobbo Soba	Machar Marshes	South Sudan	Sobat River	
53 W	/hite Nile	White Nile Floodplain	Ethiopia, South Sudan	White Nile	
	/hite Nile	Gebel Auliya	Sudan	White Nile	
	lue Nile	Dinder Floodplain	Sudan	Dinder River	YES
	lue Nile	Lake Tana	Ethiopia	Lake Tana	
	lue Nile	Fincha-Chomen	Ethiopia	Blue Nile	
	lue Nile	El Roseires	Sudan	Blue Nile	
	lue Nile	Sennar	Sudan	Blue Nile	
	ekeze Atbara	Khashm el Girba	Sudan	Atbara River	
	lain Nile	Wadi El Rayan Protected Area	Egypt	Nile	
	lain Nile	Lake Qarun	Egypt	Nile	
	lain Nile	The Nile Delta	Egypt	Nile Delta	
	lain Nile	Lake Maryut	Egypt	Nile Delta	
	lain Nile	Lake Idku	Egypt	Nile Delta	
	lain Nile	Lake Burullus	Egypt	Nile Delta	YES
	lain Nile	Lake Manzala	Egypt	Nile Delta	120
JU M	ium mie	Lune mulizulu	Lyypt	Alle Delta	

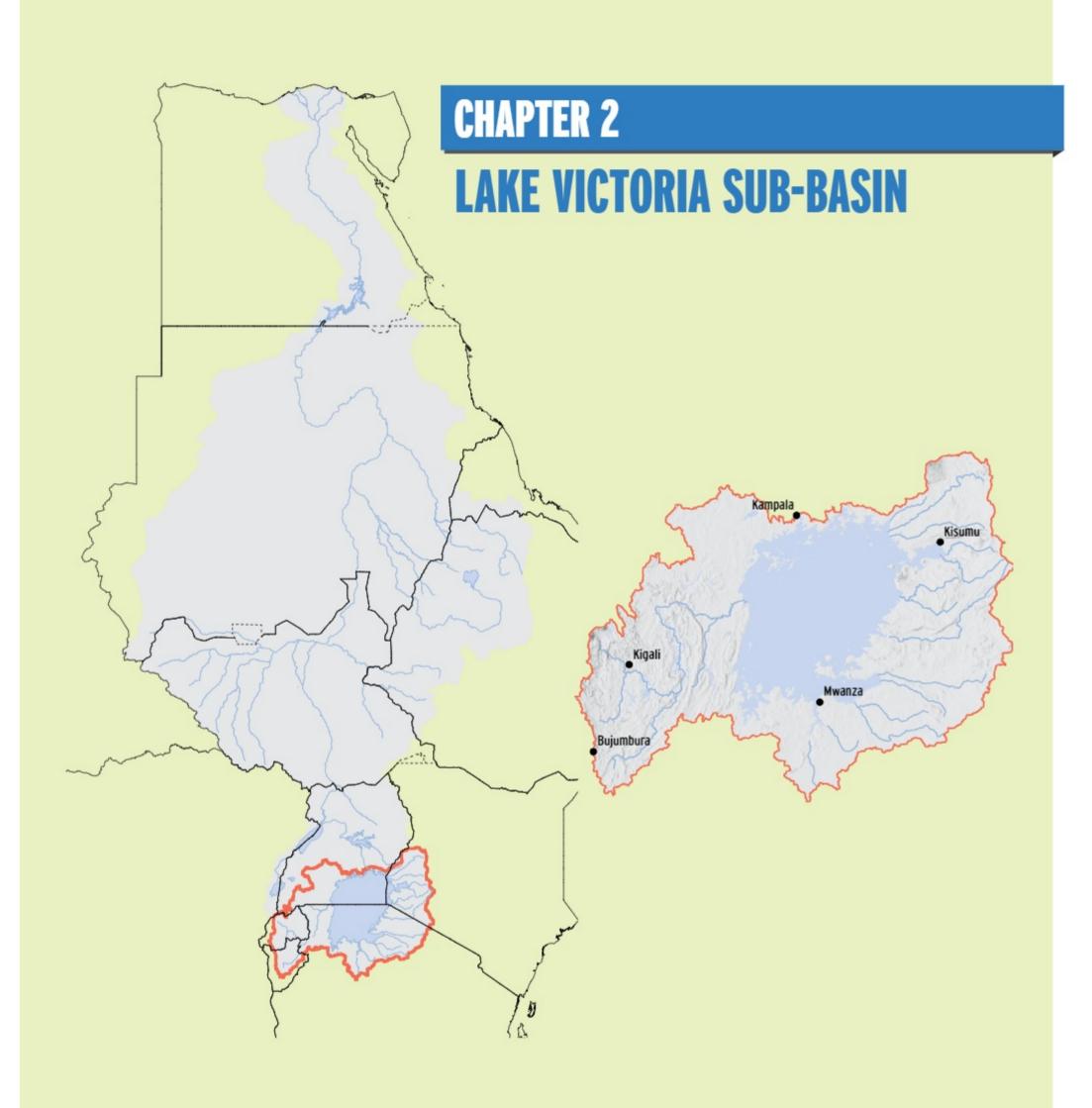
LIST OF TECHNICAL REPORTS ON NILE WETLANDS

NBI has generated Knoweldge products in the area of wetlands that have contributed to the data presented in this atlas. These products are avilable on NBI website (www.nilebasin.org) and NBI document repository. The Table 3 below presents the list of the available documents. NBI Wetlands Atlas.

Table 3: List of Publications developed under the NBI Wetlands Project until 2022

TITLE	REFERENCE	LINK
Policy Documents		
NBI Wetlands Management Strategy 2022-2032	NBI Wetlands Management Strategy 2022-2032	https://nilebasin.org/node/11885
Basin-wide Technical Reports		
Baseline Studies		
Wetlands of the Nile Basin Inventory	NBI Technical Reports-WRM/WBS-2022-01	https://nilebasin.org/node/11932
Nile Basin Wetland Modelling Report	Updated version in progress	https://nilebasin.org/node/11931
Nile Basin Wetlands Monitoring Guideline	NBI Technical Reports- WRM/ WBS 2021-14	https://nilebasin.org/node/11917
Nile Basin Wetlands Ecosystem Services Assessment Report	NBI Technical Reports-WRM/WBS-2022-04	https://nilebasin.org/node/11929
Nile Basin Wetlands Ecosystem Services Assessment Methodology	NBI Technical Reports - WRM/WBS-2022-08	https://nilebasin.org/node/11919
Nile Basin Wetlands Biodiversity Assessment Report	NBI Technical Reports - WRM/WBS-2022-07	https://nilebasin.org/node/11920
Environmental Flows Assessment Methodology for Nile Basin Wetlands	NBI Technical Reports-WRM/WBS-2022-03	https://nilebasin.org/node/11930
The Economics of Ecosystems and Biodiversity (TEEB)		
Nile Basin Wetlands TEEB Synthesis Report	NBI Technical Reports- WRM /WBS -2020 - 08	https://nilebasin.org/node/11941
Sudd Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development	NBI Technical Report - WRM/WBS-2020-03	https://nilebasin.org/node/11926
Economic Assessment of Wetland Biodiversity and Ecosystem Services as an Input for Development of Wetland Investment Plans: A Case Study of the		
Sio-Siteko	NBI Technical Reports- WRM 2020-04	https://nilebasin.org/node/11937
Economic Assessment of the Ecosystem Services of the Semliki Delta Trans- boundary Wetland in Uganda and the Democratic Republic of Congo	NBI Technical Reports- WRM 2020 - 05	https://nilebasin.org/node/11938
Economic Assessment of the Ecosystem Services of the Rweru-Bugesera Transboundary Wetlands Complex (Rwanda-Burundi)	NBI Technical Reports- WRM/WBS-2020-03	https://nilebasin.org/node/11939
Machar Marshes Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development	NBI Technical Reports- WRM 2020- 04	https://nilebasin.org/node/12023
Environmental Flows	Not reclinical Reports Wilm 2020 04	nttps://iniebasin.org/node/12023
Coarse Environmental Flow Assessment for selected reaches in the Nile Basin	NBI Technical Reports - WRM/WBS-2022-06	https://nilebasin.org/node/11921
Environmental Flows Assessment Methodology for Nile Basin Wetlands	NBI Technical Reports-WRM/WBS-2022-03	https://nilebasin.org/node/11930
Coarse Environmental Flow Assessment for selected reaches in the Nile Basin	NBI Technical Reports - 2020-01	https://nilebasin.org/node/11921
Peatlands		
Assessment of Carbon (CO2) emissions avoidance potential from the Nile	NBI Technical Reports- WRM 2019-01	https://nilebasin.org/node/11944
Basin peatlands Options for financing emission avoidance from drained peatlands in the Nile		
Basin: Discussion paper	NBI Technical Reports - WRM 2019-02	https://nilebasin.org/node/11940
Governance		
Burundi Wetlands Governance and Management Profile	NBI Technical Reports -WRM/WBS-2022-15	https://nilebasin.org/node/11895
Democratic Republic of Congo (DRC) Wetland Governance and Management Profile	NBI Technical Reports -DWRM/WBS-2022-14	https://nilebasin.org/node/11891
Kenya Wetlands Governance and Management Profile	NBI Technical Reports -WRM/WBS-2022-13	https://nilebasin.org/node/11892
Rwanda Wetlands Governance and Management Profile	NBI Technical Reports- WRM/WBS-2022-12	https://nilebasin.org/node/11893
and the second s	South Sudan Wetlands Governance and Management	The state of the s
South Sudan Wetlands Governance and Management Profile Wetland Specific Reports	Profile, NBI, Entebbe, Uganda, 2018	https://nilebasin.org/node/11896
Sudd Wetland		
Sudd Wetland Monograph - Volume 1: Overview of the Sudd Wetland - Ecosystems and Land use	NBI Technical Reports- WRM 2020 - 09	https://nilebasin.org/node/11928
Sudd Wetland Monograph - Volume 2: Detailed eco-hydrological planning model for the Sudd	NBI Technical Reports- WRM 2022 - 05	https://nilebasin.org/node/11927
Codd Webler d Manager L. Malay C. C. C. Malay C.		
Sudd Wetland Monograph - Volume 3: Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development	NBI Technical Reports- WRM 2020 - 07	https://nilebasin.org/node/11926
Sudd Wetland Monograph - Volume 4: Environmental Flows Assessment	NBI Technical Reports- WRM 2020 - 06	https://nilebasin.org/node/11925
2		,

TITLE	REFERENCE	LINK
Sudd Peatlands and Climate Change Status, Policy and Finance	Sudd Peatlands and Climate Change Status, Policy and Finance,	https://nilebasin.org/node/11918
Machar Marshes		
Machar Marshes Eco-Hydrology Assessment Project, Final Technical Report Mara Wetlands	Machar Marshes Eco-Hydrology Assessment Project, Final Technical Report, NBI-ENTRO, Addis Ababa, Ethiopia	https://nilebasin.org/node/12022
Lower Mara River Environmental Flow Assessment - NELSAP POLICY BRIEF 2020-01	NELSAP POLICY BRIEF 2020-01	http://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/31-low- er-mara-eflow-policy-brief-lower-mara-river-en- vironmental-flow-assessment/file
Lower Mara River Environmental Flow Assessment Final Resource Quality Objectives and Reserve Assessment Report	NELSAP Technical Reports: Basin Development Series 2020 - 01	http://nelsap.nilebasin.org/index.php/en/in- formation-hub/technical-documents/58-mara- eflow-full-report-nelsap-giz-april-2020/file
Sio Siteko Wetlands		
Wetland Monograph for the Sio Siteko (Kenya - Uganda) Wetland Landscape	NELSAP Technical Reports: Basin Development Series 2020 - 09	https://nelsap.nilebasin.org/index.php/en/infor- mation-hub/technical-documents/78-sio-site- ko-wetland-monograph-kenya-uganda/file
Transboundary Wetland Management Plan for the Sio Siteko Transboundary Wetland between the Republic of Kenya and the Republic of Uganda (2020- 2030)	Transboundary Wetland Management Plan for the Sio Siteko Transboundary Wetland between the Re- public of Kenya and the Republic of Uganda (2020- 2030), NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/en/infor- mation-hub/technical-documents/56-sio-site- ko-transboundary-wetlands-management-plan/ file
Conservation Investment Plan for the Sio Siteko Transboundary Wetland between the Republic of Kenya and the Republic of Uganda	Conservation Investment Plan for the Sio Siteko Transboundary Wetland between the Republic of Kenya and the Republic of Uganda, NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/ en/information-hub/technical-docu- ments/87-sio-siteko-conservation-invest- ment-plan-cip-feb-2020-final
Sango Bay - Minziro Forest Landscape		
Monograph for the Sango Bay Minziro (Tanzania - Uganda) Wetland landscape	NELSAP Technical Reports: Basin Development Series 2020 - 07	https://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/76-san- go-minziro-wetland-monograph/file
Transboundary Wetland Management Plan for the Sango Bay - Minziro Trans- boundary Wetland between the Republic of Uganda and the United Republic of Tanzania (2020 - 2030)	Transboundary Wetland Management Plan for the Sango Bay - Minziro Transboundary Wetland between the Republic of Uganda and the United Republic of Tanzania (2020 - 2030), NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/54-san- go-bay-minziro-transboundary-wetlands-man- agement-plan-july-2020/file
Conservation Investment Plan for the Sango Bay - Minziro Transboundary Wetland between the Republic of Uganda and the United Republic of Tanzania	Conservation Investment Plan for the Sango Bay – Minziro Transboundary Wetland between the Repub- lic of Uganda and the United Republic of Tanzania, NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/89-san- go-bay-minziro-conservation-invest- ment-plan-cip-feb-2020/file
Semliki Wetlands		
Wetland Monograph for the Semliki Delta (Democratic Republic of Congo - Uganda) wetland landscape	NELSAP Technical Reports: Basin Development Series 2020 - 08	https://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/77-sem- liki-delta-wetland-monograph/file
Transboundary Wetland Management Plan for the Semliki Delta Transbound- ary Wetland between the Democratic Republic of the Congo and the Republic of Uganda (2020 - 2030)	Transboundary Wetland Management Plan for the Semliki Delta Transboundary Wetland between the Democratic Republic of the Congo and the Republic of Uganda (2020 – 2030), NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/en/ information-hub/technical-documents/55-sem- liki-delta-transboundary-wetlands-manage- ment-plan-july-2020/file
Conservation Investment Plan for the Semliki Delta Transboundary Wetland between the Democratic Republic of the Congo and the Republic of Uganda	Conservation Investment Plan for the Semliki Delta Transboundary Wetland between the Democratic Republic of the Congo and the Republic of Uganda, NBI-NELSAP, Kigali, Rwanda	http://nelsap.nilebasin.org/index.php/ en/information-hub/technical-docu- ments/88-semuliki-delta-conservation-invest- ment-plan-cip-feb-2020-final/file



Introduction	. 25
Socio-economic context of wetlands in Lake Victoria Sub-basin	. 26
Hydrological context of wetlands in Lake Victoria Sub-Basin	. 27
Sio, Nzoia, Yala and Nyando Wetlands	.28
Nyando Wetland	. 29
Yala Swamp	31
Nzoia River Wetland	. 33
Sio Siteko	. 35
Mara Wetland	. 37
The Kagera River and Wetland Systems	.40
Ruvubu National Park Wetlands	. 42
Wetlands in the Paysage Aquatique Protégé du Nord	.44
Akanyaru Swamps	.46
Akanyaru River Swamps	. 47
Rugezi Marsh	.48
Kamiranzovu Swamp	.50
Nyabarongo Wetlands	51
Akagera Wetlands	. 52
Lake Mburo-Nakivali System	.54
Sango Bay-Musambwa Islands	.56
Lake Victoria Shoreline Wetlands	. 57
Lake Wamala	.58
Nabajjuzi Wetland	. 59
Lake Nabugabo	61
Mabamba Bay	. 63
Lutembe Bay	.65

Overview

The Lake Victoria Basin (LVB) has a total area of 194,000 km2 and forms the drainage basin of the world's second largest freshwater lake by area. The surface area of Lake Victoria is 68,800 km2. A total of 44 % (85,000 km2) of the basin's drainage area lies in Tanzania, while Kenya (22 %), Uganda (16 %), Rwanda (11 %) and Burundi (7 %) make up the rest of the basin's area (LVBC, 2011a). Kenya, Tanzania and Uganda are part of the shoreline of Lake Victoria, whereas Rwanda and Burundi are not directly connected to the lake. The outlet of Lake Victoria is located at Jinja in Uganda, and in the wide definition, considered the beginning of the White Nile. The amount of water flowing out of the Lake depends on the operation of the Nalubaale, Kiira dam complex (Vanderkelen et al., 2018).

In the first half of the twentieth century the lake level remained relatively stable until an abrupt rise in 1961. In the last 65 years the lake water level has fluctuated up to 3m. Generally it follows a downward trend since 1964 with the lowest water levels in October 2006. A drop in the lake water level exacerbates lake transportation problems, may expose drinking water supply

intakes, affects fishing and reduces hydropower production. During low water level situations littoral fish breeding grounds in wetlands around the shoreline of Lake Victoria are disconnected from the pelagic lake zone.

Lake Victoria itself is not considered a wetland due to its depth, however the shallow portions close to the shorelines and sheltered bays have wetland characteristics. The LVBC (2011a) identified sixty six (66) river mouths along Lake Victoria of which 24 are in Kenya, 20 are in Tanzania and 22 in Uganda. These river mouths often host extensive wetland vegetation and are rich in biodiversity. A total of 422 wetlands surround Lake Victoria, of which 61 are in Kenya, 142 in Tanzania and 219 in Uganda (LVBC, 2011a). An extensive network of wetlands covers the lake edges, due to a low gradient, which impedes rapid flows of the rivers draining into the lake. Of the total wetland surface area in Kenya, 37 % can be found in the Lake Victoria Basin. In Uganda 13 % of the total national wetland area lies in the Lake Victoria Basin. In the Tanzanian part of the Lake Victoria Basin 422,000 ha of wetlands can be found of which 73 % are seasonal swamps and 14 % are permanent swamps. The LVBC (2011a) identified 34

wetlands with areas greater than 10 km² seven of which are in Kenya (Sio, Yala, Nzoia, Nyando, Kuja, and Kenga/Kibos/Nyam), ten are in Uganda (Mugango, Waya-1, Sango Bay, Nabugabo, Bussi, Bule-Kyagwe, Naguru/Namatu, Buyiri, Kaazi, and Katonga) and 17 are in Tanzania (Kagera/Ruzinga, Ngono, Sola-Bauman Gulf, Nyaruhwa, Simiyu-Magu Bay, Rubana, Kalukekele-Bauman Gulf, Mara, Yerarumbo, Ilalambogo, Mbalika, Ruiga, Nungwe, Luhorongoma, Mori, Ng'walogwabagole, and Mhalamba). There are several management initiatives in place operating on different scales in the transboundary LVB. The

There are several management initiatives in place operating on different scales in the transboundary LVB. The Lake Victoria Environmental Management Project (LVEMP) for example is an East African Community (EAC) project that are coordinated by the Lake Victoria Basin Commission (LVBC). Other transboundary institutions are the Lake Victoria Fisheries Organization (LVFO) and the Nile Basin Initiative (NBI).

Climate

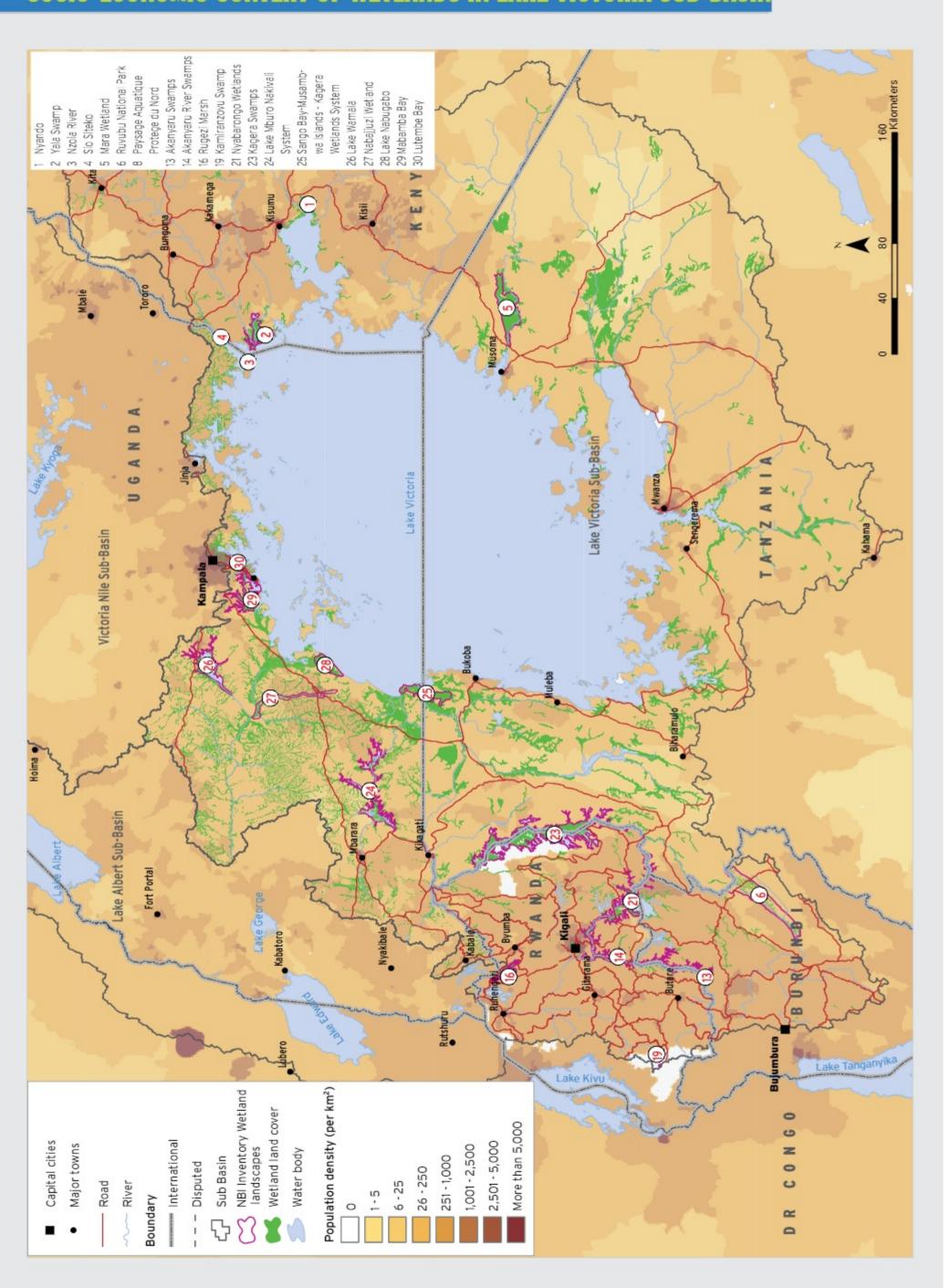
The climate in the LVB is equatorial hot and humid with long rains from March to May and short rains from October to November, However, rainfall varies considerably from one part of the basin to another. Seasonal winds influence hydrological processes in the basin. During January and February and from June to September dry winds from the east cross the lake parallel to the equator. On their way across Lake Victoria these winds pick up moisture, which is deposited in the western part of the catchment, especially in the Bukora Catchment in Uganda (LVBC and GRID-Arenda, 2017).

Ecosystem Services

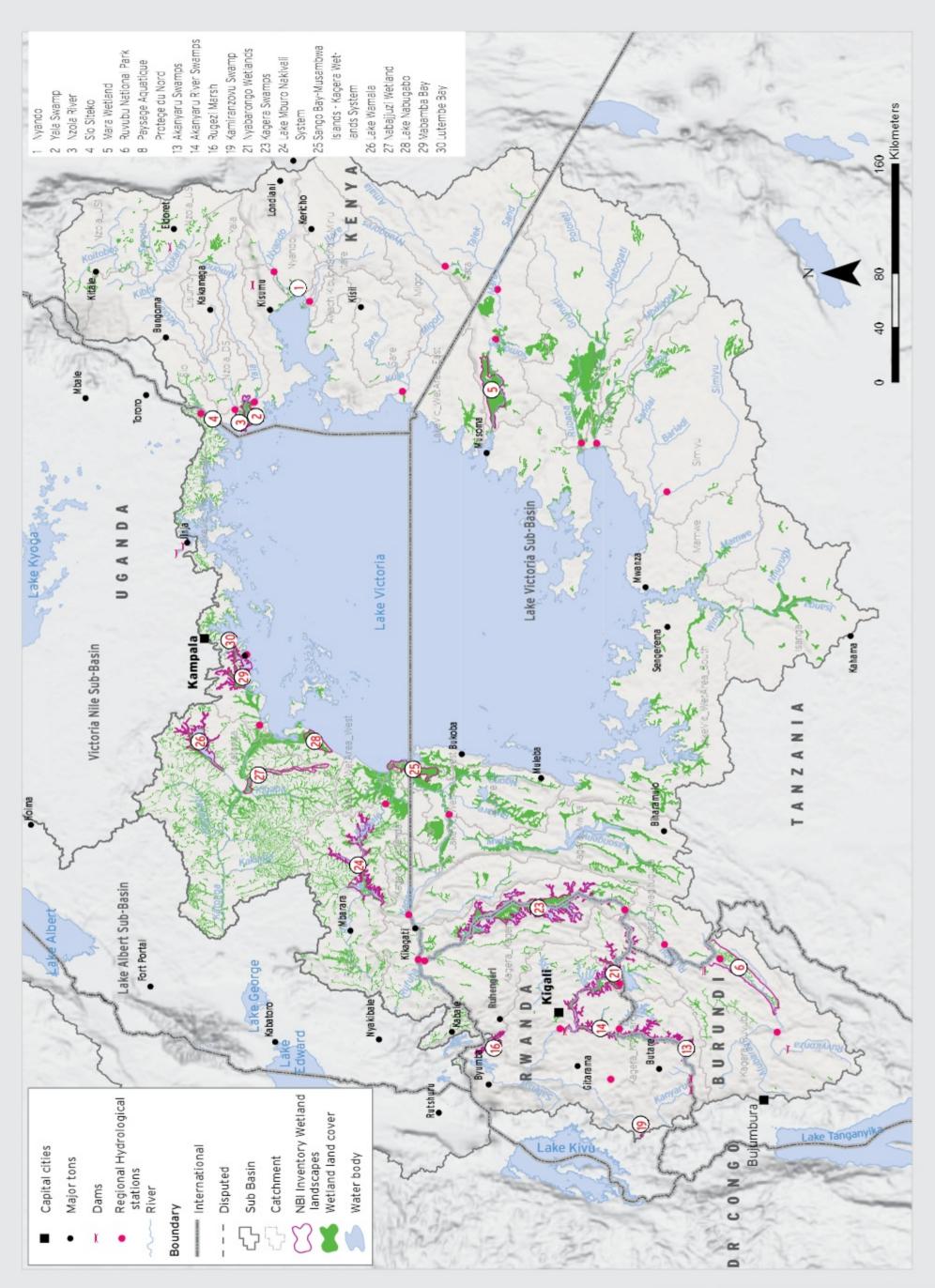
Besides the wetlands themselves (described herein) forests and other terrestrial ecosystems located in the high parts of the basin provide important services that feed and protect the wetlands, such as water infiltration, water purification, erosion regulation, nutrient cycling, and maintenance of genetic diversity (Kulindwa, 2006).



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN LAKE VICTORIA SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN LAKE VICTORIA SUB-BASIN



SIO, NZOIA, YALA AND NYANDO WETLANDS

Overview

The Rivers Sio, Nzoia, Yala and Nyando (SNYN) originate in the highlands and rift valley escarpment of western Kenya and flow westwards to drain into Lake Victoria. The Sio originates in hills near Bungoma town; the Nzoia originates in the Cherangany Hills; the Yala originates in the Nandi Escarpment; and the Nyando originates in the Mau Forest complex. These four rivers, plus other rivers in the Lake Victoria catchment in Kenya (the Sondu-Miriu, Gucha, Mara, Migori and Awach Rivers), contribute approximately 42.4% of surface water inflow to Lake Victoria (LVBC, 2006). In each of the river basins multiple wetlands can be found, which are often grouped and referred to under a single name. In the upper courses of these rivers and their tributaries. there are seasonally flooded areas and also permanent swamps. The river catchments are in high rainfall zones and have similar flooding patterns (Raburu et al. 2012).

Climate

The inter-tropical convergence zone mainly influences the climate in the Nyando catchment. There are long rains between March and June and short rains from October to December. The short rains account for 22% and the long rains for 34% of the 1500 mm average annual rainfall. Extreme floods or drought in are linked to large-scale climate phenomenons such as the

El Niño Southern Oscillation or the Indian Ocean Dipole. Temperature ranges from 13 to 31°C. The temperature peaks in March and October. In the lowlands mean monthly temperature is 21°C and in the higher regions 16°C. Actual evapotranspiration in the Lake Victoria Basin remains the same throughout the year with between 60-80 mm/month (Khisa et al., 2013; NBI, 2016).

Biological Features

There are 117 taxa in the Sio Nzoia Yala Nyando group that have an IUCN threat status of interest. In total there are 22 flagship species for example Balaeniceps rex, Balearica regulorum, Crocodylus niloticus, Cyperus papyrus, Hippopotamus amphibius, Nettapus auritus, Phoeniconaias minor and Tragelaphus spekii. Azolla nilotica Lates niloticus and Pistia stratiotes are important alien species in the wetland group. The biological features of the SNYN wetlands are described for each of the four wetlands individually.

Ecosystem Services

The SNYN wetlands provide goods such as fish, game, vegetables, fruits, grains and potentially insects. Indirectly the wetlands provide fodder for livestock and farmland for crop cultivation (Abila, 2002). The three most important products according to Schuijt (2002) are water (for cooking, washing, drinking and irrigation), fish, and

agricultural grounds. Fishing provides fish for commercial and non-commercial purposes. In addition it creates other income generating activities such as fish net and boat repairing. Wetlands also provide raw materials for construction, medicinal products. genetic materials. Larger waterbodies are also used as means of transportation (Abila, 2002; Schuijt, 2002). The value of crops, livestock, water fish, forest and non-forest products and non-market products for Nyando wetland is estimated to be approximately US\$ 1.5 Billion (US\$ 62,500 / ha / year) with an infinite present value of US\$ 75.5 Billion at 2% discount rate (Oduor et al., 2015).

The most prominent regulating services of the SNYN wetlands is water purification due to the filtering effect of the swamps where most sediments are retained (Schuijt 2002; Simonit & Perrings, 2011). Simonit and Perrings (2011) discuss the regulating services in the Yala catchment, which, although still little understood, are probably the most important ones when it comes to nutrient retention, erosion regulation, maintenance of soil fertility and water purification. These services are also key for sustaining other provisioning services, such as healthy fish populations. Modeling the interaction between fisheries and wetland conversion for agriculture, Simonit and Perrings (2011) estimated the value of these regulating services in about 3.86M US\$/year (which comprises

about 35% of the earnings when converting wetlands to farmland that could be offset through payment for ecosystem services mechanisms).

As a supporting service, the river Yala plus the satellite Lakes Kanyaboli and Sare are pathways for people living or working in isolated fringing swamps therefore facilitate communication between people living around the Yala swamp, (NBI, 2009). The SNYN wetlands are also important sites for biodiversity conservation, as they have a rich biodiversity and are habitat for endemic species, like the Sitatunga antelope (Schuiit, 2002), Besides wildlife conservation, the loss of these wetlands would also imply the loss of some socio-cultural values and sites important for their spiritual, recreational and educational purposes (Abila, 2002; Ondiek et al., 2016). For example, there are many beliefs and rituals connected to the Nyando wetland. Bathing in wetland waters for example was believed to have cleansing powers. Also special ceremonies used to be held in wetlands like appeasing the spirits of the gods. However due to western influence more and more of these traditions are lost (Raburu et al., 2012). The utilization of natural resources of the Nyando wetland is gender based due to the societal division of labour among genders. Hence, wetland degradation affects men and women in a different way (Raburu et al., 2012).



Common Papyrus seeds, Mara wetland



Threatened endemic Papyrus Gonolek, Nyando

NYANDO WETLAND

Name: Nyando Wetland, Kusa Swamp, Mikura swamp

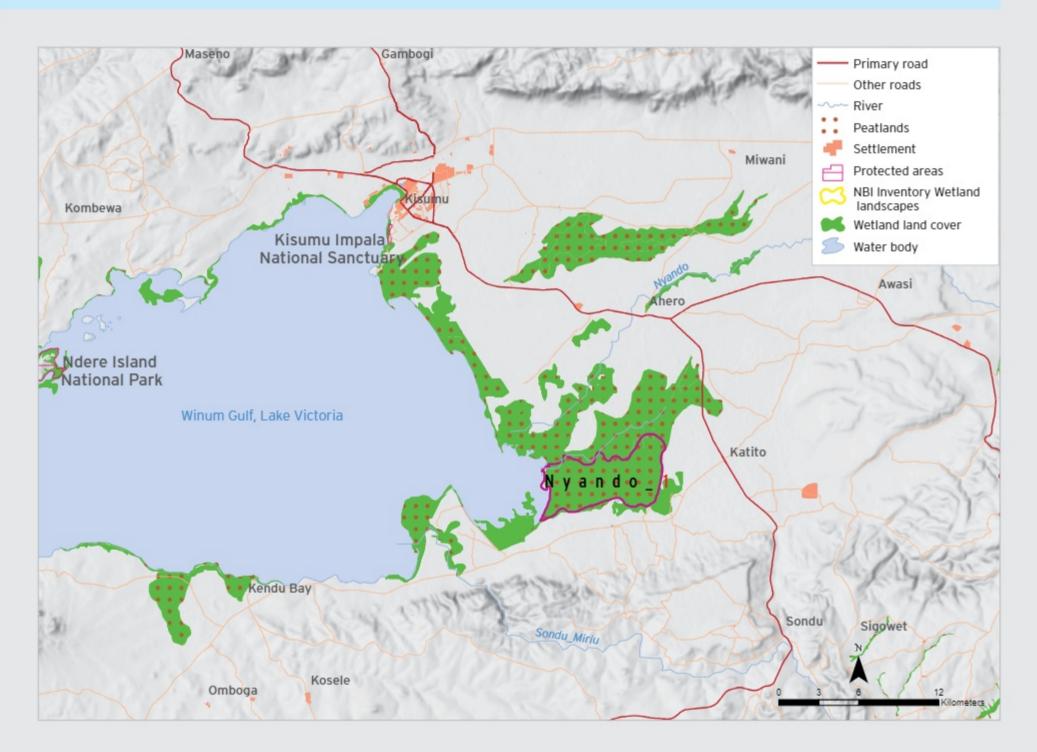
Country: Kenya

Coordinates: 0°09′ - 0°20′ S / 34°45′ - 35°00′ E

Altitude: 1,390 m a.s.l. Area: 34 km²

Nearest Towns: Kisumu, Kendu Bay

International Importance: Important Bird Area



Overview

At the easternmost end of Winam Gulf, the Nyando River enters Lake Victoria where it forms a deltaic fringing wetland at Nyakach Bay. The Nyando wetland is incised within the Kano plains and is contiguous with other lakeshore wetlands. Altogether it forms the second largest wetland on the Kenyan side of Lake Victoria with a total area of 14,400 ha (Raburu et al., 2012). The actual low-lying swamp referred to as Nyando wetland has an approximate extension of 3000-5000 ha (Khisa et al., 2013; Van Dam et al., 2013), according to our analysis it is 3400 ha large.

Physical Features

The Nyando River itself originates in the Mau Forest on the western shoulder of the Kenyan Rift Valley. After 153 km the Nyando River empties into Lake Victoria's Winam Gulf. In the river basin, there are a number of smaller wetlands that are fed by direct precipitation, runoff from upland areas, and inflow from partly seasonal rivers, recharge from aquifers and backflow from the lake during flooding. Some of the wetlands connected to the Nyando River or its tributaries are the Kepseon Swamp, the Ombevi Swamp, the Koyo Swamp, Okana Wetland, the Awach Swamp and the Oroba Swamp. In addition it is estimated, that there are more

than 480 small manmade wetlands in the Kano Plains. The Kano Plains are an extensive transitional floodplain riparian zone, which is an important agricultural area for sugarcane and rice cultivation. The plains are situated in the Kavirondo Rift Valley and occupy two thirds of the lower half of the Nyando River catchment. Several small rivers and ephemeral streams (Nyaidho, Awach, Kano and Asawo) drain the floodplains and feed into the Nyando deltaic wetland (Raburu et al., 2012).

The oldest rocks in the Nyando area date back to pre-Cambrian times (Millman, 1973). The most recent geological event is the migration of the Nyando river channel as the river used to

share a common outlet with the Nyamasaria River at the Nam Thoe Swamp (Millman, 1973). The Nyando River has migrated eastwards in the past 60 years and enters Lake Victoria though the Nyando wetland swamp. The river mouth of Nyando River has moved first southward, then northward to Nyakach Bay, creating the current delta situation with three main channels (Khisa et al., 2013). The reason for this dynamic river course is the accumulation of detritus from small rivers flowing southward from the Nandi Escarpment to Winam Gulf (Millman, 1973). Dams and dykes stabilize the current flow situation of the river.

Silt and clay material from the

surrounding hills are continually deposited and reworked in the Kano plains (Millman, 1973). These soils have poor structure and become easily compacted, as their clay content is high. Such soils are also called 'black cotton soils' (vertisol) and are problematic for agricultural development (Millman, 1973). In the wetland the soil is composed of clay, silt and sand with varying proportions with an organic matter content of 3.3 % (Rongoei & Outa, 2016).

Water is supplied to the Nyando Wetland through inflow from the Nyando River, backflow from Lake Victoria and as direct rainfall. Overtopping of the river at high river stages occur twice a year during the rainy seasons average monthly discharges range from 12 m³/s to 30 m³/s (Khisa et al., 2013). The influence of groundwater on the Nyando wetland has not been investigated well. The maximum water depth in the undisturbed wetland area is 90 cm during the wet season. Parts of the wetland can fall completely dry in the dry season (Rongoei et al., 2014). Water Retention capacity of the wetland depends on the season. During the rainy season 11.5 *106 m³ are retained, during the dry season 6.3 *106 m3 (Mule et al., 2015) are retained.

In the lower Kano plains, twenty kilometres from the river mouth, floodwater seasonally overtops the riverbank commonly at Gem Rae, spreading out to the Nyando Delta Wetland. In addition flood waves from the Awach Kano and Asawo tributaries spread out from the south-eastern part of the Kano Plains into the Nvando wetland. There are two surface water exchange scenarios in the Nyando wetland depending on the season: (i) the floodwaters link the riverwetland and the lake-wetland, which results in a formation of a single hydrological unit or (ii) the river and lake waters are separated from the adjacent wetland which means there is no or minimum surface water exchange (Khisa et al., 2013).

Biological Features

Rongoei et al. (2014) identified 30 plant species in the Nyando wetland where *Cyperus papyrus* and *Vossia cuspidate* are dominant. In the undisturbed wetland up to 99% of the plant density consists of obligate and facultative wetland plants whereas at areas where the wetland is converted to farmland, facultative, facultative upland and upland plants are very common. Water depth has a significant influence on papyrus growth, hence changing water levels affect growth and mortality of papyrus. In areas, which are frequently, disturbed such as the Wasare floodplain the papyrus growth rate is low (Rongoei et al., 2014; Rongoei & Outa, 2016).

Nyando wetland offers a number of microhabitats for many species to thrive, including the in Kenya endangered antelope sitatunga (Tragelaphus spekei). Other mammals common in the Nyando swamp are hippopotamus (Hippopotamus amphibious), African civet (Viverra civetta), spotted necked otter (Lutra maculicollis). Also amphibian species such as the great grey wetland frog (Chiromantis petersi) and reptiles e.g. the green water snake (Philothamnus hoplogaster) occur in the Nyando wetland (MEMR, 2012; Rongoei et al, 2014). Nyando is an Important Bird Area. Bird species that are endemic to papyrus swamps include vulnerable papyrus yellow warbler (Chloropeta gracilirostris), the endangered papyrus gonolek (Laniarius mufumbiri) and the papyrus canary (Serinus koliensis).

The Nyando wetland serves as breeding ground, nursery and feeding ground for several fish species. The occurrence of most of the native tilapine species (Oreochromis niloticus, Oreochromis variabilis. Oreochromis leucostictus) is noteworthy, as they are almost extinct in Lake Victoria. Fish species occurring in the wetland belong to the families Cyprinidae, Cichlidae, Bagridae, Schilbidae, Clariidae, Mastacembelidae, Anabantidae Momyridae. The invasive Nile perch, which is the most important fish for Lake Victoria fisheries can also be found in the Nyando swamp (Rongoei et al., 2014).

Management Status

The wetland is located in Kisumu County, which was part of the former Rift Valley and Nyanza Provinces in western Kenya. The wetland covers parts of three sub-counties of Kisumu County: Nyando, Nyakach and Kisumu East Sub-counties. The Nyando river channel forms the administrative boundary between these three sub-counties. The area of the Nyando wetland also covers eight administrative locations (Kawino South, Bwanda, Kakola, Kochogo, North Nyakach, Nyalunya, Pap Onditi and Kombura locations) in Kisumu County.

Drivers of Change

The LVBC (2011a) inventory classifies Nyando wetland as least degraded and least to moderately threatened. However, hydrologic as well as anthropogenic factors have directly influenced the evolution of the Nyando wetland and are strongly connected. There has been a downward trend in the lake water level for LV due to a combination of factors: depressed precipitation, variability in rainfall trends, prolonged droughts and decrease of river flow, crustal movements and withdrawal of water for water supply and hydropower generation. Okotto-Okotto et al. (2018) showed, that the wetland extent is correlated to the lake water level. If the lateral hydrological connectivity between wetland and lake is disturbed loss of key ecological functions can be the result since flooding facilitates the spatial exchange of water nutrients and sediments.

Since 1975 dykes and dams have been constructed along the riverbanks downstream from Ahero town, to prevent flooding. Therefore the river migration is constrained and the river mouth cannot move further south. This kind of anthropogenic confinement of the river has led to a deepening of the riverbed 4 to 30 km from the delta. As a result the wetland and adiacent floodplain is decoupled from the river most of the time. In addition wildlife movement and land use activities such as the construction of irrigation canals have led to recent changes in river morphology. The loss or gain of land due to river migration has been a cause of conflict between the Nyakach and Kano communities on opposite sides of the river bank (Khisa et al., 2013).

As the water level in Lake Victoria drops, the shoreline shifts away from its original boundaries making littoral zones and wetland areas available for agriculture. Seasonal changes in wetland extend also allow cultivation of crops on otherwise inundated areas of the wetland. During the dry season macrophytes are cut and the converted to sugar cane, maize, rice, and vegetable farmland. If the papyrus rhizome is not removed, it can regrow, as soon as the area is flooded again (Okotto-Okotto et al., 2018; Rongoei et al., 2014).

Soil moisture is lowered due to vegetation removal, cropping and other livelihood activities. This creates colonization opportunities for facultative and upland species, which are better adapted to dry conditions (Rongoei et al., 2014). Livelihoods activities which affect wetland extend and function include livestock herding, conversion to agriculture and harvesting of wetland products. Conversion of wetland area into farmland involves cutting or burning of vegetation, sometimes removal of vegetation rhizomes and roots, channelization for drainage and irrigation, application of pesticides and fertilizers (Van Dam et al., 2013)

Indirect drivers of change are unemployment and population pressure. Poverty increases the dependency on wetland services and goods, leading to an increased exploitation of the wetland. In densely populated areas, where markets for wetland products are available overexploitation is more common (Van Dam et al., 2013).

Change Trajectories 1985-2015

With an area of 4,500 ha in 2008 the Nyando wetland had less than half the size of its maximum extent in 1973 (9,925 ha). According to Khisa et al. 2013 the wetland area increased from 1950 to 1973 to an extension of 9,925 ha. Since then the wetland area has been decreasing to 4,200 ha in 2008. Great parts of the wetland were converted to rain-fed agriculture and small-scale irrigation schemes. Also the livestock grazing and the construction of settlements increased. The wetland extent declined by 40% between 1973 and 1986 and continued to reduce by 24% in the period 1986-2001. From 2001 to 2008 the wetland size further reduced by 7 %. An analysis by Okotto-Okotto et al. (2018) showed similar trends as 31 % of the Nyando wetland was lost between 1984 and 2010.

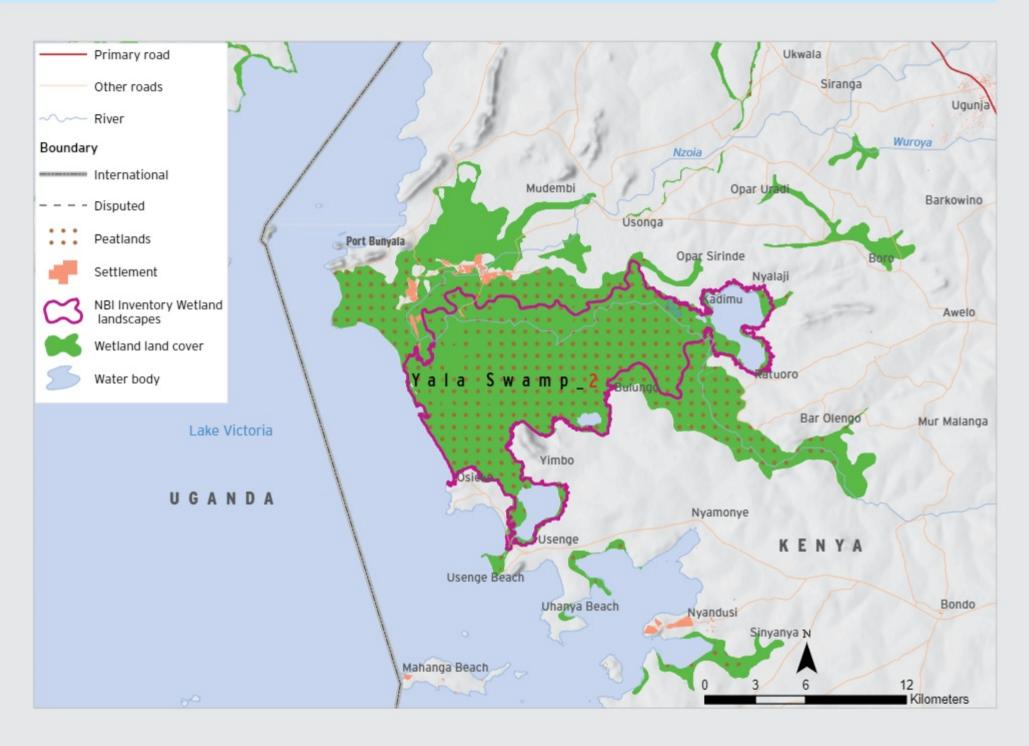
YALA SWAMP

Name: Yala Swamp Country: Kenya

Coordinates: 0°07'N - 0°01'S / 33°58'- 34°15'E

Altitude: 1,134 m a.s.l. Area: 147 km² Nearest Towns: Kisumu, Busia

International Importance: Important Bird Area



Overview

The Yala Swamp is Kenya's largest freshwater wetland. The wetland consists of a large delta where the Nzoia and Yala River empty in Lake Victoria. The wetland ecosystem contains the freshwater river and the complete lakeshore south of Ugowe Bay. The wetland is habitat for the threatened Sitatunga antelope (Tragelaphus spekii) and many haplochromine fish species as well as birds. Surrounding the wetland, there is a lot of farmland and pasture for grazing. The wetland is a water source for livestock and domestic use. Macrophytes are harvested for handicraft, building and fuel. Fishing is also an important economic activity. Part of the Yala

swamp is protected as the Lake Kanyaboli Game reserve. Other wetland areas are threatened by drainage for crop cultivation, burning, water hyacinth infestation and siltation due to deforestation (LVBC and GRID-Arendal 2017; MEMR, 2012).

Physical Features

The Yala Wetland is located between the rivers Nzoia and Yala, which both form extensive deltas, where the swamp is situated. The Nzoia Delta, the lakeshore south to Ugowe Bay and the land to the east of Lake Kanyaboli form part of the Yala Wetland. Everything included, the Yala Swamps have an extension of 30,000 ha stretch from 25 W-E and 15 km from N-S. A tributary of the Yala River, the Kimandi River has a seasonal floodplain of 4800 ha (Hughes & Hughes, 1992). According to the LVBC (2011a) the Yala Swamp extends over 15,700 ha.

Generally, the soils can be characterized as Vertisols, Planosols, Gleysols and Fluvisols. These soils vary from moderately well to imperfectly drained, deep to very deep, brown to black and in other places saline and sodic with texture being sandy, clay loam to cracking clay (Sila et al., 2017). Several different swamps lie within the Yala Basin, which are part of the Yala Wetland: Kingwal, Kajuok Swamp and Yala Swamp and its related swamps such as Gomro, Wathding, Daraja, and Aram and

three satellite lakes (Raburu et al., 2012).

Lake Kanyaboli is one of the satellite lakes of Lake Victoria with a mean depth of 3 m and an area of 10.5 km². It has a catchment area of 175 km² and located approximately 14 km west of Siaya town. Lake Kanyaboli is a favourable nursery ground and refuge area for many fish and bird species. It has been nicknamed a "living museum" for Lake Victoria fisheries because many fish species which have disappeared from Lake Victoria are still found in appreciable numbers in this lake.

Lake Sare is about 5 km² and about 5 m deep at its centre. It is part of southern outlet of the Yala River. It was a part of the Nyanza Gulf of Lake Victoria before a culvert was constructed across its present outlet into the gulf. It is surrounded by a fringe of papyrus swamp. Its only outlet is the culvert near the southern part of Got Agulu Sand Bar.

Lake Namboyo is a very small but deep lake of between 10 m and 15 m deep with surface area of about 1 km2. No other major use is known except as a water resource for local people and their livestock and fish for local consumption.

Biological Features

The common emergent macrophytes in the Yala Swamp are grasses such as Echinochloa pyramidalis which occupies seasonal wetlands. Reeds (Phragmites kirkii), sedges Cyperus papyrus and Typha domigensis and tall water grasses such as Paspalidium geminatun and Vossia cuspidata occupy permanently inundated wetlands (Handa et al., 2002). Invasive species, such as water hyacinth, water lettuce and woody shrubs have can also be found in the Yala swamp (Barasa et al., 2016).

Two distinct but small populations of the Sitatunga antelope (Tragelaphus spekii) have been recorded in Saiwa and Kingwal-Eldoret. Due to hunting and habitat degradation, the Sitatunga antelope is endangered in Kenya. In the Yala and Nandi swamps populations are scientifically

unrecorded but informal records are kept (Agwanda, 2009). Other mammals found within the Yala wetlands include Panthera pardus pardus (leopard), Hippopotamus amphibius (hippopotamus), Kobus ellipsiprymnus (waterbuck), Aepyceros melampus (impala), Aonyx capensis (clawless otter) (hedgehogs, Cercopithecus aethiops (vervet monkey). mongoose, squirrels and wild pigs. The Yala wetland is one of two known locations that hosts Potamogale velo (Giant Otter shrew). Amongst the reptiles found is the Python sebae (African rock python) (Abila, 2002; MEMR, 2012).

The Yala swamp is an Important Bird Area, however unprotected. Key bird species are the nearthreatened papyrus gonolek (Laniarius mufumbiri) and the also globally threatened (vulnerable) papyrus yellow warbler. Regionally threatened (vulnerable) species are the great egret (Ardea alba) and the Baillon's crake (Zapornia pusilla). The north and south Nandi Hill Forests in the Yala River Basin provide habitat to forest-dependent species such as the black-andwhite casqued hornbill (Bycanistes subcylindricus) (BirdLife International, 2019).

The Yala Swamp and its surrounding lakes are habitat and breeding site for many fish species such as: Clarias gariepinus, Protopterus aethiopicus, Labeo victorianus and Barbus spp. (Aloo, 2003). Satellite lakes are aquatic habitats, where isolation and size related genetic diversity can be studied. As there is continuous loss of ichthyofaunal biodiversity in the Lake Victoria Basin isolated satellite lakes are functional refuges for indigenous fish species. The genetic diversity of the African catfish Clarias gariepinus population is higher in Lake Kanyaboli than in Lake Victoria. C. gariepinus is an important predator species in the satellite lakes of the Yala swamp (Barasa et al., 2016). It is also valued for consumption, as bait for Nile perch fishing in Lake Victoria and as brood stock for commercial aquaculture. Also the critically endangered Singidia tilapia (Oreochromis esculentus) can be found in the Lakes Kanvaboli and Namboyo (Angienda et al., 2011).

Management Status

The Yala swamp covers the counties Busia and Siaya and falls within the following ward, Bunyala Central, Bunyala East, Bunyala North, Bunyala South, Bunyala West in Budalangi sub-county, Busia County. Other in Siaya county, Ugenya sub county include Central Alego, Khajula, South Central Alego, South West Alego, South Alego, Usonga, Central Yimbo, East Yimbo, North Yimbo and West Yimbo ward. In 2002, 100 km² of the swamp was leased to Dominion Farms (K) Ltd.

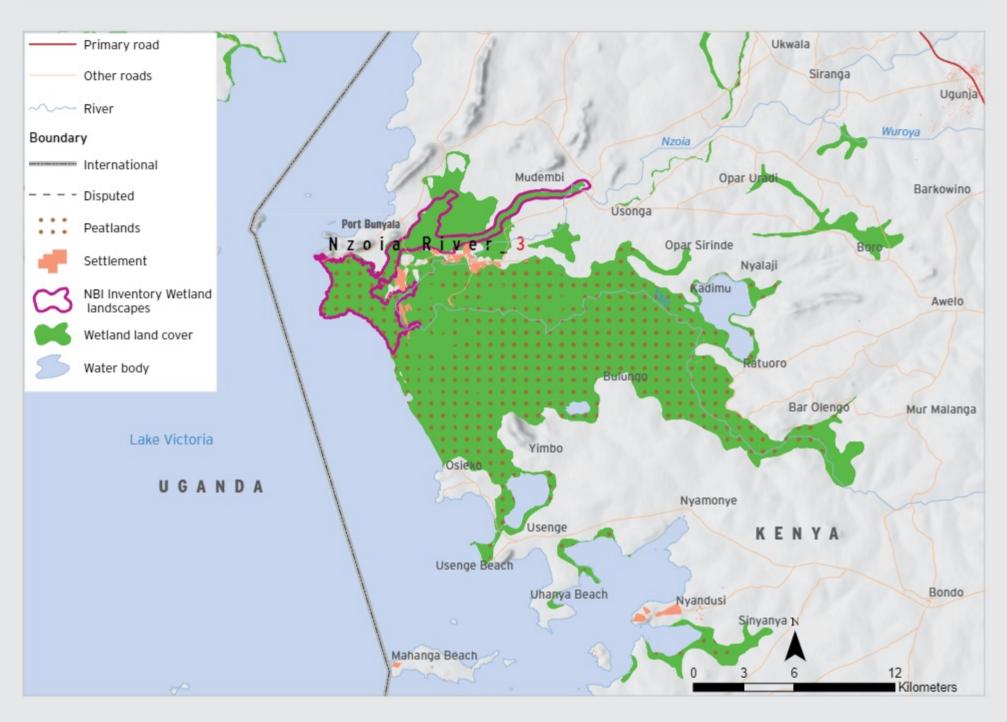
Drivers of Change

High population pressure has resulted in greater demand for land, hence the Government of Kenya carried out large scale reclamation of wetlands in the Lake Victoria Basin for agriculture. In general, areas characterized by large swamp conversions have high demographic densities and wetland accessibility. In the Yala wetland swamp, farming contributes more than 70 % of domestic food requirements. High population pressure is coupled with declining soil fertility around Yala swamp. According to an analysis by Thenya and Ngecu (2017) cultivation in the Yala swamp is the most significant proximate driver of land cover change. Other drivers of wetland conversion are grazing, mining of clay for brick making and macrophyte harvesting. The main aim of farming in the wetland is to supply domestic food and raise subsistence income. Conversion of land into settlement is not a driver of wetland degradation in the Yala swamp, as seasonal inundations do not allow the construction of permanent settlements in the swamp. As a result of land use change and deforestation the area is currently experiencing severe soil erosion and siltation of major rivers and lakes (NBI, 2009).

NZOIA RIVER WETLAND

Name: Nzoia River Country: Kenya

Coordinates: 0° 04'N / 33°57'E
Altitude: 1,134 m a.s.l.
Area: 26 km²
Nearest Towns: Kisumu
International Importance:



Overview

After the Kagera River, the Nzoia River is the second largest affluent to Lake Victoria as it contributes roughly 14.5 % of total surface water inflow to Lake Victoria. The Nzoia Wetland is a floodplain and a permanent swamp. Immediately Nort East of Kitale along the Nzoia River, there is a 6000 ha floodplain with a swamp (Hughes & Hughes, 1992). This wetland is 20 km long from NW-SE and 1-5 km wide (Hughes & Hughes, 1992). A small permanent swamp with approximately 1000 ha is situated (0°52'N/35°13'E) north of the Little Nzoia River. The Nzoia Delta forms a continuous wetland with the Yala Swamp and shares the same properties (see Yala Swamp).

Physical Features

The Nzoia Basin has an area of 12,696 km2 (MEMR, 2012). Nzoia River is 315 km long, rises high in the Cherangany Hills and receives

four major affluents from Mt. Elgon and another from the highlands along the central western part of the Rift Valley, the Mau Forest complex. Of the tributaries from Mt. Elgon, the Sosio rises over 3,500 m a.s.l, and the Ewaso Rongai, Koitobos and Kuywa Rivers have sources near the 3,000 m contour (Raburu et al., 2012). The Nzoia Wetland is described as a riverine wetland, it has both a floodplain and a permanent swamp.

Biological Features

The main vegetation of the Nzoia wetland includes Cyprus papyrus, Phragmites spp. and Vossia cuspidata (hippo grass) (MEMR, 2012; Ojwang & Ojuok, 2009).

Mammals found in the Nzoia swamp include Hippopotamus amphibius (hippopotamus), Tragelaphus spekii (sitatunga) and Aonyx capensis (clawless otter). The Nzoia swamp is one of only two known locations for Potamogale velox (giant otter shrew) the other known location is the Yala Wetland. Loss of foraging areas due to conversion of wetland to agricultural and human settlement, hunting for meat and water pollution from chemicals threaten the hippopotamus population (Agwanda, 2009).

Although some fish species in Lake Victoria have been reduced or are now extinct, wetlands such as Nzoia provide a refuge for many of these 'lost' species. Examples of fish species found in the Nzoia wetland include: Pseudocrenilabrus multicolor, Chiloglanis cf. somereni, Amphilius cf jacksonii, Barbus altianalis, Barbus apleurograma, Clarias gariepinus, Labeo victorianus and Schilbe intermedius (Ojwang & Ojuok, 2009). to Dominion Farms (K) Ltd.

Drivers of Change

Sakataka & Namisiko (2014) conducted a

study on the effects of livelihood activities on the Upper Nzoia Basin. The study concludes, that rising population and subsequent need for larger cultivation areas is the main driver of wetland degradation in Nzoia. A remote sensing land use change assessment backed by ground truthing showed, that between 1986 and 2011 30 % of Nzoia wetland were lost. Especially since the 1980s human encroachment on wetlands near the Nzoia River increased and with cultivation

extending less than one meter off the river bank.

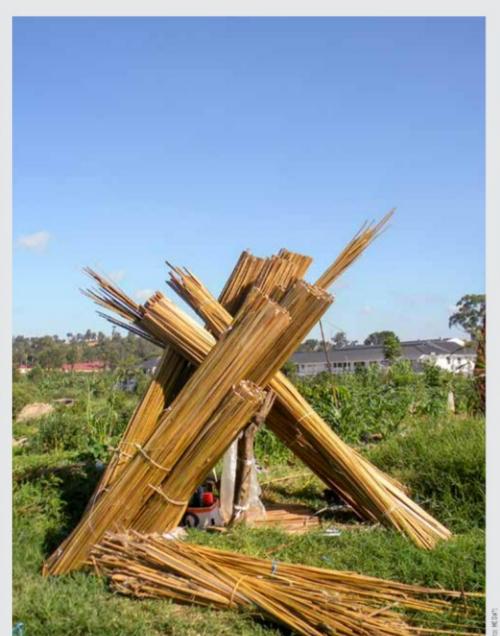
The Nzoia basin is within a sugarcane growing region and has a floodplain in Budalangi. The conversion of wetland to medium scale sugar cane farming has increased from 84 km² in 1986 to 189.5 km² in 2005. There was a reduction in riverine vegetation from 3.6 km² in 1995 to 1.4 km² in 2005. The environmental challenges on Nzoia River are caused by pollution

from discharge of poorly treated effluent from sugarcane, pulping, coffee processing factories and agricultural chemical run-offs. Effluents are from the major industries in the basin but from outside the district namely paper mills, tobacco leaf factories and cotton ginnery have degraded the environment of the basin due to improper management of industrial waste. Soil samples also have high levels of persistent organic pollutants. The pollutants have profound impacts on the

fishing industry, killing fish in Nzoia River with the water unusable for any purpose for at least 20 km from Webuye. There have been records of fish dying at the mouth of the river. Cattle owners also find it hard to water cattle in some sections of the river (Twesigye, 2011).



Papyrus fish trap, Nyando wetland



Harvesting wetland grass

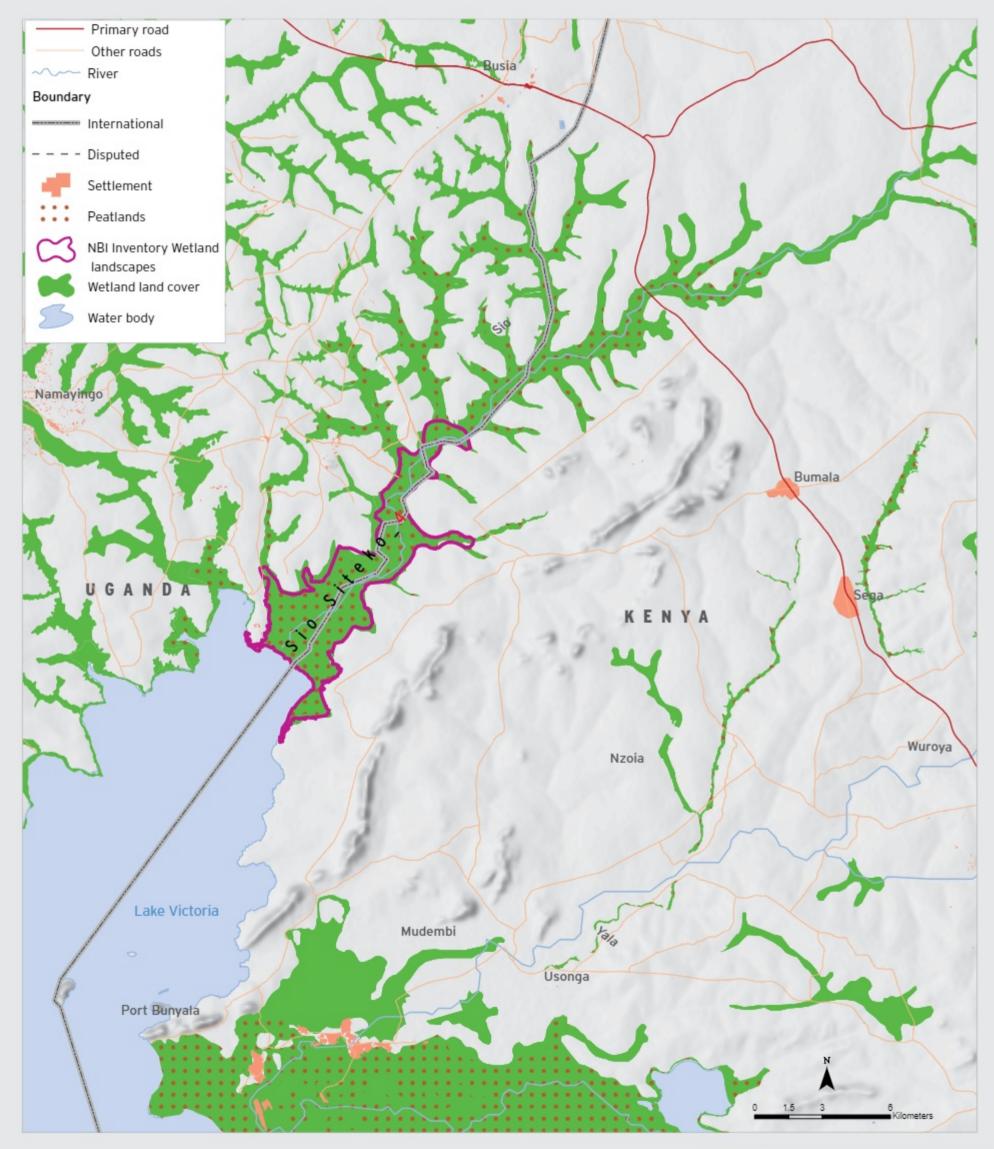
SIO SITEKO

Name: Sio Siteko Country: Kenya

Coordinates: 0°14′ – 00°24′ S / 34°00′- 34°10'E Altitude: 1,134 m a.s.l.

Altitude: 1,134 m a.s.l. Area: 30 km² Nearest Towns: Busia, Kisumu

International Importance: Important Bird Area, Transboundary Wetland



The Sio-Siteko is a transboundary wetland between Kenya and Uganda and is part of the wider Sio-Malaba-Malakisi basin area. The Sio River empties into Lake Victoria through a large riverine floodplain area. The river system is associated with an extensive temporary floodplain that extends upstream about 30 km and ranges between 5 km wide near the mouth to half a km wide upstream near the Busia-Kisumu Road Bridge. Surrounding the Sio river mouth, there is an extensive permanently flooded wetland (Hughes & Hughes, 1992; MEMR, 2012).

Physical Features

The Sio River originates from marshes to the south-west of Bungoma town (Kanduyi), and flows along the common Kenya-Uganda border before discharging into Lake Victoria. The Malaba River flows westwards into Lake Kyoga. The Sio basin area is 1,334 km² with its highest elevation in Bungoma country at about 1,400 m and its lowest point at the Sio River mouth (1,134 meters; Lake Victoria). Mt. Elgon is also the

source of the Malaba River which discharges into Lake Kyoga at the Mpologoma wetlands. The wetland consists of a number of interconnected secondary and tertiary wetland subsystems that drain into Lake Victoria (NBI, 2009)(NBI, 2009).

Biological Features

The predominant vegetation found in the Sio wetland is Cyperus papyrus, Phragmites spp. (reeds) and Vossia cuspidata (hippo grass). Invasive species such as Eichhornia crassipes (water hyacinth), Pistia stratiotes (water lettuce) and woody shrubs have invaded the wetland (Oindo, 2009).

The Sio wetland is an Important
Bird Area as it has more than 300
bird species which include three
papyrus endemics: Laniarius
mufumbri (papyrus gonolek),
Bradypterus carpalis (whitewinged warbler) and Crithagra
koliensis (papyrus canary). Circus
macrourus (pallid harrier) is also
listed as an important bird species
and Phalacrocorax africanus
(long-tailed cormorant) has the
greatest number of individuals
present at the wetland. The

mammals that occur within the wetland include Tragelaphus spekii (sitatunga), Chlorocebus pygerythrus (vervet monkey), otter, Hippopotamus amphibius (hippopotamus) and Atilax paludinosus (water mongoose) (MEMR, 2012; Ndithia, 2009).

Management Status

The Kenyan side of the basin is managed by the Sio-Malaba-Malakisi Management Unit which is part of the Lake Victoria North Basin area. The Lake Victoria North Basin area is managed by the Kenyan Water Resources Authority (WRA). The Sio-River Basin is shared by the Busia districts in Uganda, and Bungoma, and Busia, counties in Kenya.

In an attempt to address the challenges faced by the Sio-Siteko wetlands in an integrated manner, diverse stakeholders from Uganda and Kenya participated in formulating the Sio-Siteko Transboundary Wetland Community Based Management Plan (NBI, 2009). The plan was prepared under the aegis of the now closed Nile Transboundary Environmental Action Project

(NTEAP) which fell under the NBI's Shared Vision Program. The program's stated objective was 'to provide a strategic environmental framework for the management of the transboundary waters and environmental challenges in the Nile River Basin'. Instructively, wetland conservation was one of the project's components. The Sio-Siteko management plan fosters community based management of the wetland's resources

Drivers of Change

Exploitation of wetland goods in Sio-Siteko affects the hydrological characteristics of the wetland which can ultimately lead to larger inundations in the area. The population and cattle densities with 300 person and 38 cattle per square kilometre is high (Obando et al., 2007). The water quality is affected by poor animal husbandry and deforestation in the river basin, which leads to higher runoff. These conditions inevitably compromise the wetland's capacity to act as a buffer and to sieve effluents from both point (specific) and non-point (diffuse) sources of pollution (MEMR, 2012).



C HE Da

Destruction of soils in Sio Siteko wetland system

MARA WETLAND

Name: Mara Wetland (Kirumi, Masirori and Masurura Swamps)

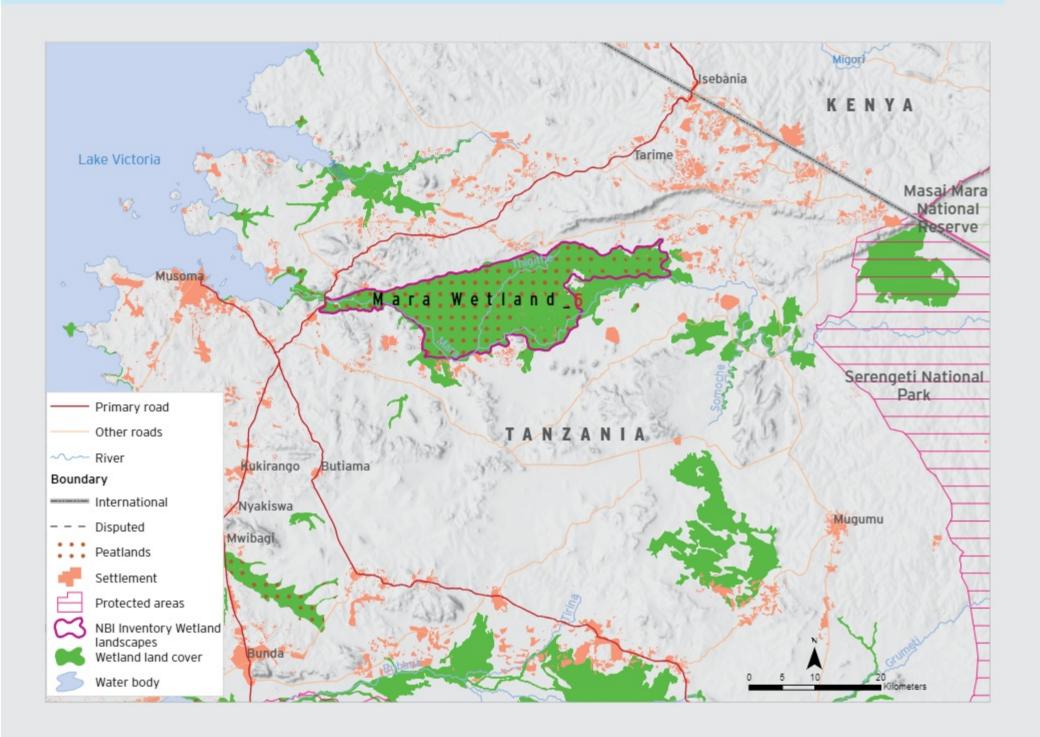
Country: Tanzania

Coordinates: 1°27′ - 1°37′ S / 33°53′ - 34°30′ E

Altitude: 1,135-1,190 m a.s.l.

Area: 405 km² Nearest Towns: Musoma

International Importance: Important Bird Area, Transboundary Wetland



Overview

Mara wetland is located where transboundary Mara River drains into Lake Victoria in Tanzania. Mara River starts in the Mau Forest in Kenya, passing through Mau-Mara and through the plains of the Mara-Serengeti savannah where it reaches Tanzania and finally Mara Wetland. The wetland receives water from both the river and the lake and is dominated by (Cyperus papyrus) and as such one of the largest remaining papyrus swamps in sub-Saharan Africa.

Physical Features

The state of the wetland depends on sufficient allocation of water from the inflow of the Mara River, and its

structure and function is affected by water quality and sediment inflows from the Mara River and from the neighbouring floodplain and subbasins surrounding the wetland. This dryland largely consists of agriculture, pasture and degraded land, with generally dispersed tree and shrub cover. The remaining woodland is more extensive on the northern than southern side of the wetland. The wetland length was measured at about 55 km from the mouth to Lake Victoria to the upper end of the wetland where it receives water from the Mara River. The whole wetland area covers about 40,500 ha. The boundary between the wetland and the fringe is visible nearly everywhere on the satellite images due to the presence of crops around the fringe. The wetland has

a width of 8-13 km in its widest portion, towards the eastern end and over about 35 km, narrowing to 2-3 km for approximately 9 km upstream of the Kirumi Bridge. From the bridge to the exit into Lake Victoria it is 1-1.5 km wide for about 4.5 km. The Mara Wetlands is an extensive swamp dominated by papyrus (Cyperus papyrus), the extent of which fluctuates within and among years. The wetland is adjacent to Lake Victoria and at the lower end of the Mara River. The core of the wetland area is surrounded by a peripheral zone that is seasonally flooded and is within a wider sub-basin of original dryland - mixed woodland.

The wetland is subject to both seasonal and longer-term

fluctuations. Annual long rains throughout the basin are typically mid-March to June with a peak in April, while short rains occur typically from September to December. The downstream part of the wetland is receives water from the lake, especially during low flows. It is not known how far the lake water penetrates the wetland.

The main issue with water quality is a high sediment load entering the wetland from the Mara River. The sediments are mostly trapped in the wetland. Data available from MSc research (Hien, 2011; Laisser, 2011; Tshering, 2011) suggest low concentrations of nitrogen and phosphorus and a neutral pH. There is concern about high faecal coliform contamination by cattle, especially

after rain events.

Biological Features

More than 20 families of plants have been recorded in the wetland (Muruza et al., 2013). The wetland is dominated by Cyperus papyrus, Typha domingensis and Phragmites australis, which are mostly found in monotype form. Other monotype plant species found within the wetlands include Azolla spp., Acacia brevispica, Psidium guajava and Ocimium spp. Together these account for more than 50 % of the plant species recorded in the wetlands.

About 30 species of terrestrial and semi-aquatic mammals have been reported in the swamp at different times, among them are hippo (Hippopotamus amphibious), sitatunga (Tragelaphus spekii), olive baboon (Papio anubis), vervet monkey (Cercopithecus aethiops), bushbuck (Tragelaphus scriptus), wild pig (Potanochoerus lavatus), warthog (Pharcochaerus aethopicus), spotted hyena (Crocuta crocuta), spotted-neck otter (Lutra maulicollis), reedbuck (Redunca redunca), waterbuck (Kobus ellipsiprymus) and topi (Damaliscus lunatus). Nile crocodile (Crocodylus niloticus) is found regularly. Other animals include senene, luba scorpions (Scorpionoidea spp.), grasshoppers (Caelifera spp.), mosquitoes (Culicidae spp.), tsetse flies (Glossina spp.) and butterflies (Rhopalocera spp.).

A total of 226 bird species has been recorded in the Mara Wetlands through surveys conducted by BirdLife in 2016 and 2017. The sighted species are from 58 families, 18 of them water birds. The list includes vulnerable (VU) species i.e. shoebill, woollynecked stork, martial eagle and papyrus yellow warbler. Among the endangered (EN) species are the grey-crowned crane and grey parrot. Near threatened (NT) species include Fischer's lovebird and bateleur. The bird list also has critically endangered (CR) species of white-backed vulture (BirdLife International, 2019).

Munishi (2007) has described the biodiversity of the Mara Wetlands. The dominant vegetation is Cyperus papyrus. About 14 types of fish species are known to exist in the swamp, though at different levels of abundance. Three fish species that are also of great socioeconomic significance to the local communities are catfish (Clarias sp.), African lungfish (Protopterus sp.), and Nile tilapia (Oreochromis nilotica). Others include Schilbe mysteus, Nile perch (Lates niloticus), Cynodontis afrofishery, Rastrineobola argentea (a silver cyprinid species known by its local names as dagaa in Tanzania, omena in Kenya and mukene in Uganda) and Clarius aluwardi.

Ecosystem Services

The Mara Wetlands provide subsistence agriculture, fisheries, construction material, non-timber products (charcoal and firewood), livestock pasture and water. The wetlands support other ecological functions, such as water purification and habitat for a wide array of wetland animals and plants. The rapid economic value of the Mara Wetlands has been estimated to be TSh 6,341 million (USD 5 million) per year (LTS Africa Ltd & Tetra Tech ARD, 2016), with crop agriculture contributing the most, followed by water for commercial use, livestock and fisheries, tourism and non-timber forest products. The total land under cultivation in the Mara Wetlands is 10,340 ha. Among the crops grown are maize, cassava, millet, sorghum and horticultural crops for subsistence, with the surplus being sold at nearby markets. Crop production in the Mara Wetlands has been estimated to be USD 1.39 million/year (LTS Africa Ltd & Tetra Tech ARD, 2016). The livestock population in the wetlands is estimated at more 2 million head, mainly local breeds, which have low production yields (LTS Africa Ltd & Tetra Tech ARD, 2016).

Ninety percent of the population depends on firewood and charcoal as a source of energy for cooking. Most of the firewood and charcoal production is from open woodlands managed by communities or from government forests or open areas under community management. The value of wood-based non-timber products in the Mara is estimated at USD 556,518 (LTS Africa Ltd & Tetra Tech ARD, 2016).

The wetland is an important source of water for the local community with most of the population depending on wells and boreholes but part of the population drawing water directly from the wetland. The total value for domestic water is estimated at USD 555,421 per year. The wetland is also an

important source of water for irrigated agriculture and watering livestock. The total value for water in the Mara was estimated at USD 671,259 based on willingness-topay. The total value of fodder for livestock in the Mara Wetlands was estimated at USD 395,397 per year. Papyrus is one of the important ecosystem services the wetlands provide for people. It is harvested mainly for producing mats, which are mostly sold by women for income. The annual estimates of papyrus in the wetland was estimated at USD 23,008. Honey production also occurs within the wetland, although the industry is not well developed and is mostly carried out in a rudimentary way using traditional hives. Honey production was estimated to be TSh 14.17 million (USD 11,140) per year. Most of the capture fisheries in the Mara Wetlands is artisanal and ends up being sold locally or in Musoma town. The value of capture fisheries in the Mara is estimated at USD 414,393 per year. The wetland has important ecological and hydrological roles such as providing suitable breeding habitat for fish, increasing soil fertility, and sediment trapping. The wetland also acts as a sink for waste and residue and is important for groundwater recharge but it also plays a significant role in carbon sequestration. The estimated value carbon sequestration for the Mara Wetlands is USD 835,989 per year (LTS Africa Ltd & Tetra Tech ARD, 2016).

The Mara Wetlands is a destination for recreation and is important for tourism, game hunting, biodiversity and conservation. The wetland has beautiful scenery, landscapes, species and sites that are of spiritual significance. The wetland also supports research and education and has done so over many decades. The total value of cultural services in the Mara is estimated at TSh 25.04 million (USD 19,688) per year (LTS Africa Ltd & Tetra Tech ARD, 2016).

Management Status

Under Tanzanian law wetlands are classified as state property. Management and protection of wetlands fall under several environmental and land acts. In 2000 Tanzania became a signatory to the Ramsar Convention and although the Mara Wetland is not designated as a formal Ramsar site, its protection and management falls within the National Sustainable Wetlands Management Strategy

under the National Wildlife Policy of 2007. The Mara River is transboundary in nature, and both Kenya and Tanzania are signatories to the Treaty for the Establishment of the East African Community (EAC) and protocols for the Sustainable Development of the Lake Victoria Basin, falling within the auspices of the Lake Victoria Basin Commission (LVBC). At the regional level, the Nile Equatorial Lakes Subsidiary Program (NELSAP), an investment program of the Nile Basin Initiative, has a Mara River Basin Management Unit. The most prominent specific legislation that affects management of the wetlands and surrounding lands are: the Water Resources Management Act (2009); Water Supply and Sanitation Act No. 12 of 2009; National Environmental Management Act (2004); Forest Act (2002); Lands Act (1999); Land Use Planning Act, No. 6 of 2007; Village Act (1999); and Wildlife Conservation Act (2009). The Mara River Transboundary Integrated Natural Resources Management Plan of 2016 (LVBC, 2016) provides a framework for management actions that link the Upper with the Lower Mara.

The Mara Wetlands lies within four political jurisdictions: Butiama, Rorya, Serengeti and Tarime districts; although Butiama covers only a small part of this overall area. While the central Mara regional administration unit for the wetland is in Musoma, local Rural District Councils are also responsible for management of water, agriculture, land and natural resources and community development, including primary and secondary education and public health (Health Protection, Primary Care and Hospitals). The river and northern shores of the wetlands form the boundary between Tarime and Musoma/Serengeti Districts. The border between Serengeti and Musoma district is located between the villages of Wegero and Maji Moto. Altogether 20 villages surround the Mara swamp: in Butiama District Bukabwa, Buswahili, Kirumi, Kitasakwa, Kongoto, Kwisaro, Ryamisanga and Wegero; in Serengeti District, Majimoto, Merenga and Seresere; in Rorya District, Kwibuse, Marasibora and Nyanchabakenye; and in Tarime District, Bisarwi, Kembwi, Nkerege, Nyamerambaro, Surubu and Weigita.

Drivers of Change

Among the main challenges to biodiversity and ecosystem services in Mara Wetlands are the development of the MRB as the basin has been targeted for the development of four dams. Land use and land cover change, mainly due to agricultural expansion, is also leading to increased soil erosion and sedimentation within the basin. The expansion of the Mara Wetlands over the years has been attributed partially to the increasing sediment deposits in the river channel resulting in a growing flood area.

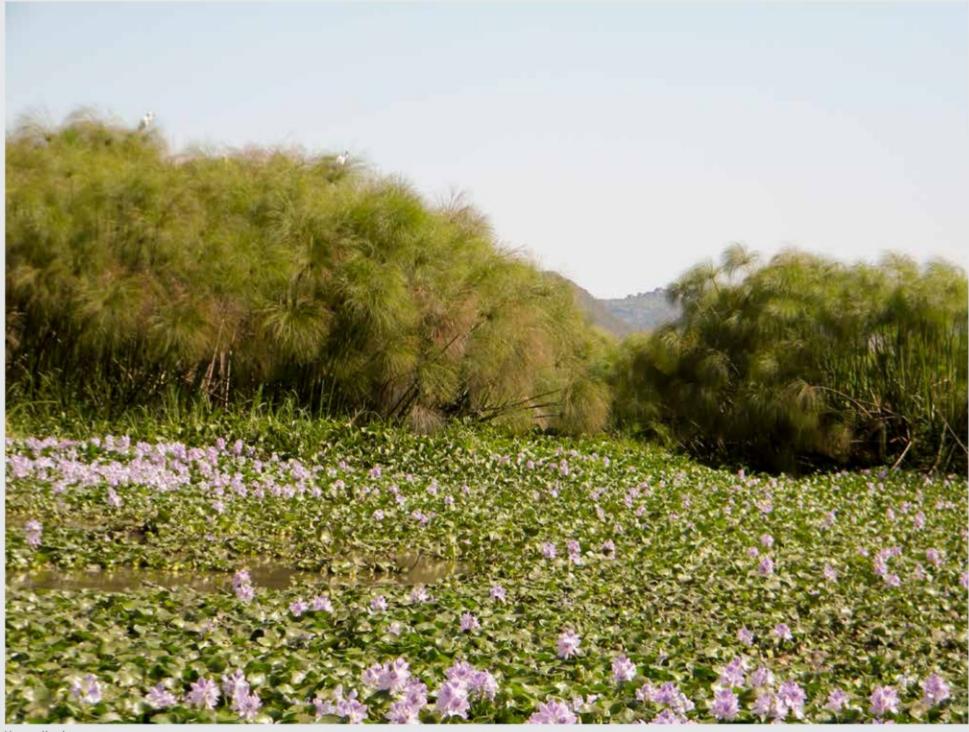
Poor coordination and management of wetland is a threat. The Mara Wetlands lies within the MRB which extends from the Mau Forest in Kenya to Lake Victoria, traversing a complex landscape of different land uses and governed by different legislation in Kenya and Tanzania.

Wetlands are inherently dynamic ecosystems, with high productivity. The rapid regrowth and the density of the papyrus swamp also promotes practices of burning of papyrus to clear access for fishing, or to promote other activities such as entrapment of game. While fires can be widespread, and are frequently visible, it is not clear what impact this has on the ecological character of the wetland.

Fundamental changes to hydrology and increased pollution loading can lead to long-term degradation of wetlands due to pollution. Increased and intense rainfall and evapotranspiration represents the greatest concern for the Mara Wetlands in the face of climate change. This will result in more frequent floods and siltation (Mango et al., 2011). Climate change will aggravate other pressures like deforestation and overgrazing, these pressures through the impacts of increased periodic flooding, soil erosion, silt accumulation, sedimentation and eutrophication, with far-reaching effects that threaten the continued existence of the wetland in its current state.

Change Trajectories

Historical remote sensing images from 1973 to 2000 (Mati et al., 2008; Mutie et al., 2005) show the expansion of the wetland and reductions of shrub and grassland. From 1973 to 2000 the wetland had a conspicuous increase in size, more than a doubling of extent between 1986 and 2015 (LVBC, 2016) and as depicted by the recent comparisons in 2017.



Mara wetlands

THE KAGERA RIVER AND WETLAND SYSTEMS

Overview

The Kagera (Akagera) River, which has its origins in the Congo-Nile ridge in Burundi and Rwanda has the furthest and most remote headstreams of the Lake Victoria Basin. The Kagera has two main tributaries – the Ruvubu and Nyabarongo rivers that come together near Rusumo to form the Kagera (Akagera) River.

The Ruvubu River rises in the north of Burundi, near the town of Kayanza and gets its name from the Kirundi word for hippopotamus (imvubu), because it is home to a large population of hippos. From Kayanza, the Ruvubu River travels through Burundi in a southward arc and is joined by the Ruvyironza River near Gitega. From there it travels northeast, through the Ruvubu National Park, crosses the border into Tanzanian border, and continues traveling in a northeast direction until it meets with the Nyabarongo River on the Tanzania-Rwanda border near Rusumo Falls.

The Nyabarongo begins its course at the confluence of the Mbirurume and Mwogo rivers in the south west of Rwanda. These two rivers themselves begin in the Nyungwe Forest on the Congo-Nile Ridge. From the confluence point, the Nyabarongo flows northward and then changes course to flow southeast wards after meeting the Mukungwa River. About 20 km south of Kigali, the Nyaborongo river meets with the Akanyaru River and soon afterwards the combined rivers meander east and then south through a complex of lakes and wetlands in a flat valley running in a south east direction. The Nyabarongo floods this valley to create a series of permanent wetlands and small open lakes. Lake Mugesera, one of the small lakes, lies on the east bank of the river, and is the largest Rwandan lake in the complex. Lakes Birara and Sake also lie along the left (east) bank of the river. The lakes on the right (west) bank, from north to south, are Gashanga, Kidogo, Rumira, Maravi, Kilimbi, Gaharwa, Rweru and Kanzigiri. (Hughes et al., 1992). Lake Rweru, which mostly lies in Burundi, drains in a northeast direction into the river through a short swampy section. The river that emerges from Lake Rweru is called the Kagera (Akagera). The river forms the border between Rwanda and Tanzania and flows in an easterly direction until it meets

the Ruvubu river near the town of Rusumo. From Rusumo, the combined river flows over Rusumo Falls and continues northwards through Akagera National Park and further north to the border between Rwanda, Uganda and Tanzania. At this point, the river turns to the east, and travels along the Tanzania-Uganda border before crossing into Uganda to discharge into Lake Victoria through a meandering and swamp-covered course.

The Kagera River Basin has many wetlands systems as described above. The main wetlands that will be covered under the Atlas are the following:

- Parc National de la Ruvubu: This national park, which measures 508 km², is the largest park and Ramsar site Burundi. The park is named after the Ruvubu River, which runs through the length of the park. Much of the course of the river is covered by papyrus-dominated swamps. The river and the park are home to a number of waterassociated wildlife species, most notably hippopotamus, Nile crocodile, Cape buffalo, and waterbuck. It also has zebra, numerous duiker species, and five primate species, including olive baboon, vervet monkey, red colobus monkey, blue monkey, and Senegal bushbaby. Approximately 200 species of birds have been recorded in the park.
- Paysage Aquatique Protégé du Nord (the Northern Protected Landscape and Ramsar Site): This landscape, located in the Bugesera region in northern Burundi, and with an area of 162 km2, integrates the management of a number of protected areas, namely the Murehe forest reserve. the managed reserves of Lakes Rwihinda, Rweru and Cyohoha, and the integrated protected zones of Lakes Gacamirinda, Mwungere, Nagitamo, and Kanzigiri. The natural vegetation of the area is characterized by Cyperus papyrus swamps on the fringes of the lakes, and rooted surface floating plants like Nymphaea and Potamogeton. The landscape has been gazetted as a Ramsar site, and some of the lakes have sizable populations of water fowl, some of which is migratory. A total of 49 bird

- species have been recorded in the area, including Pelecanus rufescens, Phalacrocorax africanus, Dendrocygna viduata, etc.
- Akagera Wetland. The Akagera Wetland National park is a narrow strip of wetland that extends along the Rwanda-Tanzania river in a south to north direction following the course of the Akegera River. The wetland, which has an area of 1,002.3 km², is co-dominated by hippo grass (Vossia cuspidata) and papyrus (Cyperus papyrus) but also has small pockets of floodplain forests and swamp forests (Nyayisaba et al., 2017). Small-to medium-sized lakes are located within the wetland on both sides of the frontier. The lakes on the Rwanda side are Mpanga, Cyambwe, Nasho, Ihema, Kivumbu, Hago, Mihindi and Rwanyakizinga, while the lakes on the Tanzanian side are Bisongu, Lwelo, Mujunju, and Rushwa. The wetland marks the periphery of the Akagera National Park and is home to various wild animals, especially hippos, buffaloes, giraffes, topi, impalas, sitatunga and elephants. The wetland is also home to many species of birds, including the rare Shoebill stork (Balaeniceps rex), swamp flycatcher (Muscicapa aquatica), Great white egret (Ardea alba), little egret (Egretta garzetta), papyrus gonalek (Laniarius mufumbiri), yellow-bellied sunbird-asity (Neodrepanis hypoxantha), grey crowned rested crane (Balearica regulorum) and grey heron (Ardea cinerea).
- The Rugezi-Bulera-Ruhondo wetland complex. This system is Rwanda's only Ramsar site. The Rugezi marshes, which are an integral part of this wetland complex, consists of a system codominated by Miscanthidium and Papyrus vegetation. The Rugezi marsh feeds the Burera and Ruhondo lakes. The Ramsar Site is a unique and important ecosystem that hosts endangered species including Grauer's swamp warbler (Bradypterus graueri) and the grey crowned crane (Balearica regulorum),

- and threatened birds including the papyrus yellow warbler (Calamonastides gracilirostris).
- Sango Bay Miziro wetland landscape. Sango Bay-Minziro is a transboundary wetland between Uganda and Tanzania wetland located where River Kagera flows into Lake Victoria. Minziro Forest Reserve, on the Tanzanian side, was gazzeted in 1947 as a nature reserve. It is a groundwater-forest with extensive areas of grasslands, swamps and marshes and is the largest forested area in northwest Tanzania, part of the Guinea-Congo lowland forests. To its north is the contiguous Malabigambo Forest Reserve on the Ugandan side, part of the Sango Bay complex (NELSAP, 2020). In Uganda the landscape consists of seasonally flooded grasslands, scatterings of woodlands and papyrus covered course of the Kagera River.

The above wetland systems are further described in the sections below.

Climate

Three climatic zones characterize the basin (humid, sub-humid and semi-arid). Mean annual temperature is 15–18 upstream and 21–30 downstream. The rain pattern is bi-modal, with long rains occurring during September to January, and shorter rains from March to June. Annual precipitation has a high variation and ranges from over 2000 mm upstream to 800 mm downstream (Wasige et al., 2012).

Biological features

The Kagera Basin lies in the transition between the East and West African vegetation zones and this biogeographical ecotone makes it biodiversity rich. There are 41 taxa within the Kagera Wetlands that have an IUCN threat status of interest. In total there are 28 flagship species for example Balaeniceps rex, Balearica regulorum, Crocodylus niloticus, Cyperus papyrus, Hippopotamus amphibius, Nettapus auritus, Oreochromis esculentus, Oreochromis variabilis and Tragelaphus spekii. Azolla nilotica, Eichhornia crassipes and Pistia stratiotes are important

alien species in the weland group.
Albright et al. (2004) observed, that
lakes closer, or more connected to
the Kagera River are more likely
to experience a more severe water
hyacinth invasion, such as Lake
Mihindi.

The majority of the Kagera wetlands consist of papyrus swamp with many islands of floating vegetation. The Cyperus papyrus (papyrus) grows 4-5 m tall, with an understorey of Cyclosorus interruptus, Ipomoea rubens, Polygonum spp. Echinochloa crus-pavonis, Hydrocotyle ranunculoides, Leersia hexandra, Utricularia inflexa and Vossia cuspidate occur in the water along the outer margins of the papyrus. Miscanthidium violaceum are rooted in the shallower parts of the swamp. There are patches of swamp forest and seasonal floodplains outside of the permanent swamp system. Groves of Phoenix reclinata and thickets of Aeschynomene elaphroxylon, Dissotis incana, Ficus verruculosa and Myrica kandtiana occur on the margins, levees and island shores. Permanent deep water is covered by carpets of floating Lemna paucicosta, Ludwigia stolonifera, Nymphaea caerulea, N. nouchali, Pistia stratiotes and Trapa natans with submerged Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton pectinatus, Utricularia spp. and Vallisneria spiralis (Hughes & Hughes, 1992).

A species rich mammal diversity occurs within the Kagera wetlands. There is the black-and-white colobus monkey and a subspecies of the blue monkey. The endangered Tragelaphus spekii (sitatunga) occurs along with Hippopotamus amphibious (hippotamus), Hippotragus equinus (Roan antelope), Kobus ellipsiprymnus (water buck), Loxodonta africana (African elephant), Panthera paradus (leopard), Redunca arundinum (Southern reedbuck), Sylvicapra grimmia (common duiker), and Syncerus caffer (African buffalo). In addition water turtles (Pelusios), crocodiles, monitors, snakes, otters and rodents also occur within the wetlands (Hughes & Hughes, 1992).

The Bugesera area is known as one of the rare sites in Burundi, where the grey crowned crane (Balearica regulorum) and the endangered Madagascar pond heron (Ardeola idea) are found. Both species are classified as endangered by IUCN, are listed in CITES Appendix II and suffer from increasing pressure on their wetland habitats. The northern lakes are a well-known habitat for migratory birds on their way from Europe to their winter habitats in southern Africa and Asia. (BirdLife International, 2019).

Two of the important fish species found within the Kagera wetlands are Labeo victorianus (critically endangered) and Synodontis ruandae, a fish species endemic to the Akagera River System. Other fish species found include Lates niloticus, Oreochromis niloticus Bagrus docmak, Mastacembelus frenatus, Clarias liocephalus, Marcusenius victoriae, Pollimyrus nigricans. Brycinus jacksonii, Labeo victorianus, Synodontis afrofischeri, Schilbe intermedius, Petrocephaluscatostoma (Hughes & Hughes, 1992).

Ecosystem Services

The main hydrological functions of the Kagera wetlands are water storage, flood control, ground water recharge, and water purification. The marshes in and around the lakes in the Kagera basin act as a natural filtration system for sediments. As water flows to or from the lake systems through thick marshes, water is slowed down and allows sedimentation of suspended solids thereby reducing sediment load into Lake Victoria. Peatland, present in the Rugezi marsh contributes to carbon storing, therefore helps to mitigate climate change.

Communities who live close to the marshes benefit from papyrus which is used to manufacture handicrafts or as firewood, in areas, where wood is rare. Other plants such as Dodonea viscosa or Zanthoxylum chalybeum are valued for their medicinal properties. The lakes are an important drinking water source for local communities and their cattle (Byaruhanga & Kigoolo, 2005b; Ngaboyamahina, 2015; Rufuguta, 2013b).

Beekeeping is a common and profitable activity for the population bordering the thickets and savannahs of Bugesera. Several species are known as melliferous particularly *Erythrina abyssinica*, *Grewia similis*, and various species of Acacia. The branches of certain shrubs help the bee-keepers to install their hives, particularly Lannea schimperi, Erythrina abyssinica and Pappea capensis. In addition, Cyperacea marshes offer extremely appreciated zones of pasture (Rufuguta, 2013b).

Local communities depend on the lakes and wetlands for fishing and farming, part of the Rugezi Wetland and other secondary wetlands are artificially drained and turned to arable land. To allow transportation across the wetland, a number of water channels are kept free from vegetation. The Burera and Ruhondo lakes downstream of the marsh are the main points for hydropower generation in Rwanda (Ngaboyamahina, 2015).

The social and cultural values of the Kagera Wetlands are relatively undocumented. Larger wetlands such as lakes Rwihinda, Burera and Ruhondo have ecotourism potential, especially for birdwatching. Each year 200 to 300 tourists from mainly Bujumbura, Rwanda and Kenya visit Lake Rwihinda for birdwatching (Rufuguta, 2013b).

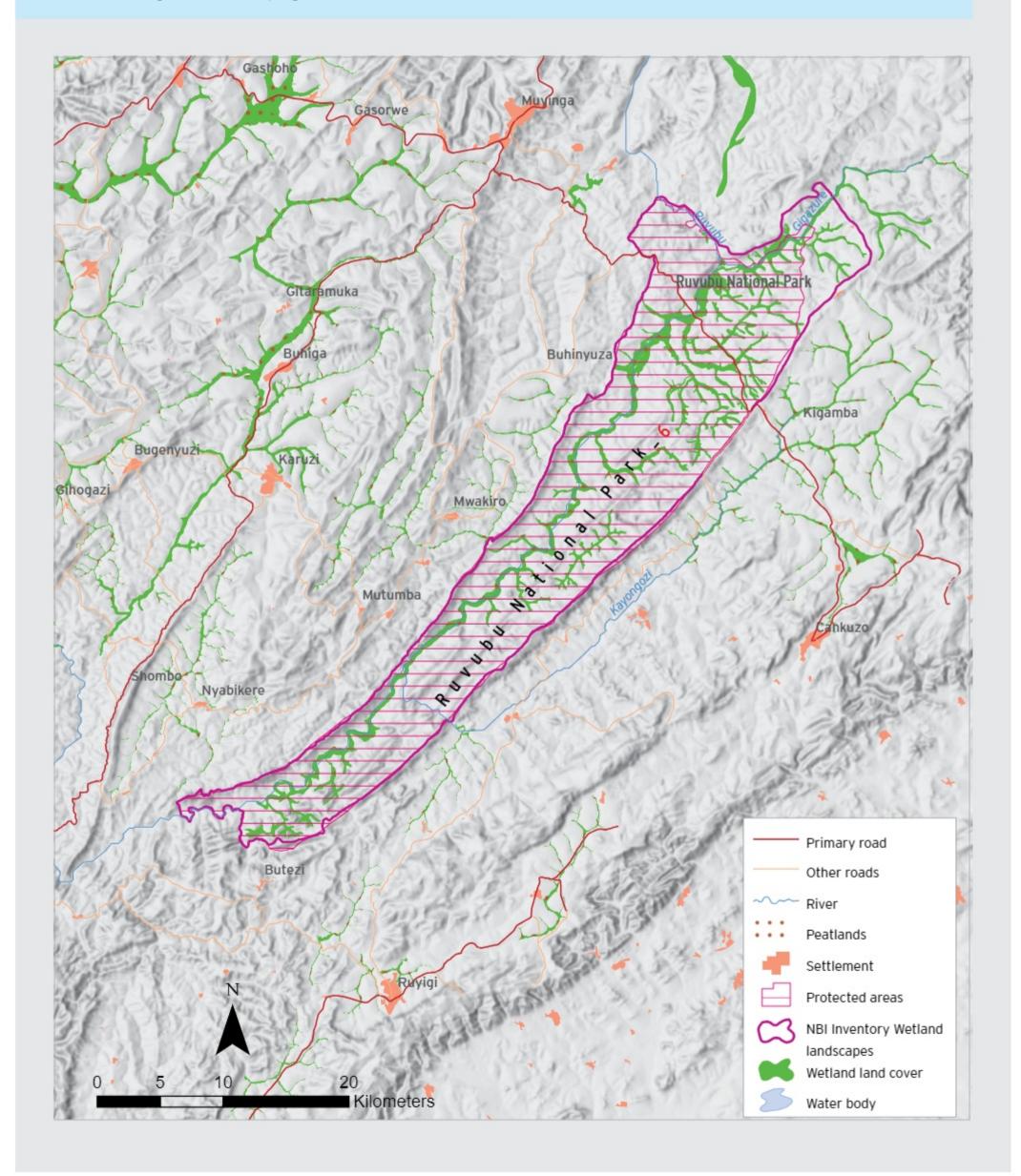
RUVUBU NATIONAL PARK WETLANDS

Name: Ruvubu/ Ruvubu National Park, 'Parc National de la Ruvubu'

Country: Burundi Coordinates: 3°10'S / 30°20'E Altitude: 1,300 – 1,800 m a.s.l.

Area: 576 km²

Nearest Towns: Gitega, Ruyigi, Cankuzo, Muyinga, Karusi International Importance: Ramsar, Important Bird Area



The Ruvubu National Park was established in 1980 and is situated in the North-East of Burundi on the border to Tanzania in the provinces of Karusi, Muyinga, Ruyigi and Cankuzo. Since 2013 the park is a Ramsar site. The park stretches along a 62 km long part of the River Ruvubu and is orientated in south-western to north-eastern direction. The width of the park varies between 5 and 13 km. The park's relief is very contrasting, alternating mountain ranges, hilly areas, deep ravines and small plains. The Ruvubu river valley comprises a series of meanders flanked by swamp vegetation, gallery forest and, further inland, savanna woodland (BirdLife International, 2019; Rufuguta, 2013a).

Physical Features

The river known as Ruvubu has several tributaries. It starts at the confluence of the rivers Karuzi and Ruvyironza and runs northeast, crossing the Ruvubu National Park for 62 km to the Tanzanian border. After a stretch along the border, the Ruvubu crosses into Tanzania, before joining the Nyabarongo River on the Tanzania-Rwanda border near Rusumo Falls, to form the Kagera River.

The Ruvubu watershed includes three quarzitic mountain ranges that are oriented from Northeast to Southwest. Elsewhere, the watershed is dominated by a few hills with rounded tops. In the South, there is a carved relief different from that found more in north. There are also hills with tabular summits or hills.

The Ruvubu River is the southernmost tributary of the Nile and drains more than a quarter of Burundi. It rises in the mountains of the Congo-Nile ridge, and is part of Kagera Basin. It has many meanders and its flow is linked to a fairly even topography between the entrance and the exit of the park. Seasonal variations in the water level are 2 to 3 m. Throughout the Ruvubu River there are small ponds and many tributaries. The valleys of the Ruvubu are largely flooded and occupied by permanent wetlands (Rufuguta, 2013a).

The vegetation in the park is mainly composed of a wooded savannah with Parinari spp. and Pericopsis spp. trees. These small forested strips are distributed along the river or are lining the flooded wetland areas which are dominated by species from the family Cyperaceae.

Management Status

The Ruvubu National Park is under the supervision of the Burundian Ministry of Water, Environment, Territorial Planning, and Town Planning. The direct manager is the National Institute for the Environment and Nature Conservation (INECN), Burundi. Around the park, the land belongs to private individuals. The management of Ruvubu

National Park received strong support under a project entitled "Improvement of Management Effectiveness of Protected Areas of Burundi" financed by UNDP and GEF. The project was focused on (i) the establishment of basic infrastructure and tourist trails, (ii) preparation of management plans, training of game rangers, and initiating income-generating activities for local populations (REMA, 2009; Rufuguta, 2013a).

Drivers of Change

The ecosystem site is under pressure from anthropogenic activities such as game hunting, fishing, exploitation of wood, agriculture in peripheral areas, and collection of medicinal plants (Rufuguta, 2013a).

WETLANDS IN THE PAYSAGE AQUATIQUE PROTÉGÉ DU NORD

Name: Paysage Aquatique Protégé du Nord

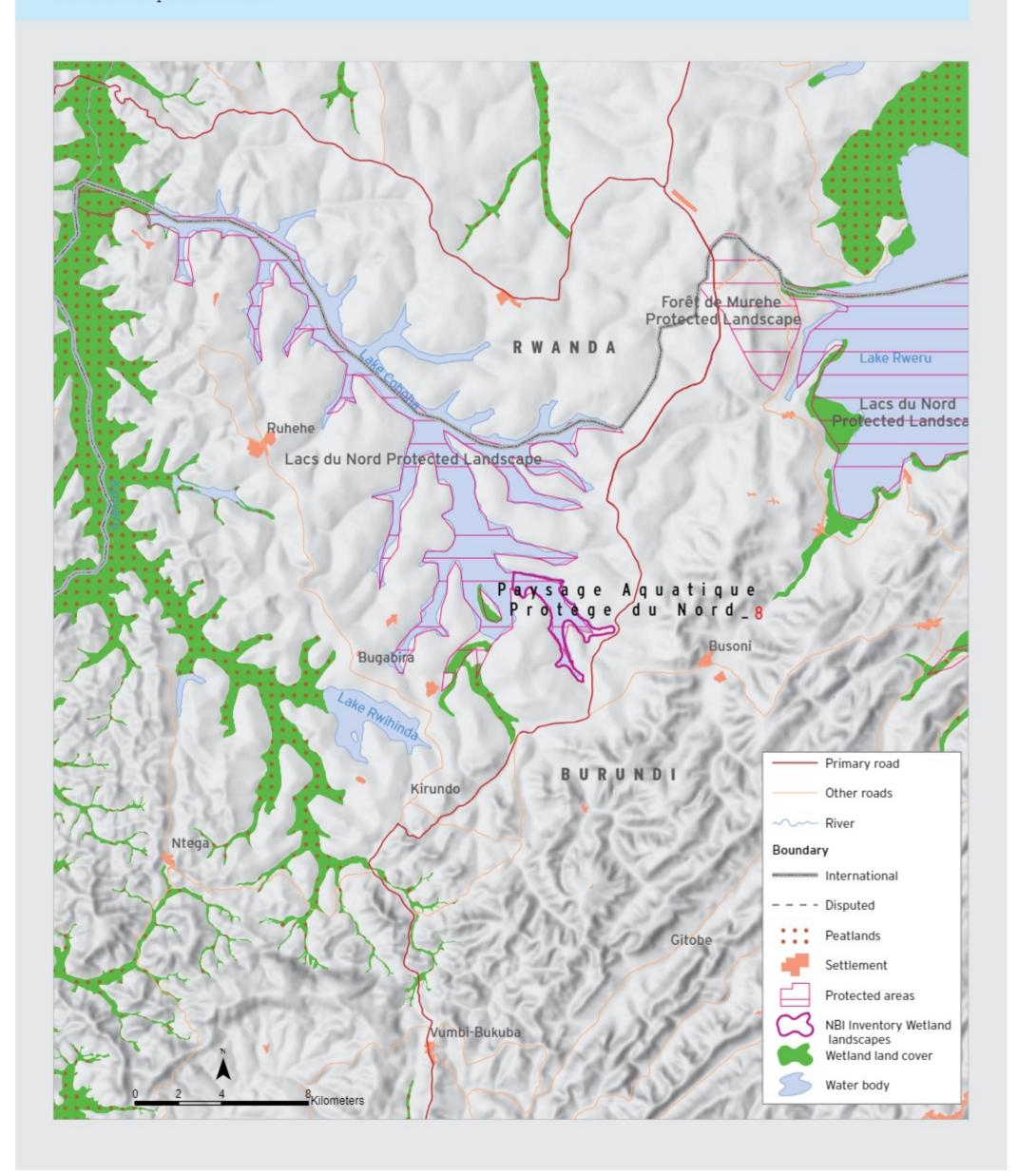
Country: Burundi

Coordinates: 02°34'S - 02°56'S / 29°96'- 30°32' E

Altitude: 1,350-1,500 m a.s.l.

Area: 162 km² area of entire Ramsar site Nearest Towns: Muyinga, Bujumbura, Gitega

International Importance: Ramsar



The Paysage Aquatique Protégé du Nord, a Ramsar site since 2011, includes eight lakes and the Murehe Forest. The wetland complex is situated in the ecoregion Bugesera Depression in the province Kirundo in the north of Burundi, adjacent to the boarder with Rwanda. In the valley bottom, extensive marshes with papyrus are interspersed with several lakes. The Ramsar site is limited to the west by the Akanyaru River, bordering Rwanda.

Some larger wetlands which lie within the Ramsar site are described in more detail below:

> Lake Cohoha South Lake Rwihinda Lake Kanzigiri Lake Rweru

Physical Features

In the eastern part of the Ramsar site, a natural savannah stretches over the hills of Murehe and constitutes the basin of Lake Rweru. In the western part, the swampy valley of the Akanyaru upstream extends over a width of 200 m to 4 km, is 70 km long, and has an estimated area of 200 km². Akanyaru River meanders through the swamp covered with Cyperus papyrus. The tributaries of the lower Akanvaru are surrounded by marshland. A number of elongated secondary valleys contain many lakes within part of the Akanyaru basin. From downstream to upstream, these lakes are: Cohoha (4500 ha), Gacamirindi (250ha),

Gitamo (21 ha), Rwihinda (425 ha), Naruganzi (61 ha) and Mwungere (20 ha). A number of elongated secondary valleys contain many lakes within part of the Akanyaru basin. Lake Naruganzi and Gitamo are part of the Nyavayamo swamps (Rufuguta, 2013b).

The hydrological system of Bugesera is part of the Nile basin and the Kagera sub-basin. Upstream, Bugesera is home to the swampy and lacustrine complex of the Akanyaru, whereas downstream the swampy and lacustrine Nyabarongo-Kagera system occurs. Several secondary valleys are connected to the Akanyaru River through extensive marshlands. These marshes function as barriers that keep water from draining out of these valleys, resulting in the presence of several lakes. During the rainy seasons, the Akanyaru River floods the marshy valleys and lakes extensively. During the dry season and beginning of the following rainy season, water from the lakes is slowly released though the marshland back to the rivers. These marshes are, therefore, important for retaining water used by natural ecosystems and agriculture. The hydrological surplus or deficit influences river flow the following year. The annual water level of the lakes fluctuates between 1 and 1.5 m (in extreme rainfall situations up to 3.5 m) (Nzigidahera, 2007). Hydrologically the wetlands are important for groundwater recharge, flood control, sediment retention and river stabilization.

The Bugesera ecological region is a central granitic basin surrounded by round hills with gentle slopes and broad valleys. The rocks in the area are of Precambrian and belong to the lower Burundian. This area is dominated by folded sediments of the Karagwe-Ankole system and consists of successive layers of politic rock, especially phyllite and argillaceous schist arenaceous rocks like quartzose and quartzites. The hills surrounding the central basin are dominated (left slope of Akanyaru) by a terrazzo-gneissic complex to the west, and quartzitoschistous, also associated with quartzitic ridges, to the south-east. These hard stone outcrops become even more abundant and are more strongly folded downstream of Rwern Lake.

The soils in the hills consist of highly erodible ferralsols, with only a thin humus bearing layer. Alluvial soils are found at the valley bottoms and colluviums on the edges. In the flooded valleys and at the bottom of the lakes, organic soils contain mainly silt and sand. The decomposition of organic matter at the lake bottoms is slow owing to acidic and anaerobic conditions. Hence, peat depositions are formed at the lake and wetland bottoms with organic matter contents of 80 % and higher (Nzigidahera, 2007). The Bugesera Natural Region is characterized by Sudan-Zambian vegetation. The site comprises ecosystems representative of this biogeographic region. The submerged vegetation and fauna are

typical of Equatorial East African Plateaux lakes (Rufuguta, 2013b).

Management Status

The Ramsar site 'Paysage Aquatique Protégé du Nord' belongs to the 'Etat en qualité de patrimoine du domaine privé de l'Etat' which is under the responsibility of the MEEATU and is managed by INECN. A management plan for the 'Paysage Aquatique Protégé du Nord' was developed in September 2009 but is no longer in force.

In the area designated as a Ramsar site, the soils surrounding the lake are used mainly for subsistence farming. Fishing in the lakes is allowed for fisherman with a license. Around the lakes, there is a small buffer zone protecting the lake covered by natural vegetation before the areas reserved for agriculture.

Drivers of Change

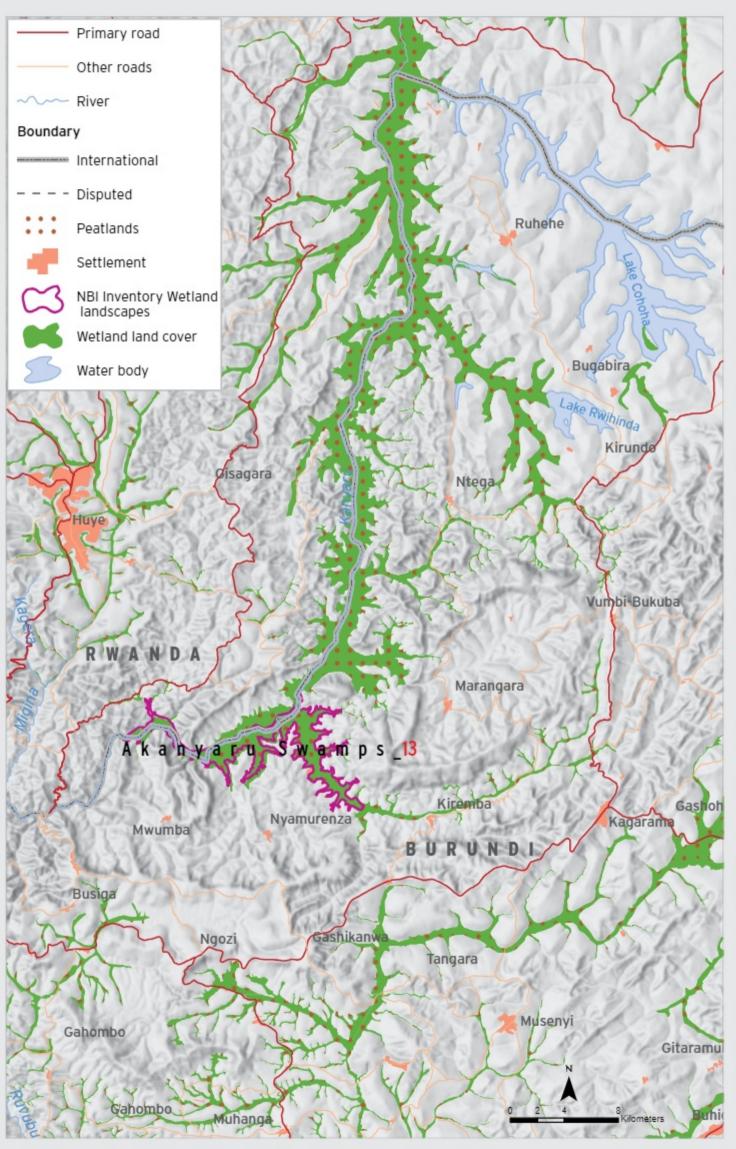
In general the site is threatened by overexploitation and soil erosion from deforestation. The region of Burgesa is relatively dry and regularly subject to drought. Removal of wetland vegetation and drainage increases water stress, since marshes can regulate water residence time and store water (Russi et al., 2013).

AKANYARU SWAMPS

Name: Akanyaru River, Kanyaru River

Country: Burundi/ Rwanda Coordinates: 2°46'S/29°50'E Altitude: 1,350 m a.s.l. Area: 72 km² Nearest Towns: Ngozi

International Importance: Important Bird Area, Transboundary Wetland



Overview

The Akanyaru River is part of the Kagera basin and is the main tributary to the Nyabarongo River. The Akanyaru rises in the western highlands of Rwanda and Burundi at altitudes of about 2,300 m and 2,450 m a.s.l., respectively. In the lower part of the River, in the Bugesera region, the Akanyaru is part of the Ramsar site 'Paysage Aquatique Protégé du Nord'. This Ramsar site includes eight shallow lakes, six of which are in the Akanyaru basin.

Physical Features

The Akanyaru River flows east and then north along the border between Burundi and Rwanda. In its lower course the Akanyaru meanders through a shallow valley, flanked on both banks by permanent swamps, beyond which are seasonally inundated savannas. The swamp belt is most extensive on the Burundi side, especially at the confluences of tributaries. Permanent swamps with an estimated area of 14,600 ha occur along a 63 km long river stretch in Burundi (Hughes & Hughes, 1992).

Drivers of Change

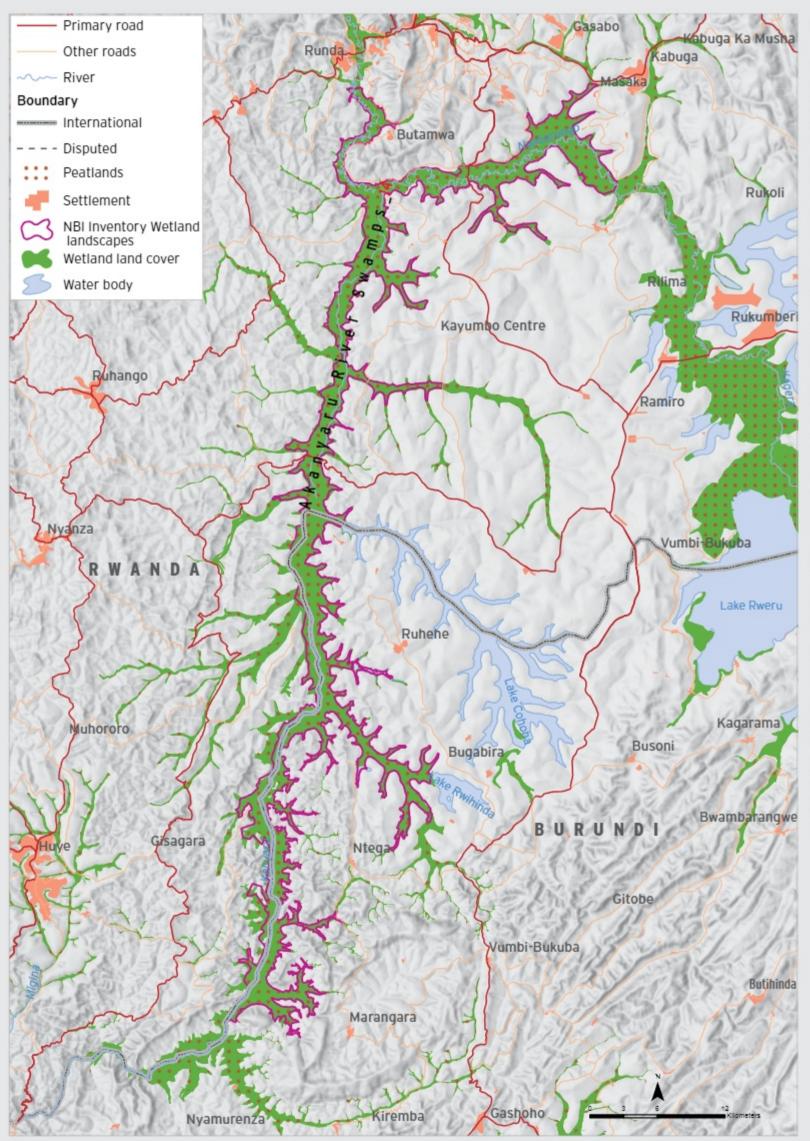
The river and swamps are fished by local communities, and much of the seasonally inundated land is cultivated. Akanyaru wetlands are unprotected and under pressure from drainage for agriculture. Marsh vegetation is cut and burned during the dry season, resulting in progressive habitat degradation. As pasture on the hills is often insufficient, stockbreeders especially in the province of Kirundo move their herds towards the valley and the marshes of the Akanyaru River. Rwanda is currently developing electricity generation from exploitable peat reserves. Since about 77% (Rwanda Energy Group Limited, 2018) of peat reserves are near the Akanyaru and Nyabarongo rivers and the Rwabusoro plains, peat mining is a potential threat to the Akanyaru swamps.

AKANYARU RIVER SWAMPS

Name: Akanyaru River, Kanyaru River

Country: Burundi, Rwanda Coordinates: 2°46′S/29°50′E Altitude: 1,370 m a.s.l. . Area: 267 km² Nearest Towns: Gitarama, Nyanza

International Importance: Important Bird Area, Transboundary Wetland



Overview

The Akanyaru River is part of the Kagera basin and is the main tributary to the Nyabarongo River. The Akanyaru rises in the western highlands of Rwanda and Burundi at altitudes of about 2300 m and 2450 m a.s.l., respectively. It flows east and then north along the border between the two countries. In its lower course, in Rwanda, the Akanyaru River flows sluggishly through a broad belt of permanent swamps, up to 7 km wide and 82 km long immediately above its confluence with the Nyabarongo. The swamps cover some 25 000 ha, of which the lower 7000 ha are in Rwanda. The Akanyaru River descends from 1465 m a.s.l. at the head of the swamps in Burundi (2°47'S/29°50'E), to 1400 m a.s.l. at the confluence with the Nyabarongo (2°05'S/3°01'E) where the swamps end. Upstream of this, in the swamp belt in Rwanda, it receives overspill from the two Cohoha Lakes (north and south) on the right bank (Hughes & Hughes, 1992).

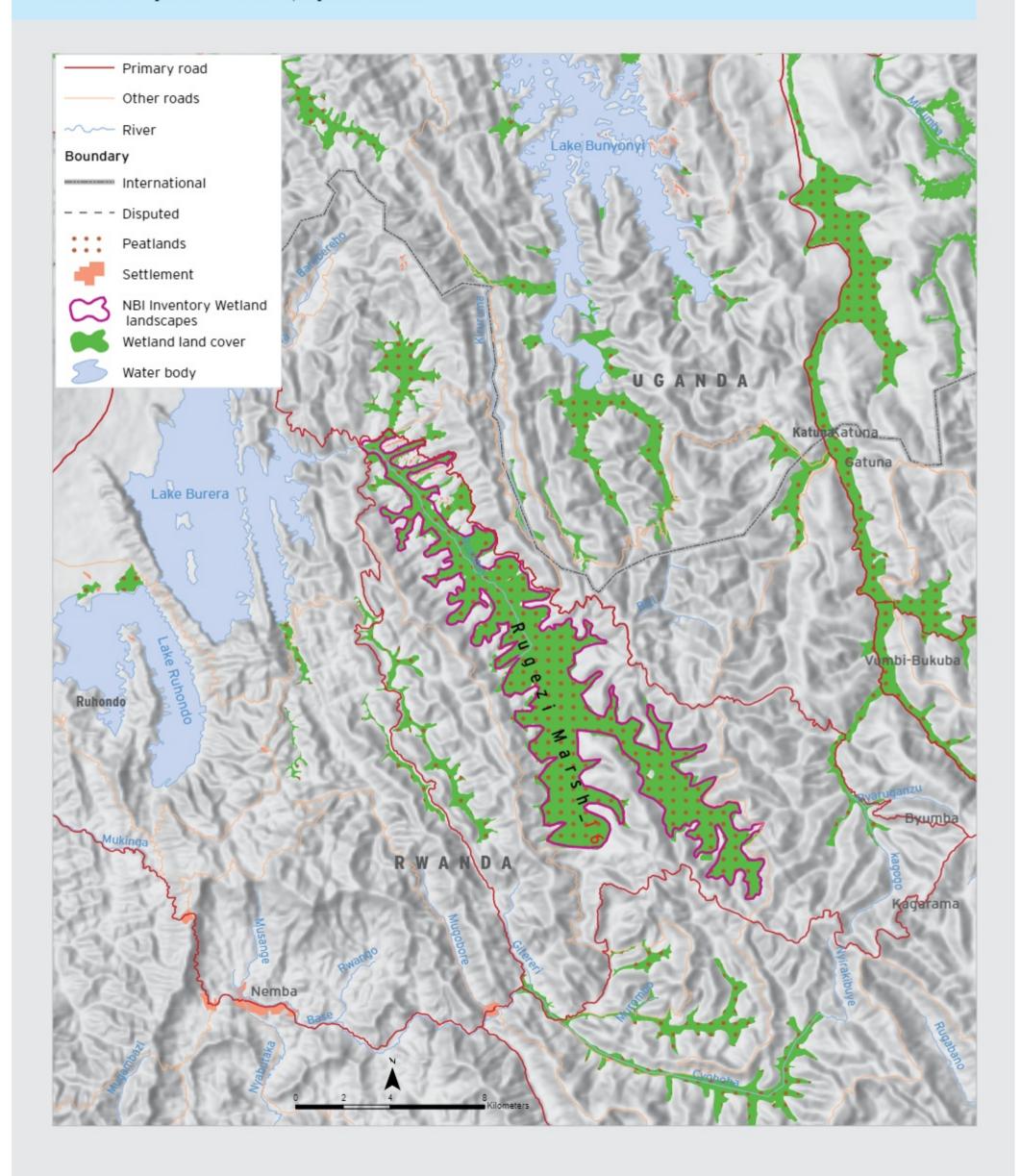
RUGEZI MARSH

Name: Rugezi Marsh Country: Rwanda

Coordinates: 01°21'- 01°36'S / 29°49'- 29°59'

Altitude: 2,050 m a.s.l. Area: 61 km² Nearest Towns: Byumba

International Importance: Ramsar site, Important Bird Area



The Rugezi Marsh is located in an inundated valley in the north of Rwanda to the East of Lake Burera (Bulera) on the border to Uganda. The wetland is one of two high altitude wetlands in Rwanda. The Rugezi Marsh is an important element in the Kagera River System for its services which are important for conservation and the Rwanda's economy. The marsh covers part of an Important Bird Area and was designated a Ramsar site in 2005. The Rugezi Wetland is a good example for Rwandan conservation efforts of wise use and restoration of wetlands. In 2010, Rwanda won the Green Globe Award for the restoration of Rugezi-Burera-Ruhondo wetlands.

Physical Features

The whole swamp is surrounded by quarzitic crests from the upper and middle Burundian (Fischer, 2011). The soils are made of volcanic materials which are mainly composed of mineral soil, poorly drained cambique soils, highly and partly decomposed organic soils which are also poorly drained (Ngaboyamahina, 2015).

The wetland is influenced by a tropical humid climate characterized by a short dry season and heavy monsoonal rains. The Rugezi Marsh lies within the Nyabarongo and Kagera river basin. The biggest tributary to the wetland is the Rwangabavu River, which passes through the wetland and flows into Lake Burera (5.5 km2) and Lake Ruhono (2.8 km²) after the 200 m high Rusumo Falls. The Rugezi Wetland Complex plays a major role in the regulation of water flow to the lakes Burera and Ruhondo. The runoff from this marsh contributes 50% of inflow into Lake Bulera.A number of small streams also provides water to the Rugezi Marsh. In its natural state the Rugezi Marsh forms a dense mat over a floating peat formation in its deeper waters (Hategekimana & Twarabamenye, 2005).

Management Status

The Rugezi wetlands are locally managed by the District of Bura

and Gicumbi. At national level all wetlands are under supervision of Rwandan Ministry of Environment and Natural Resources. Day to day management is responsibility of the Sector and District authorities but overall management is under the jurisdiction of Rwanda Environmental Management Authority. Areas surrounding the wetland are privately owned. The Rugezi Marsh is a designated Ramsar site since 2005 and is listed as an Important Bird Area (BirdLife International, 2019).

Drivers of Change

Wetland exploitation is mainly due to harvesting of plants for animal feeding and construction, especially in the northern part of the valley. Demographic pressure is one of the main causes of anthropogenic degradation of the Rugezi Marsh. Between 1978 and 2000, the population density in the Rugezi basin grew from 337 to 577 inhabitants per km². Due to population increase the steep hillsides and the low hillsides adjacent to the swamp are used for farming. Consequently runoff and

erosion increased of the expenses of infiltration (Hategekimana & Twarabamenye, 2005). This exploitation pattern has changed. According to the local population, plants are no longer cut for various uses, since the area is under protection. Still, paths are cut through the vegetation for means of transportation (Ngaboyamahina, 2015). Water management for hydropower production could be a potential threat to the wetland in the future.

Change Trajectories

Different illegal activities have been noted in Rugezi including grass cutting, and illegal fishing, trade of chicks of the grey crowned crane. In 2003, almost 56% of the swamp was destroyed by agriculture and grazing activities (Hategekimana & Twarabamenye, 2005). In 2005 the wetland was affected by an environmental crisis, related to water level fall and sedimentation. However, in 2010, Rwanda made great efforts to restore the Rugezi wetland (REMA, 2015).

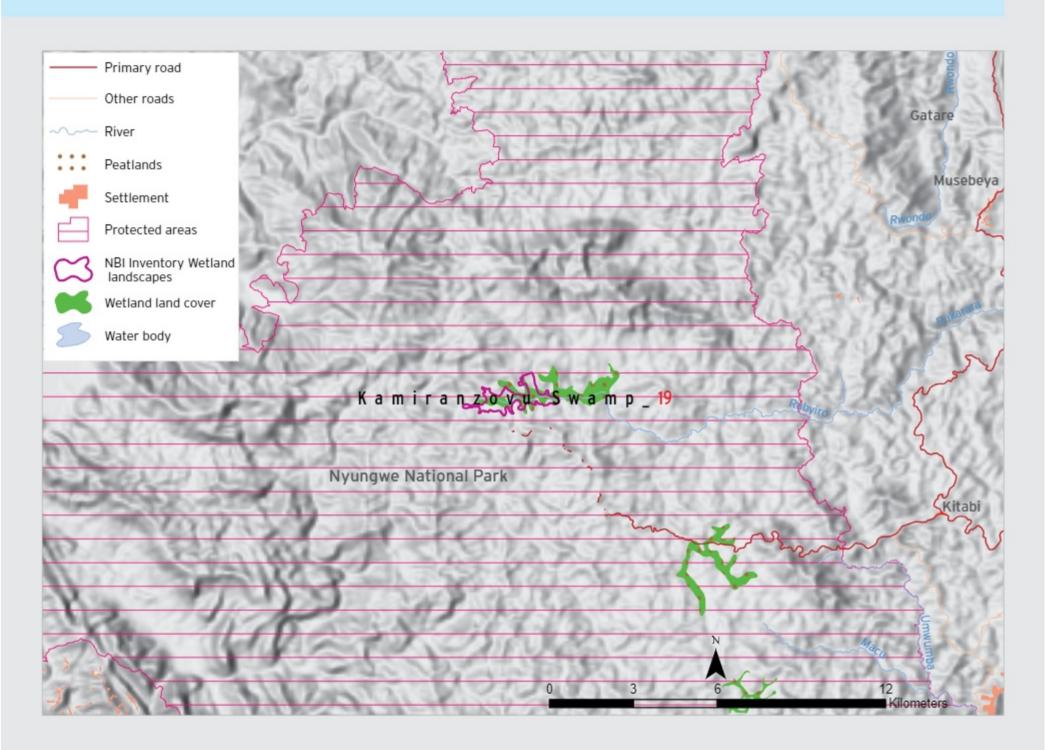
KAMIRANZOVU SWAMP

Name: Kamiranzovu Swamp

Country: Rwanda Coordinates: 2°29 'S/29°15 'E Altitude: 2,300 m a.s.l. Area: 2 km²

Nearest Towns: Gikongoro, Butare

International Importance:



Overview

The Kamiranzovu wetland is a high altitude swamp, situated on the eastern slope of the Congo-Nile watershed. It is protected as part of the Nyungwe National Park and forms the largest peatbog in Continental Africa (Fischer, 2011). The wetland complex lies in an area receiving some 2200 mm rain/year in the Afro-montane vegetation zone on the high dorsal of southern Rwanda. The swamp is an important

natural reservoir near the source of the Lukarara River, a headwater tributary of the Nyabarongo River in the Nile Basin but it is also source of the Kamiranzovu River, which flows into Lake Kivu and the Congo Basin. The swamp is hardly influenced by anthropogenic activities, as it is part of a national park.

Physical Features

The Kamiranzovu Swamp is part of the Nyungwe National Park. The

high altitude wetland hosts distinct flora, especially endemic orchids which are a noteworthy feature of the wetland. Downstream of the swamp there is Kamiranzovu waterfall (Nyungwe Forest National Park, 2019).

The Kamiranzovu River experiences high floods during the rainy season and low flow periods during the dry season. The sediment load of the river is high, before agricultural development, the waters of the streams were very clear. In the 1980 land along the Kamiranzovu River was drained for trial of an agricultural development program. The plan was to establish green beans and ramie agriculture. However, the project failed and the hydraulic conditions were not maintained. The land was turned into plantations of Irish Potatoes, maize and sorghums (Hategekimana & Twarabamenye, 2005).

NYABARONGO WETLANDS

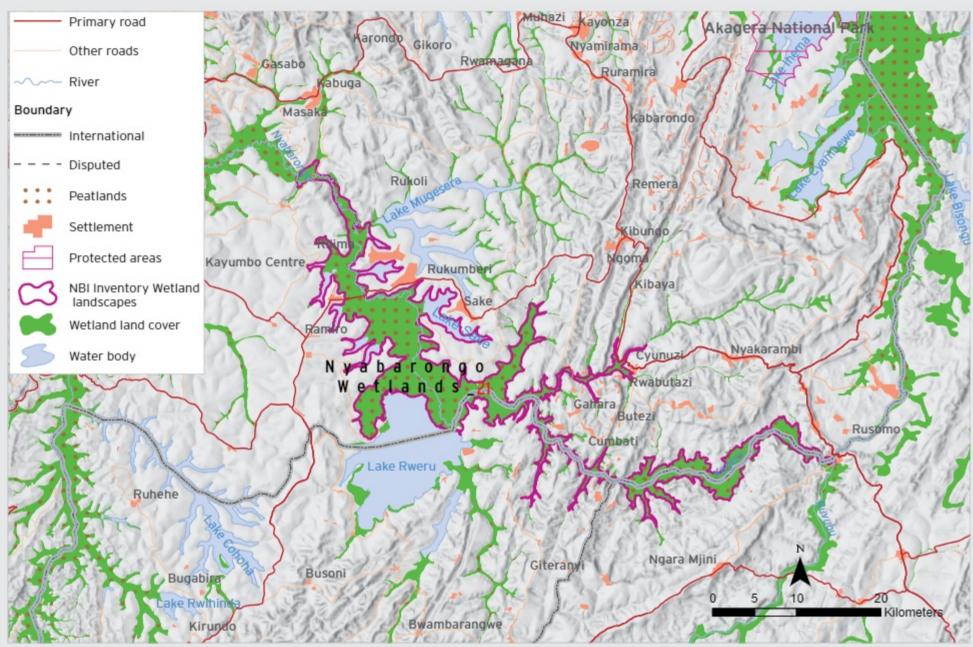
Name: Nyabarongo wetlands

Country: Rwanda

Coordinates: 2°04'-2°28'S/30°12'-30°27'E

Altitude: 1,300 m a.s.l. Area: 340 km² Nearest Towns: Kigali, Kibungu

International Importance: Important Bird Area



Overview

The system occupies the lowest part of a very flat valley, 35 km wide, aligned NNW-SSE. The Nyabarongo River meanders through this, overtopping its banks, filling depressions which contain lakes, and inundating a zone of permanent swamps and a peripheral floodplain. The permanent swamps occupy a central zone up to 14 km wide, but are best developed on the right (west) bank of the river. There are 4 lakes on the left (east) bank: Lake Mugesera, an unnamed lake, and Lakes Birira and Sake. From north to south the right (west) bank lakes are: Lake Gashaga, Murago, Rumira, Milay, Kilimbi, Gaharwa, Rweru and Kazigiri. The latter is situated entirely within Burundi, while Lake Rweru is mostly in Burundi. Flood waters which are not dissipated in the main swamp basin collect back into the Nyabarongo as

it exits Lake Rweru. The river then leaves the south-eastern end of the basin and flows through a narrow swamp belt to a confluence with the Ruvubu River immediately above the Rusumo Falls to form the Kagera River (Hughes & Hughes, 1992).

Physical Features

The Nyabarongo River is Rwanda's longest river and has several sources in southern Rwanda in forested country at 2600 -2750 m a.s.l. The main sources are the Birurume and Lukarara/Mwogo Rivers. Below the confluence of these major headwater tributaries the Nyabarongo flows east, through boggy highland country, before descending to 1500 m and entering a deep and narrow valley oriented N-S. It continues in this valley for 80 km before swinging SE at Muramba (1°43'S/29°36'E). From here it meanders over its narrow

valley floor, receiving overspill from Lake Mohasi. Some 35 km on the Akanyaru River flows in the Nyabarongo on the right bank. Below the Akanyaru/Nyawarungu confluence, the swollen river flows east in a broad valley which soon becomes swampy again. This is where the Mugesera-Rweru Lake/ Swamp Complex begins. The base of the valley, which hosts the swamp complex, is characterized by colluvial soils. The geological base consists mainly of Precambrian granitic and quarzitic rocks (Fischer, 2011).

Drivers of Change

The floor of the high valley of the Nyabarongo is inundated in the wet seasons but is intensively cultivated in the long dry season. There is mining along the river at several points. Swamps in some tributary valleys along the Nyabarongo River's

upper course have been drained, more or less completely, with attendant problems of increased erosion, and decreased soil fertility. Along the swampy middle course, some areas are being used for rice cultivation and many drier sites have been converted for the cultivation of sugar cane. Fischer (2011) observed regular burning of vegetation in the Mugesera-Rweru Swamp Complex. Also invasive plants, especially the water hyacinth Eichhornia crassipes, are a mayor threat to the natural vegetation. The area is not protected. In 2018 BirdLife International classified the Nyabarongo wetlands as an Important Bird and Biodiversity Area in Danger', as the site is under high pressure and in need of immediate action (BirdLife International, 2019).

AKAGERA WETLANDS

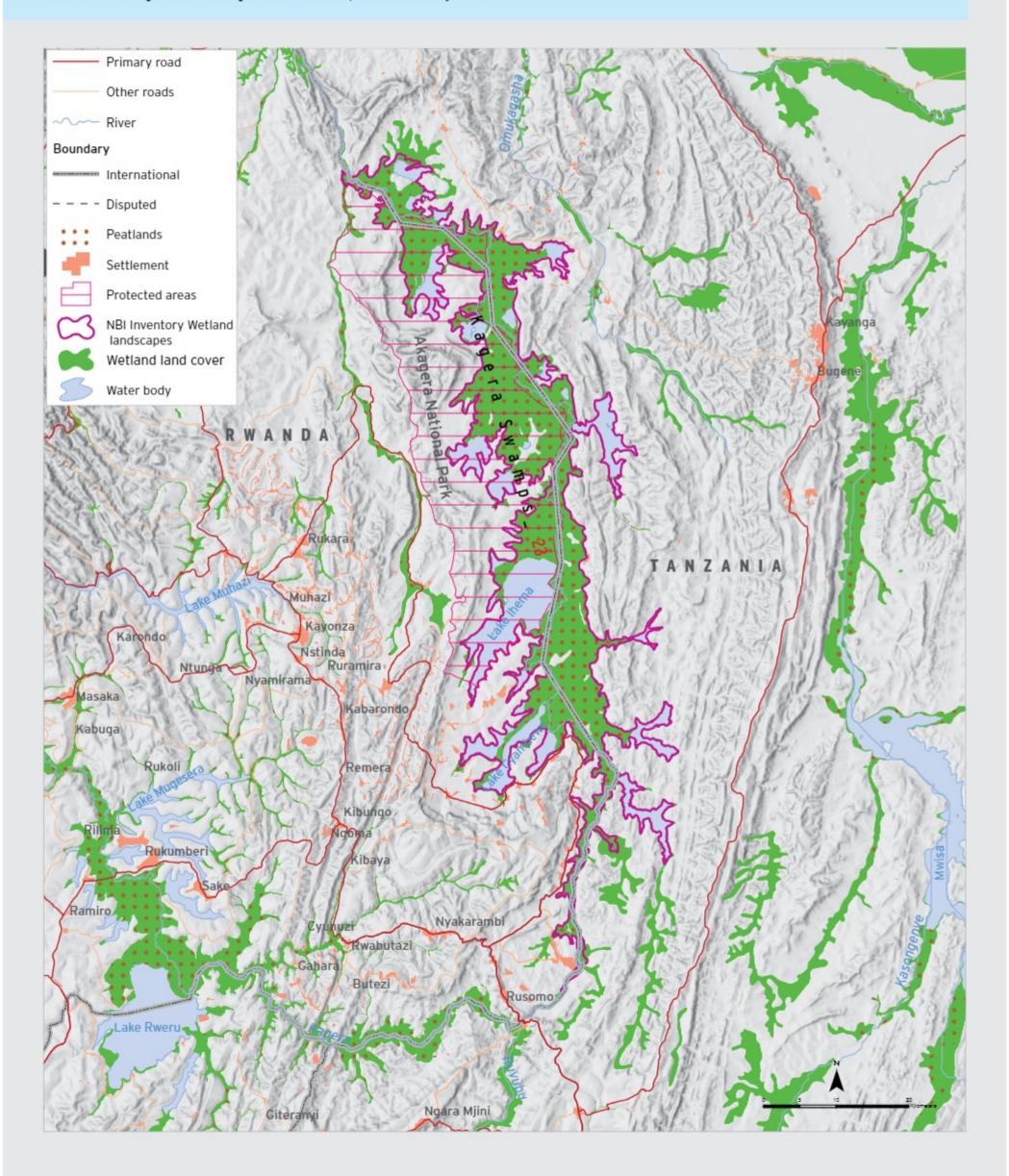
Name: The Kagera Swamps and Lakes (Akagera Wetlands)

Country: Rwanda/Tanzania

Coordinates: 1°19'-2°1 1 'S/30°33'-31°01'E Altitude: 1,270-1,300 m a.s.l. Area: 1,058 km²

Nearest Towns: Kigali, Kibungu

International Importance: : Important Bird Area, Transboundary Wetland



The Kagera Wetland consists of a transboundary network of wetlands along the Kagera River. The wetland lies in on the Rwanda/Tanzania border between two ridges of low rolling hills in N-S direction, downstream of the Rusumo Falls. The Kagera River, which defines the Rwanda/Tanzania border, meanders along the centre of the flat bottomed valley for about 110 km, spilling over to inundate a swamp belt 2-18 km wide. Ndayisaba et al. (2017) delineated the wetland area and estimated a total wetland extend of 1,002 km².

The floodplain is lined on each margin by a series of lakes. Twenty lakes are situated on the eastern bank in Tanzania. These are from north to south, lakes Gwelu, Nyakatale, Nyaruwale, three unnamed lakes, Lubuga, Ishaka, Duko, Kashani, Twamwala, Mujunju, unnamed, Kashanga, Weru Kwa Kalambi, three unnamed, Katabi-Kazinga and Bisongo. The swamp belt is more extensively developed on the western bank, in Rwanda, where there are 21 lakes, and from north to south these are Lakes Ferongo, Rwanye-Kizinga, Mihindi, unnamed, Kishandju, two unnamed, Muhari, Hago, Nkelenhe,

Kivumba, Sekama, five unnamed, Ihema, Rwakibale, Nasho, Rwehikama and Rwampanga. The lakes lie partly in and partly out of the permanent swamp belt. Outside the permanent swamps some are fringed by seasonally inundated savannas. The river descends about 40 m from the foot of the Rusumo Falls to an altitude of 1,270 m a.s.l. at the northern end of the swamp complex. The largest lakes are Ihema (9,100 ha) Lake Mujunju (2,250 ha) and Bisongo (2,000 ha) (Hughes & Huges, 1992).

Physical Features

Many small seasonal streams feed the lakes or swamps directly and flow twice a year, but the bulk of the riverine inflow is provided by the Kagera River, which also rises in response to seasonal rains. Very few of the lakes have permanent connections with the Kagera River, and in the past, the river has changed course and lost connection with some of the lakes. Direct precipitation contributes some 650-900 mm/rain/year, and the water level in the system has an annual amplitude of 1-1.5 m. During the dry season several of the lakes are isolated from the river (NBI, 2009).

Management Status

A part of the Kagera Swamp lies within the Kagera National Park, which has recently been reduced from an area of 2,500 to 1,000 km². The whole Kagera National Park in Rwanda is an Important Bird Area. On the Tanzanian side of the Kagera River an area of 1,116 km² is an Important Bird Area referred to as 'Kagera Swamps' (BirdLife International, 2019).

Drivers of Change

A controlled fishery operates on Lake Ihema but otherwise outside the National Park fishing is uncontrolled and overfishing occurs locally. Fishing in the Kagera National Park is illegal but this fact does not prevent it from occurring. Many channels are cut through vegetation by local fishermen to connect the lakes with the river. In Tanzania the hills next to the swamps are extensively cultivated but within Rwanda these hills are within the Kagera National Park. Even though human activities are limited in the National Park still some anthropogenic activities occur and continue to exacerbate pressure on the swamps, notably agriculture, cattle grazing, production of loam

bricks, and the cutting of plants for animal feeding and construction purposes, especially at swamp edges (Fischer, 2011). future.

Change Trajectories

Notable changes have occurred in the shoreline of Lake Mihindi and Lake Ihema since the early 1990s. These changes coincide with the invasion of Eichhornia crassipes in the region. Water hyacinth infestation is more prevalent in regions lying in the closest vicinity of the river Kagera. The surface area of Lake Rwanyakizinga, which is more distant from the Kagera River, remained relatively stable since 1987, even slightly increased from 1999 to 2015. Lake Ihema's surface area considerably increased between 1994 and 1999, before shrinking to its lowest level (8855 ha) in 2010. Lake Mihindi dramatically shrank from the 1987 extent to its lowest level in 1994, while Lake Kivumba slightly declined between 1999 and 2005, losing about 100 ha. Lake Hago did not significantly change between 1987 and 2010, except for the period of 5 years between 2010 and 2015, when the area of the lake considerably increased by nearly 150 ha (Ndayisaba et al., 2017).

LAKE MBURO-NAKIVALI SYSTEM

Lake Mburo-Nakivali Wetland System (The Kijanebalola Lake/Swamp Complex) Name:

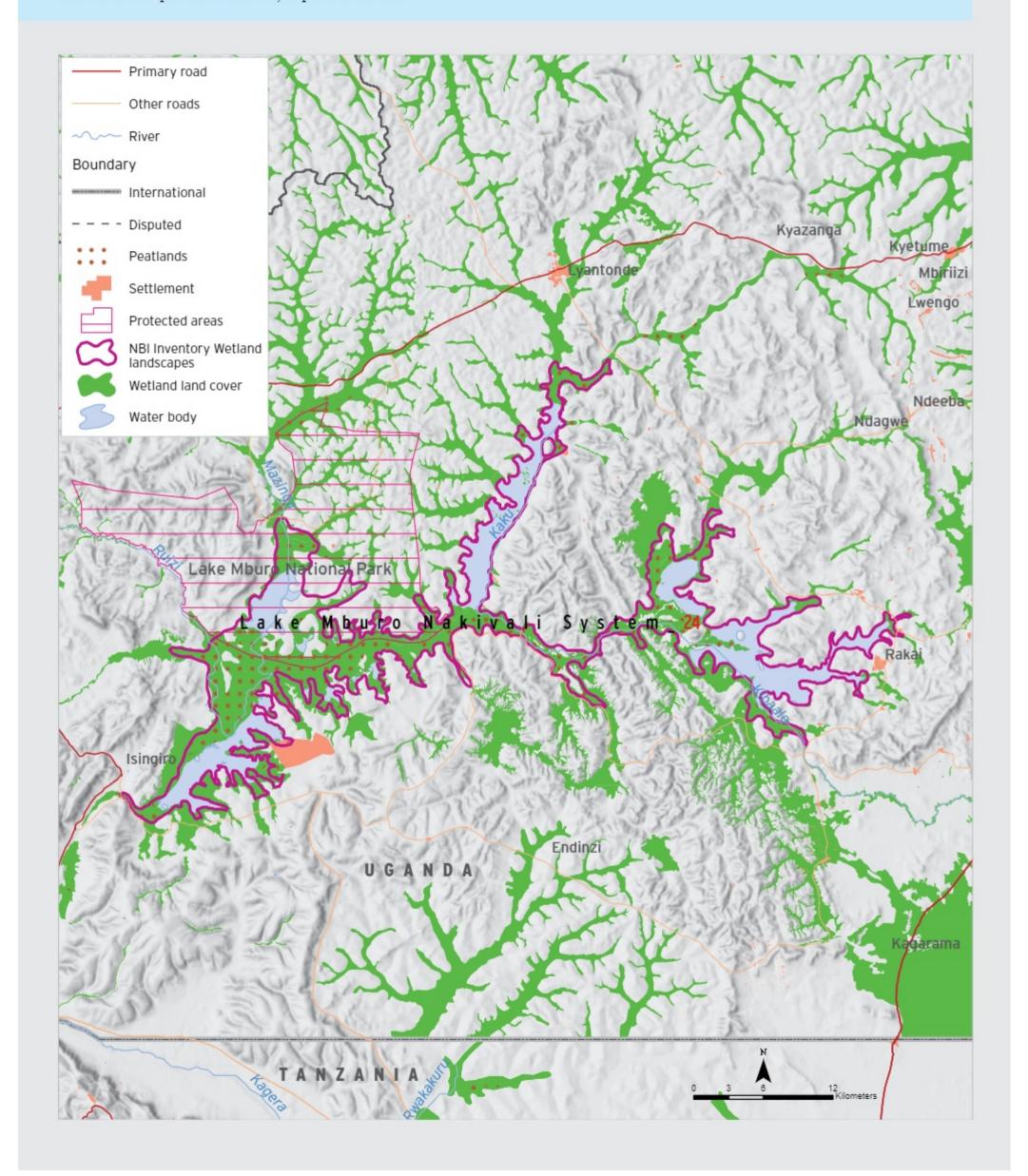
Country: Uganda

1°10 ' -1°34 'N / 0°50 '-31°25 'E 5 1,226-1,250 m a.s.l. Coordinates:

Altitude:

369 km² Area: Nearest Towns: Mbarara

International Importance: Ramsar, Important Bird Area



The Lake Mburo-Nakivali wetland system lies in the south-western part of the Mbarara District in south central Uganda close to the borders with Tanzania and Rwanda. Most of the wetland system lies within the Mburo-Nakivali National Park which includes open and wooded savanna, seasonal and permanent wetlands and several lakes. The system is in the convergence zone of two biogeographical zones, the Lake Victoria regional mosaic and the Guinea-Congolian biogeographic region, therefore it hosts a high diversity of animals and plants. Most of the wetland system lies in the National Park, which was gazetted in 1982. Lake Nakivali and the surrounding swamps in the sub counties of Rugaaga, Kashumba, Ngarama and Kabingo lie outside the national park.

Physical Features

The Nakivali-Lake Mburo wetlands system are part of the Ruizi-Bukora River System, which neighbours the Kagera River system. The central swamp occupies a tract of land 44 km long and up to 15 km wide, covering 15,000 ha. The principal affluent of this lake/wetland complex is the Ruizi River, which rises from a headwater swamp (0°46'S/30°11'E) and flows eastwards to a central swamp (0°32'-0°45'S/30°51'-31°16'E) that is oriented E-W. There are a number of lakes, situated at the ends of valleys connected to a central swamp. The largest lakes from west to east are Lake Nakivali, Mburo, Kachira and Kijanebalola. Other small lakes also from W-E are Lakes Kiretwa, Kasasa, Mutukura, Kazuma, Mishera, Ruma, Karitima, Bwara and Karunga (Hughes & Hughes, 1992).

The swamp drains from Lake Kijanebalola at the eastern end of the system to Lake Victoria via the Kibale River which reaches the lake in an extensive swamp at Sango Bay north of the mouth of the Kagera River. Lake Nakivali is 14 km long and 3 km wide, and has an area of 3,080 ha at high water, when the maximum depth is 3.5 m. Lake Mbura to the north is 6.2 km long and 3 km wide at maximum and has a mean area of 1190 ha at high water. Lake Kachira is the largest lake 22.8 km long and up to 3.4 km wide with a maximum depth of 4.1 m. It has an area of 3,960 ha. However, Lake Kajanebalola is the best known lake of the complex. It is 17 km long and up to 4.3 km wide and has a maximum depth of 4.8 m. It contains two large islands at its western end (Byaruhanga & Kigoolo, 2005b).

Pre-Cambrian rocks underlie Lake Mburo wetland system. The rocks comprise a mixture of Cenozoic Pleistocene to Recent rocks, wholly granitized Granitoid and highly granitized rocks, and Karagwe — Ankolean system. Argillite rocks predominate but are more arenites and silty rocks, which are regularly, distributed as thin bands throughout the system. The system is predominated by ferrallitic soils which are mainly sandy loams and sandy clay loams (Byaruhanga & Kigoolo, 2005b).

All these lakes are areas of open water in an extensive papyrus swamp. The main inflow is the Ruizi River from the west, which has a common headwater swamp with the River Ntungwe, which flows to Lake Edward. The main outflow is the River Kibali, which flows into Lake Victoria. The major outlet of Lake Kijjanebarora is the Kibale River.

It is much the same depth all over and when the water level is high it overflows into the Kibale River. This happens about every 12 years and in between such times it has no outlet (Byaruhanga & Kigoolo, 2005b).

The system is in the convergence zone of two biogeographical zones, the Lake Victoria regional mosaic and the Guinea-Congolian biogeographic region. Hence it contains the Lake Victoria dry woodlands restricted range species and the Lake Victoria basin biome species. The predominant vegetation is mainly the wooded Savanna with Acacia / Commiphora thicket and grasslands. The wetland complex is surrounded by savanna grasslands but inter connected by aquatic grass and herb swamp (Byaruhanga & Kigoolo, 2005b).

Management Status

According to the 1995 Constitution, the Government of Uganda holds wetlands in trust for the people. Therefore the government owns Lake Mburo wetlands system. Land in the surrounding areas is under customary ownership. The rest of the system lies on public land. The whole area including Lake Nakivali and the surrounding swamps, which lie outside of the swamps, was declared a Ramsar site in 2005. Uganda Wildlife Authority established a community conservation department whose activities among others are to educate the local communities about conservation issues. The community conservation department of Lake Mburo National Park established an education centre at Minenkve where the Park's headquarters are located (Byaruhanga & Kigoolo, 2005b).

Drivers of Change

Formerly well drained hillsides and low lying hilltops were very open and provided grazing areas for cattle and wildlife. Overgrazing and burning of these areas has led to a widespread establishment of Acacia hockii. Hunting and habitat destruction through cultivation and settlement has led to a reduction in diversity of large mammals such as elephants, black rhinos, lions and roan antelope. Fish stocks in the lakes are threatened by overexploitation. There are ongoing animosities between local communities over grazing and water. Transformation of the wetter parts of the area into farmland is also a potential threat and settlement schemes have also been established on the fringes of the park (Byaruhanga & Kigoolo, 2005b).

Change Trajectories

The Lake Mburo National Park was formerly a Game Reserve, where 241 families, with their cattle herds, resided. There used to be conflict of settlements in the park, which was resolved during the 1990's when the Ranches Restructuring Board resettled the landless pastoralists. The settlement of the landless saw the park reduced by over 50% of its former size (Byaruhanga & Kigoolo, 2005b). The area size did not significantly change between 1987 and 2010, except for the period of 5 years between 2010 and 2015, when the area of the lake considerably increased by nearly 150 ha (Ndayisaba et al., 2017).

SANGO BAY-MUSAMBWA ISLANDS

Name: Sango Bay-Musambwa Islands-Kagera Wetland System (SAMUKA)

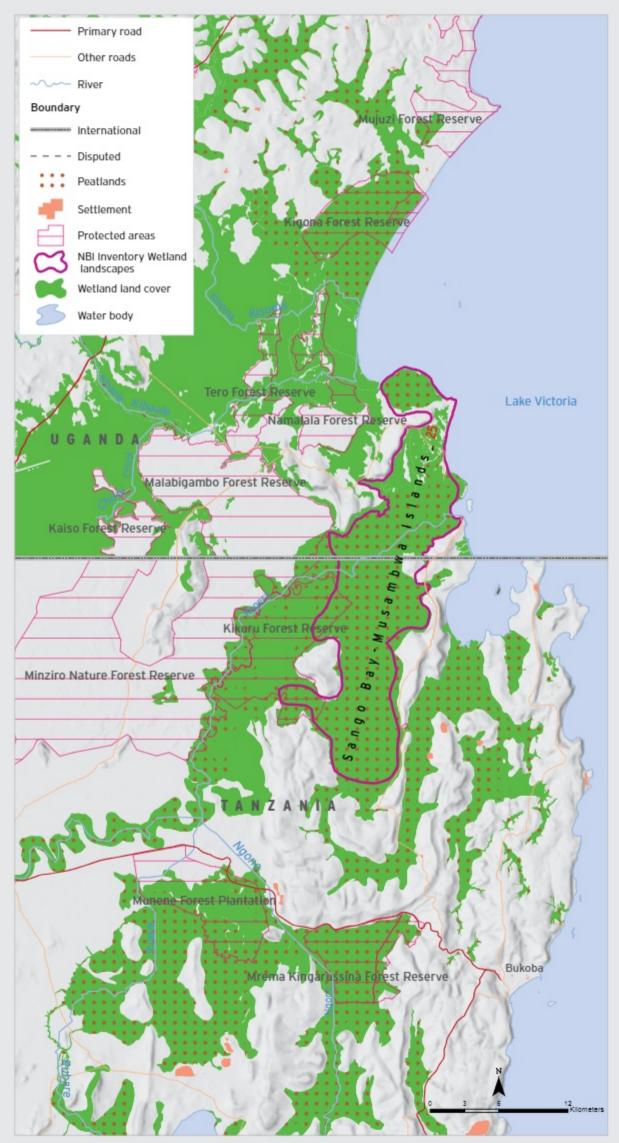
Country: Uganda

Coordinates: 0°59' - 00°49'S / 31°39' - 31°52'E

Altitude: 1,130 – 1,190 m a.s.l.

Area: 222 km² Nearest Towns: Masaka, Bukoba

International Importance: Ramsar, Important Bird Area



Overview

The Sango Bay-Musambwa Island Kagera Wetland System (SAMUKA) is a complex comprises of three wetland systems: (a) the Kagera River wetlands from the point the Kagera river cross the Tanzania-Uganda border to its delta at Kasensero; (b) the wetlands fringing Sango Bay, which is found on the western shoreline of Lake Victoria; and (C) Musambwa Island, which is located 3 km off the shoreline of Sango Bay.

The SAMUKA complex covers part of the sub-counties of Kyebe, Kakumiro, Kasasa and Kabira in Kyotera district, and Kyanamukaka in Masaka district.

Physical Features

The SAMUKA complex covers two Important Bird Areas (Sango Bay Complex and Musambwa Islands). Sango Bay Musambwa Islands consists of three rocky islets, about 3 km offshore in the Sango Bay. The largest is about 5 ha and the next about 3 ha (these are locally known as ennene (large) and entono (small). The smallest island is just a rocky outcrop jutting out of the lake. The shoreline has no fringing swamp or sandy beaches (Byaruhanga & Kigoolo, 2005i).

The area includes the forest reserves of Kigona, Kaiso, Tero, Namalala and Malabigambo. The Sango Bay forests are rather homogenous in nature and the biggest section can be broadly classified as swamp forest. The area is considered to be of biogeographic interest because it lies in the transition between the East and West African vegetation zones and this biogeographical ecotone makes it biodiversity rich. Malabigambo Forest and Kaiso Wetlands are contiguous with the Minziro Forest Wetlands of neighbouring Tanzania and important as an international cross-border management site. The site contains a mosaic of wetland types. Malabigambo Forest is contiguous with Kagera wetland and floodplain. The Sango Bay Wetlands are extensive, stretching along a varied shoreline consisting of sandy shores, rocky shores, forest shores, and the fishing villages. Large portions of the seasonal swamp forests are included within the six forest reserves. The Rakai District forest offices manage these forest reserves (Byaruhanga & Kigoolo, 2005i).

Lacustrine coastal processes during the quaternary dominate the Sango Bay area. The soils consist of lacustrine deposits and fluvial sediments from Pleistocene and Holocene formations and belong to the Sango series, covering the shoreline of Lake Victoria a. The Sango soils occupy 70 – 80 % of the shore plain west of Lake Victoria. They are grey coarse sands or loamy sands some 1.5 – 3 m thick, or more, with gravel from river alluvium, grey clays from the lake deposits and pebbles in the horizons. The topsoil contains low organic matter and is generally acidic limiting nutrient uptake by plants (Byaruhanga & Kigoolo, 2005i).

LAKE VICTORIA SHORELINE WETLANDS

Overview

In the official wetland definition by Ramsar, water bodies shallower than 6 m at low tide are considered wetlands. Even though Lake Victoria has an average depth of 40 m, its shallow shoreline hosts extensive wetlands. These wetlands are influenced by the fluctuations in lake water level or by both, lake and river hydrology.

Climate

The climate in the LVB is equatorial hot and humid with long rains from March to May and short rains from October to December. However, rainfall varies considerably from one part of the basin to another. Seasonal winds influence hydrological processes in the basin. During January and February and from June to September dry winds from the east cross the Lake parallel to the equator. On their way across Lake Victoria these winds pick up moisture, which is deposited in the western part of the catchment, especially in the Bukora Catchment in Uganda (LVBC, 2017)

Biological Features

There are 169 taxa within the Lake Victoria Basin that have an IUCN threat status of interest. In total there are 37 flagship species for example Aonyx capensis, Balaeniceps rex, Balearica regulorum, Crocodylus niloticus, Cyperus papyrus, Hippopotamus amphibius, Nettapus auritus, Oreochromis esculentus, Oreochromis variabilis and Tragelaphus spekiii. Azolla nilotica, Eichhornia crassipes, Eucalyptus, Lates niloticus Poecilia reticulate and Pistia stratiotes are important alien species in the Lake Victoria Shoreline Wetlands.

Lake Victoria Basin can be divided into two habitat areas namely terrestrial and freshwater. Trees and grasses grow on the seasonal floodplains with stands of *Acacia* (Vachellia). Key mammals found around Lake Victoria and its
wetlands include hippopotamus,
African clawless otter, spottednecked otter, marsh mongoose,
sitatunga, bohor reedbuck, defassa
waterbuck, cane rats, and giant
otter shrews. The area has a large
population of Nile crocodiles,
African helmeted turtles, various
mud turtles and endemic to the area
is Williams' mud turtle.

Wetlands, particularly papyrus swamps, are a prominent feature of the marginal zones of Lake Victoria in Uganda. In Lake Victoria various aquatic macrophytes extending from land to a water depth of 1 to 2 m are subjected to wave action and water level variations. The distance from the shore varies from 20-50 m on rocky shores to 100-200 m in sheltered bays and over sandy beaches. The swamp areas typically have Cyperus papyrus (Papyrus), Phragmites (Reeds), Typha (Bullrush) and Vossia (Hippo grass) (Balirwa, 1995). The invasive floating plant water hyacinth (Eichhornia crassipes) can be found in all shoreline wetlands of Lake Victoria. However, extend of water hyacinth mats varies between shorelines, as Ugandan and Kenyan shores are more severely infested by water hyacinth, than the southern, Tanzanian shoreline (Albright et al., 2004).

Several microalgae species such as Oscillatoria, Microcystis, Aulacoseira, Nitszchia, Melosira and Pediastrum are frequently encountered in the food items of detritivorous and phytoplanktivorous cichlids in Lake Victoria. Excessive algal proliferation may cause death to a number of aquatic animals either due to lack of oxygen or from toxins (Balirwa, 1995).

The original fish community of Lake Victoria had 300 species, mostly haplochromine cichlids and 14 cyprinids. By the 1950's target species (especially Oreochromis esculentus, Oreochromis variabilis and Labeo victorianus) numbers had drastically declined due to over fishing and modernisation of techniques. Several tilapias (Oreochromis niloticus, O. leucostictus and Talapia zillii) and a predator the Nile perch (Lates niloticus) were introduced to boost the fisheries which led to a drastic reduction in the fish species diversity, particularly of the haplochromine cichlids. Lake Victoria fisheries are presently based on three species: a small native pelagic cyprinid Rastrineobola argentea, the introduced Lates niloticus and Oreochromis niloticus (Balirwa, 1995).

Ecosystem services

The Lake Victoria wetlands provide food for the people living within these wetlands in the form of fish, fruits, vegetables, grains, and game, as well as indirectly by providing farmland and fodder for livestock. People also obtain raw materials for handcrafts or construction work, as well as medicinal products (Kakuru et al. 2013). Further, Kakuru et al. (2013) estimate the values of these provisioning services for some agroecosystems in the Uganda side of Lake Victoria. Fish spawning was valued at an approximate 363,815 US\$/year, water for domestic use at 34 million US\$/year, and livestock pastures at 4.24 million US\$/year (Kakuru et al., 2013).

The open water areas are also employed for commercial and non-commercial transportation (Kulindwa, 2006). There is management and distribution of wild honeycombs within the local communities for the extraction of honey, mostly for subsistence consumption although commercial production also takes place (Kakuru et al., 2013; Kipkoech et al., 2011; Langat & Chebwoiwo, 2002; Okwi, 2010).

Although still little understood, regulating services are amongst the most important ones (Simonit & Perrings, 2011). Flood control was estimated by Kakuru et al. (2013) at approximately 1.7 billion US\$/year, and water regulation and recharge at 7.1 million US\$/year for several Ugandan wetlands within the Lake Victoria.

In the last decades, protected areas have been established to protect other supporting services like biodiversity, its habitats, and genetic processes (Börner et al., 2009). Some examples are the Kakamega forest, Bujagali Falls Recreational Park and the Serengeti. This also provides recreation areas for local and international tourism, which add an important and valuable service for the local economy. For example, Bujagali Falls Recreational Park has been estimated to have a capital value of 1.3 million US\$ (Buyinza et al., 2007).

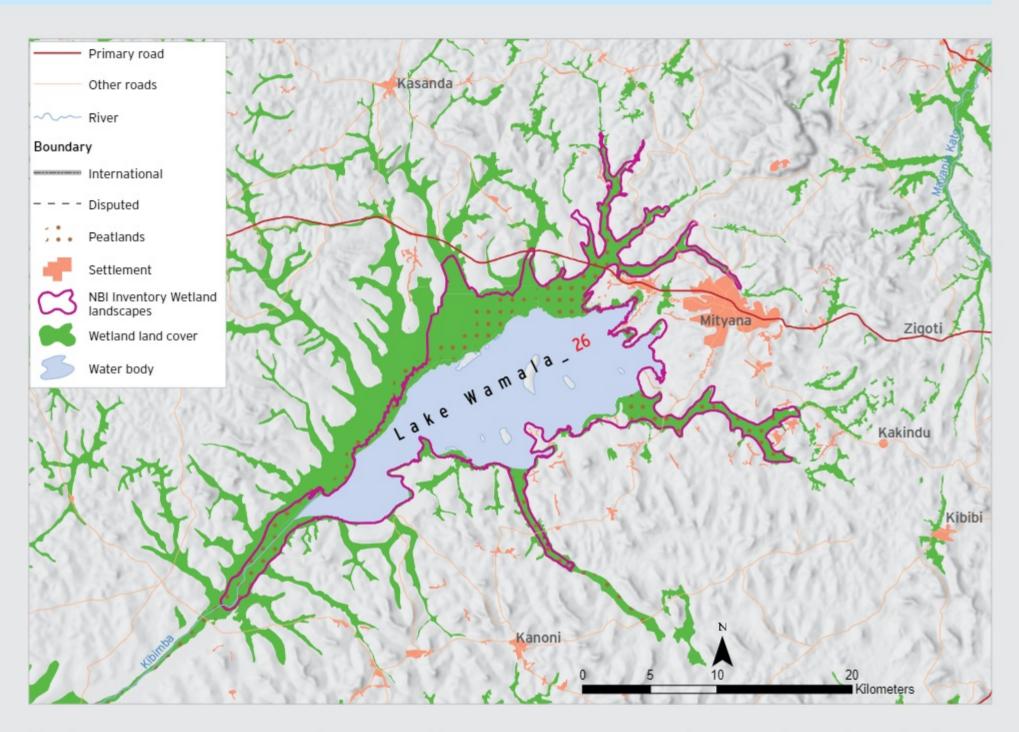
There are ecosystem service assessments (Akwataireho 2009) for specific wetlands e.g. the Mabamba Bay wetland which provides water for domestic purpose and transportation, sand for construction, handcraft materials like papyrus, and fish for local consumption and commercial purposes. In addition the wetland supports wetland-edge cultivation, carbon storage services and there are areas for recreation and tourism. Akwataireho (2009) estimated the annual total economic value (TEV) of these on approximately 3.6 million US\$/year, of which only 8.9% corresponds to the non-marketable services. Adonia (2013) estimates, for lake Nakivale, that the poor land use practices cost an approximate 2.9 million US\$/year, adding to the economic justification for wetland management, sustainable land use planning and restoration programs. The beneficiaries of all these services are at the household, local community, district, national and international levels (Adonia, 2013; Akwetaireho, 2009). The ecosystem services identified for the Lake Victoria wetlands are further presented in WP 3: Ecosystem Service Assessment.

LAKE WAMALA

Name: Lake Wamala Country: Uganda

Coordinates: 0°12 '- 0 °25 'N / 31°41 '-32°02 E

Altitude: 1,290 m a.s.l. Area: 283 km² Nearest Towns: Mityana International Importance:



Overview

Lake Wamala is one of the six most important sources of fish in Uganda. About 785 people depend on the fisheries from the lake for their livelihoods. The lake hosts a total of 25 landing sites. Lake Wamala is a hotspot for human-induced environmental change and has been influenced by climate change (Musinguzi et al., 2016).

Physical Features

Lake Wamala is surrounded by swampland, the whole system occupies some 51 000 ha. The lake has a mean length of 27 km and a mean width of 10 km. It has a variable area of 16-25 000 ha. The peripheral swamp is 44 km long, oriented WSW- ENE, and has a maximum width of 16 km. The system receives numerous minor affluent watercourses and drains via the Kibimba River to the Katonga River. However, the Kibimba is almost permanently dry and only occasionally carries overspill from Lake Wamala to Katonga River. The Wamala Basin (2,654 km²) is therefore usually separated from the Katonga Basin (Hughes & Hughes, 1992).

Drivers of Change

Rainfall has increased annually by 9.65 mm since 1980 with years of above average rainfall in between. There is also a warming trend around Lake Wamala with mainly above average minimum temperatures since 1980. Climatic changes have influenced the fish population of Lake Wamala. The peak fish yield was reached in 1960 when 7,100 tons of fish were landed in a year. In 2013 the annual fish yield was 1,200 tons. Also the dominance of fish species has changed. In 1999 after the El Niño rainfalls of 1997/98 about 90 % of fish caught in Lake Wamala were Nile tilapia. When the water level dropped again, fewer tilapia were caught, contributing less than 1 % to the total fish catch. On the other hand African catfish contributed 20 % to the total fish catch in the 1990s, but increased to 85 % by 2013. Fishermen are adapting to this change in fish yield and to more frequent floods and droughts, which damage, gears, boats, landing sites

and in general negatively influence fishing activities. Hence, fishermen change target species, spend more time on fishing grounds or diversify to high-value crops and livestock 2013 (Musinguzi et al., 2016).

Change Trajectories

Between 1984 and 1995 the lake area shrunk by half. Between 1995 and 2008 the size of the lake increased again, however in 2014 the lake was still not back to its original size. The lake's depth was 1.5 m in 1995, increased to 4.5 m during the El Niño in 1997/98 and dropped again to 3.8 m in 2014. Associated to rainfall and depth changes of the lake, the fish yield also varies (Musinguzi et al., 2016).

NABAJJUZI WETLAND

Nabajjuzi Wetland System Name:

Uganda Country:

31°33' – 31°49'E / 0°27' – 0°05'S 1,200 – 1,300 m a.s.l. Coordinates:

Altitude:

170 km² Area: Nearest Towns: Masaka

International Importance: Ramsar, Important Bird Area



Nabajjuzi wetland system lies south west of central Uganda in Masaka district Sembabule district and Mpigi district. It stretches up to the Kagera River basin area to the north and past the periphery of Masaka Town Municipal Council along Masaka – Mbarara highway to the south. Nabajjuzi is dominated by Cyperus papyrus with patches of Miscanthus violaceus in most parts. Nabajjuzi wetland has been relatively intact over the past few years. The array of resources extracted from the wetland has been the same but over the last twenty vears there has been increased commercialisation of the resource products hence increased resource off-take. Some of the surrounding areas have been modified and are built up into trading centres and small towns and this has further caused an increase in demand for resources (Hughes & Hughes, 1992).

Physical Features

The Nabajjuzi Wetland is a long narrow stretch of swamp from the periphery of Masaka Municipal Council to the major Katonga River system. Nabajjuzi wetland contains Nabajjuzi River which flows northwards. The swamp receives water from wetland tributaries, which include Gambuzi. Ndibatamadu, Ksaba, Lusamatu, Kabuka, Mugumba, Nalongo, and drains into the Katonga wetland (Byaruhanga & Kigoolo, 2005h). Pre-Cambrian rocks underlie Nabajjuzi. The soils in the wetlands include grey humose clays, grey coarse sands and peaty sands and clays. The parent material to these soils is river alluvium, lake deposits and papyrus residue respectively (Byaruhanga & Kigoolo, 2005h).

The wetland types based on dominant plants include freshwater emergent reed swamps dominated by single reed species (*C. papyrus*, *Loudetia sp. and Miscanthus sp.*); seasonally flooded herbaceous wetlands where species composition is variable; seasonally flooded wooded grassland; freshwater floating leaved but rooted vegetation and freshwater rooted macrophytes. These species are tolerant to soils that are acidic and deficient of plant nutrients. The seasonal floodplains are mainly wooded grasslands with Acacia sp. trees, which in certain instances form dense bushes. Noteworthy species include the shoebill, papyrus gonolek and the papyrus vellow warbler. Other fauna include the Sitatunga (Tragelaphus spekei). Two species of fish, which constitute the fisheries industry of the area and worthy of noting, are Mudfish (Clarias mossambicus) and Lungfish (Protopterus aethiopicus) (Byaruhanga & Kigoolo, 2005h).

Some of the flora and fauna contained in the wetland are closely associated with the cultural norms and traditions especially the totems. Because of this, there is considerable cultural attachment of the surrounding areas to the wetland. The wetland is the source of water supply for Masaka Town Council and the immediate townships such as Kyabakuza-Kimanya. The system is also a source of fish, clay, papyrus

and other crafts materials and game meat (Sitatunga). Grazing of dairy cattle is carried out especially in the seasonal floodplains. The local community has initiated ecotourism activities in the wetland (Byaruhanga & Kigoolo, 2005h).

Drivers of Change

The urban centres adjacent to the wetland are rapidly growing. This has several effects on the wetland. There is considerable conversion of the wetland for settlement and cultivation. The demand for crafts and materials harvested from wetlands is considerably increasing and can lead to an unsustainable exploitation of the wetland. There are army barracks nearby the wetland. Hunting of the Sitatunga for meat especially by the military personnel is of particular concern. In some areas close to the wetland, there is sand extraction. A tannery nearby the wetland discharges wastewaters directly into the wetland, which largely contributes to wetland pollution (Byaruhanga & Kigoolo, 2005h).



Papyrus (Cyperus papyrus) swamp in Lake Victoria, Uganda, Africa.

LAKE NABUGABO

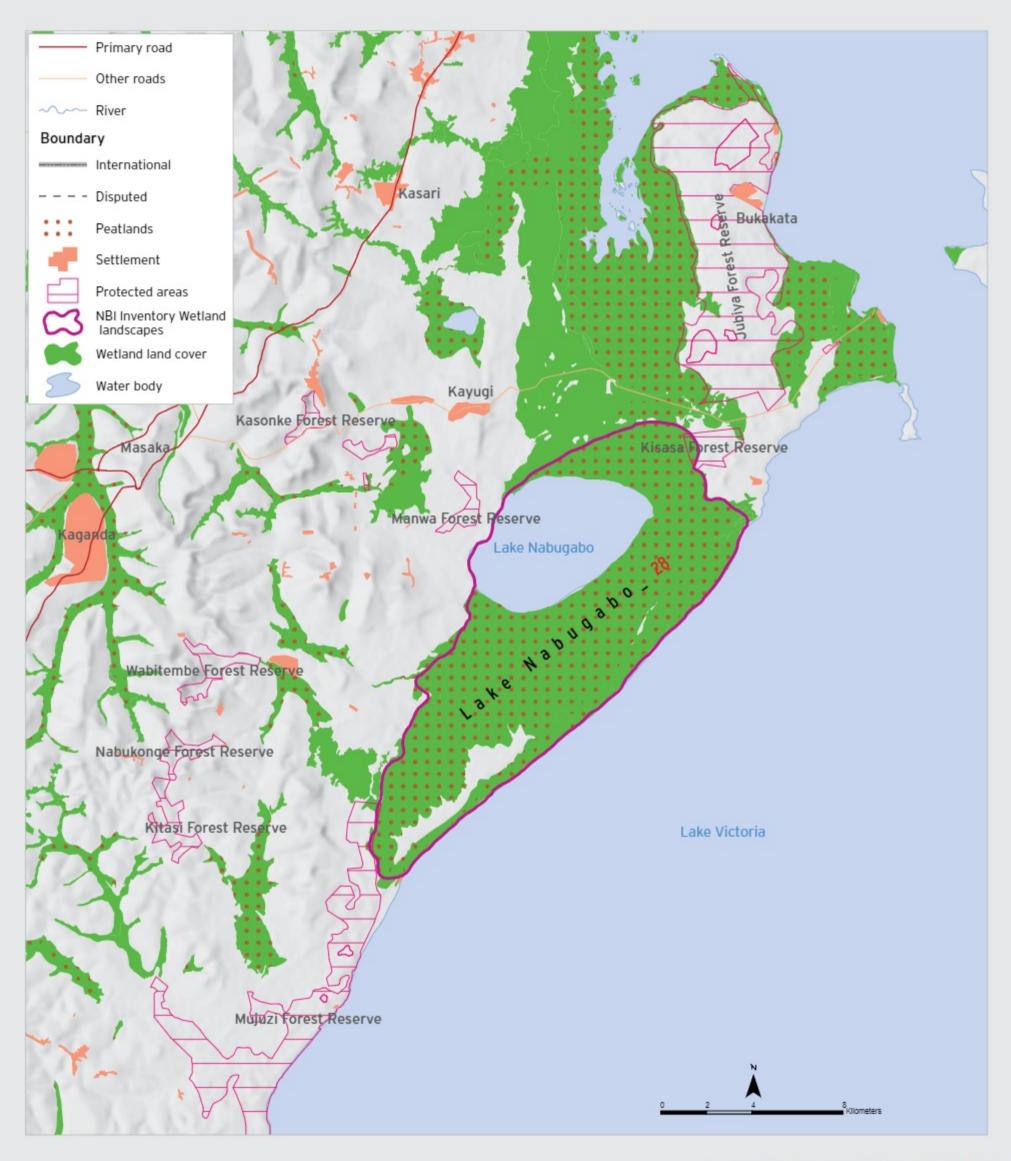
Name: Lake Nabugabo Wetland System

Country: Uganda

Coordinates: 31°50' – 31°58'E / 0°19' – 0°29'S Altitude: 1,136 m a.s.l.

Altitude: 1,136 m a.s Area: 146 km² Nearest Towns: Masaka

International Importance: Ramsar, Important Bird Area



Lake Nabugabo is a shallow freshwater lake about 8.2 km long by 5 km wide; three much smaller satellite lakes (Kayanja, Manywa and Kayugi) are located in the same basin 4-6 km to the NW. Nabugabo is separated from Lake Victoria by a 1.2 to 3 km wide sand bar. The lake is mostly surrounded by very extensive Loudetia swamp, especially to the north and south. Miscanthidium. Vossia and Sphagnum bog are also present. There is a forest along the north-western shore and sandy beaches along the windward, eastern shoreline (Hughes & Hughes, 1992).

Physical Features

Rainfall and two or more streams sustain Lake Nabugabo. The lake has now surface outflow however, there is seepage across the eastern sandbank into Lake Victoria. Water depth in Nabugabo fluctuates seasonally by less than 50 cm, with the maximum depth being about

5 m. No detailed data is available on water depth, permanence and fluctuation for the satellite lakes but they remain permanent except for Kayugi, which may dry up in extremely dry seasons. Nabugabo and the satellite lakes are natural and are believed to have been originally a bay connected with Lake Victoria. Approximately 3,500 years ago the lake level fell and the Nabugabo system became separated from Lake Victoria. Further loss of water separated the three lakes from Lake Victoria and left a thin sandbar in between. Soils are generally ferrallitic, characterised by red sandy clay loams, yellowish sandy loams and along the lakeshores, soils are hydromorphic (Mafabi, 2003).

Due to its wide varieties of habitats Lake Nabugabo Wetland System supports an unusually high diversity of plant species, including insectivores of the family Droseraceae. The wetland around Lake Nabugabo (Lwamunda Swamp) is dominated by Miscanthidium and Loudetia spp. Along the western

side of the sandbar to the northeast there is a natural swamp forest. Further swamp forest exists on the sandbar adjacent to Lake Victoria. Lake Kavanja is surrounded by a dense miscanthidium swamp. Lake Kayugi is surrounded by a pure papyrus swamp associated with Ficus congensis. It is a free-floating swamp. The open water is devoid of Nymphaea sp., Nymphoides nilotica or Ceratophyllum demersum. The fish populations in the four lakes have been isolated from Lake Victoria for 3,500 years. Therefore they differ in size and have developed into unique subpopulation units. These changes have been either preceded or precipitated by introductions of non-indigenous species that outcompeted the native forms (Mafabi, 2003).

Endemic fish species are Cichlids
Oreochromis esculentus and
O. variabilis, Haplochromines
Haplochromis velifer, H. simpsoni,
H. annectideus, H. beadlei, H.
venator. Nabugabo is also important
for migratory bird species on their

way to the south or the Palearctics. The Lake Nabugabu Wetlands are valued because of provision of fish and water, agriculture, livestock farming and tourism (Mafabi, 2003).

Drivers of Change

There seems to be a trend towards encroachment into the lake of the wetland vegetation especially in the north and south east of the lake. Many lake edge trees have died possibly because of the high water level resulting from El Nino. Threats to the wetland are overfishing. burning of grassland and additional nutrient input through livestock which grazes around the lakes. Lake Nabugabu has been assessed as a potential water supply for the Masaka Township. The lakes have potential for the development of tourism, which could degrade the system if not regulated (Mafabi, 2003).

MABAMBA BAY

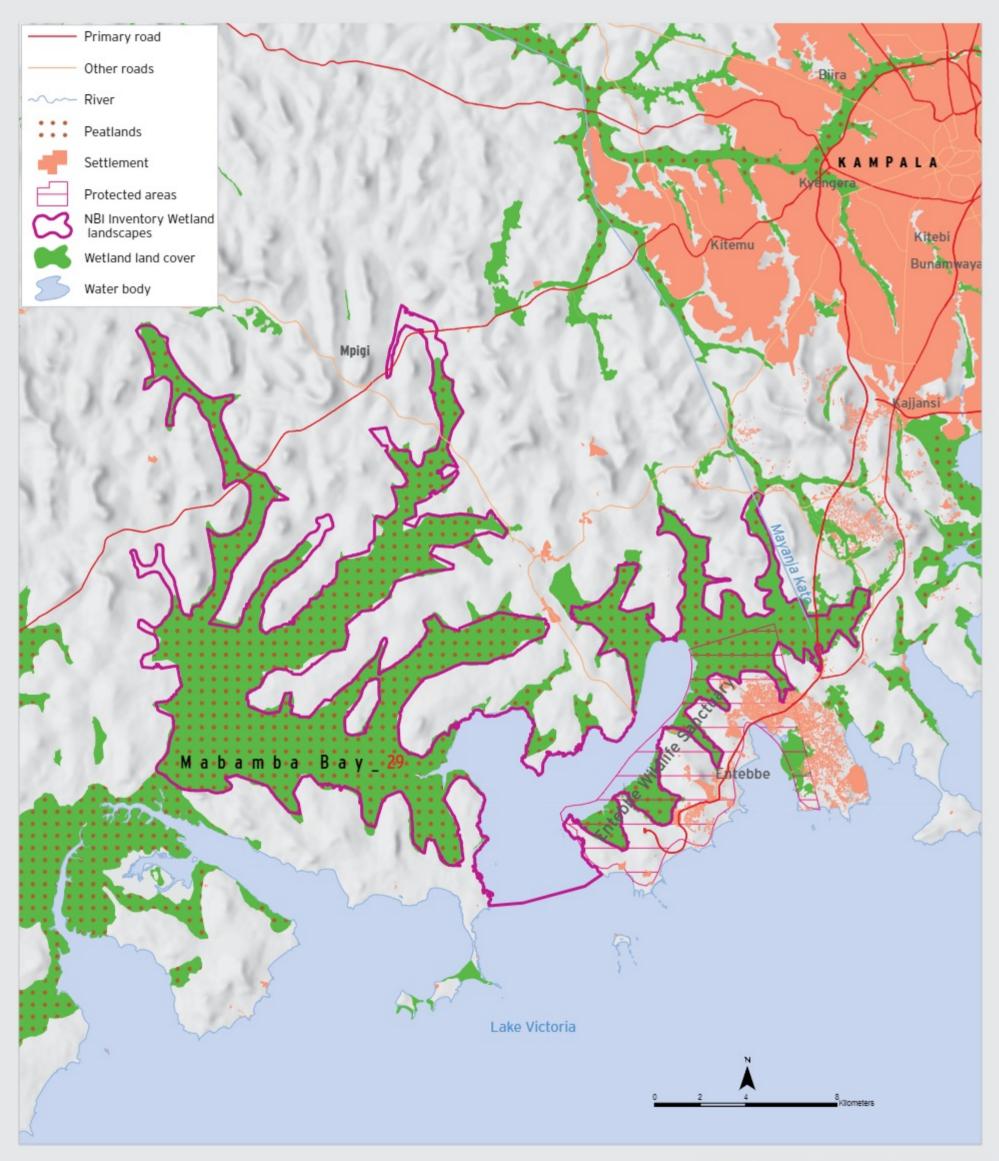
Name: Mabamba Bay Wetland

Country: Uganda

Coordinates: 32°14′ – 32°27′E / 0°02′ – 0°12′N Altitude: 1,150 m a.s.l.

Altitude: 1,150 m a.s.l. Area: 226 km² Nearest Towns: Entebbe, Mpigi

International Importance: Ramsar, Important Bird Area



Mabamba Bay Wetland System is an extensive marsh stretching through a narrow and long bay fringed with papyrus towards the main body of Lake Victoria. The marsh lies 35 km south west of Kampala and is dominated by Cyperus papyrus and Miscanthus sp. occasioned with Loudetia phragmatoides. It is part of Waiya Bay south west of Nakiwogo Bay. It is situated in Wakiso District in the sub-county of Kasanje and Mpigi district in the sub-counties of Kamengo and Mpigi. Mabamba Bay Wetland System is the only swamp close to Kampala where one can find the globally threatened shoebill (Balaeniceps rex) anytime of the day (Hughes & Hughes, 1992).

Physical Features

Mabamba Bay Wetland System lies west of the Entebbe International Airport and is part of Waiya Bay, situated in Wakiso District. Mabamba Bay falls in the Lake Kivu, Edwards, George and Victoria freshwater ecoregion. The wetland lies on the shorelines of Lake Victoria and is influenced by water level fluctuations of the lake. The soils in the bay are mostly sandy loams and sandy clay loams. The Wetland System is adjacent a medium altitude moist semi deciduous forest. It is a complex papyrus swamp connected to Makokobe, Kasa and Kasanga papyrus swamps. In the immediate surroundings one also finds Savannah mosaics of medium altitude and medium altitude moist

evergreen forests (*Piptadeniastrum* - *Albizia* - *Celtis*). The major habitat types are open water, papyrus swamp, marsh and Miscanthus swamp (Byaruhanga & Kigoolo, 2005f).

Mabamba Bay is of global conservation interest as it provides habitat for several globally threatened Bird Species. The wetland supports 38% of the global population of the blue swallow (Hirundo atrocaerulea). Other important birds found in Mabamba Bay are the globally threatened shoebill (Balaeniceps rex) and the papyrus yellow warbler (Chloropeta gracilirostris). Due to the presence of the shoebill, Mabamba Bay is a popular tourist destination for birdwatchers (Byaruhanga & Kigoolo, 2005f).

Drivers of Change

During the dry season, fishermen often bulid their huts in the swamp and sometimes even keep domestic animals there. As the rest of Lake Victoria shorelie wetlands, Mabamba bay has been suffereing from a water hyacinth infestation. Along the shores of Lake Victoria flower farming has become a valuable agrobuisiness. The proliferation of these intensive greenhouse farms is associated with input of agrochemicals to the wetland, which causes eutrophication (Byaruhanga & Kigoolo, 2005f).

Table 4 Protected area related to the wetland

NAME	TVDF*	DESIGNATION VEAD
NAME	TYPE*	DESIGNATION YEAR
Entebbe	Wildlife Sanctuary (IV)	1951
Kalandazi	Forest Reserve	1932
Kanjaza	Forest Reserve	1932
Mugomba	Forest Reserve	1932
Semunya	Forest Reserve	1948
Namagaza	Forest Reserve	1948
Degeya	Forest Reserve	1932
Nambuga	Forest Reserve	1948
Gunda	Forest Reserve	1948
Kalangalo	Forest Reserve	1932
Kavunda	Forest Reserve	1932
Kyansonzi	Forest Reserve	1932
Kisubi	Forest Reserve	1932
Naludugavu	Forest Reserve	1948
Mpanga	Forest Reserve	1932
Mako	Forest Reserve	1948
Lufuka	Forest Reserve	1932
Lwamunda	Forest Reserve	1948
Navugulu	Forest Reserve	1932

^{*}Number in brackets 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)

LUTEMBE BAY

Name: Lutembe Bay Wetland

Country: Uganda

Coordinates: 32°32' - 32°36'E / 0°09' - 0°11'N

Altitude: 1,135 - 1173 m a.s.l.

Area: 6 km²

Nearest Towns: Entebbe, Kampala

International Importance: Ramsar, Important Bird Area



Overview

The Lutembe Bay Wetland System is situated in Wakiso district in the sub-counties of Ssisa and Katabi in the central part of Uganda. The Bay is a secluded backwater at the mouth of Lake Victoria's Murchison Bay, between Kampala and Entebbe. Lutembe Bay is surrounded by highly populated areas, which are affected by commercial and industrial development, urban wastewater and conversion into agricultural land. It is a freshwater shallow bay and almost completely cut-off from the main body of Lake Victoria by a C. papyrus island. Some parts of the wetland remain intact, with papyrus, reeds, cattails and sedges as the dominant vegetation. The bay extends into a Miscanthus swamp and merges into the forest remnants to the north and cleared horticultural farm to the northwest on the landward side of Lutembe Bay. Murchison Bay is also the source of water for Kampala City's Gaba Water Works (Hughes & Hughes, 1992).

Physical Features

Lutembe is almost completely cut-off from the main body of Lake Victoria by thick papyrus islands. Some parts of the wetland remain intact, with papyrus, phragmites, typha and sedges as the dominant vegetation. The bay extends into a Miscanthus swamp and merges into the forest remnants to the north and recently cleared horticultural farm to the northwest on the landward side of Lutembe Bay. The wetland system is underlain by the Pre-Cambrian rocks, the predominant soil types are sandy loams with a dominant yellow colour and sandy clay loams with a dominant red colour.The Lutembe Bay and Murchison Bay swamps act as important filters of water, as they receive silt, nutrients and sediments from surface runoff. wastewaters from industries and sewage from Kampala (Byaruhanga

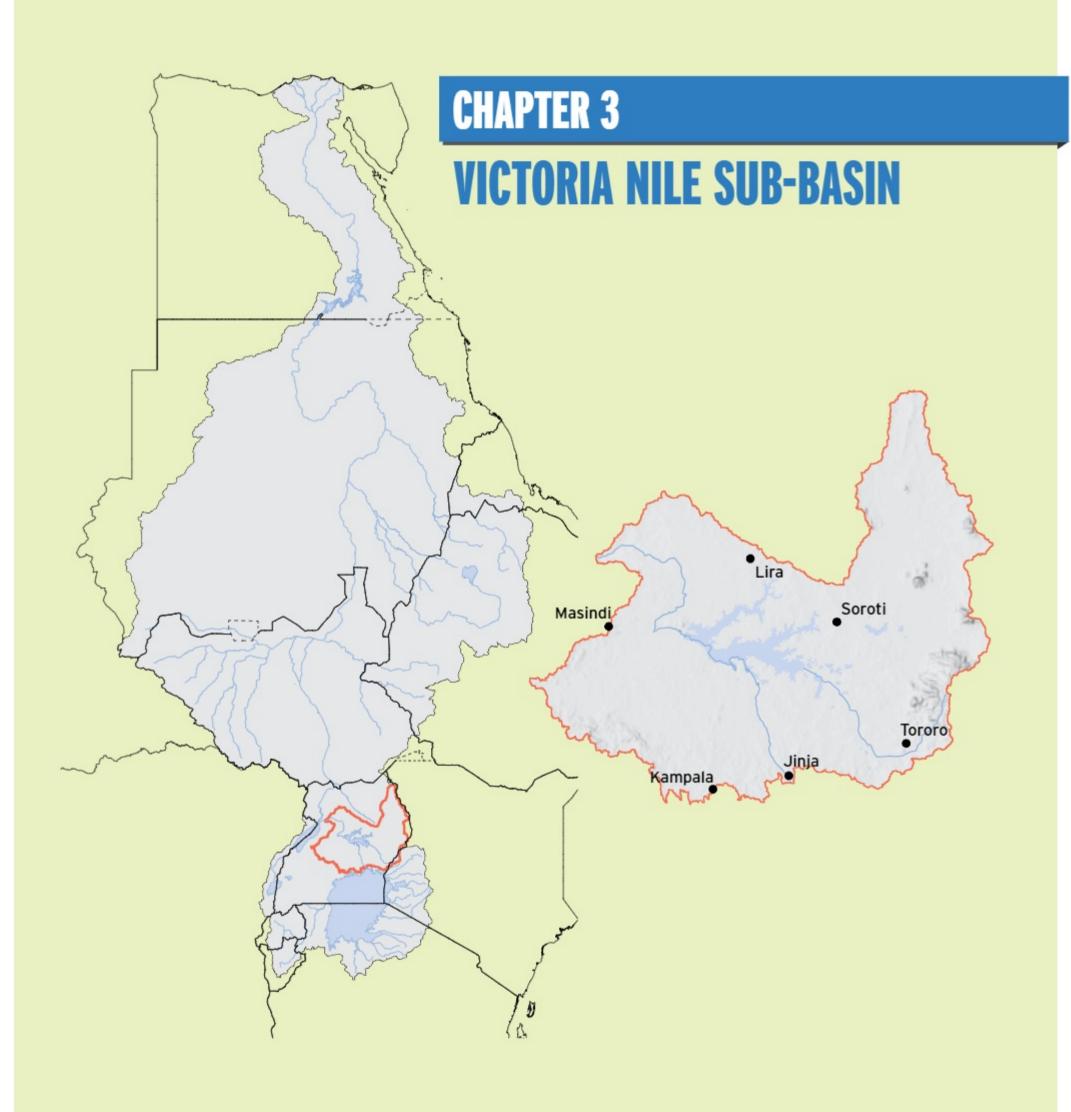
& Kigoolo, 2005e).

The bay supports globally threatened species of birds such as the Shoebill (Balaeniceps rex) and the nearthreatened Gonolek (Laniarius mufumbiri). It is also a habitat for endangered Cichlid fish, rare butterfly species, regularly supports Palaearctic and Afrotropical migrant birds, breeding ground for Clarias and lungfish, supports huge congregations of individual species of birds and more than 1% of the white-winged black terns' population. Murchison Bay is extremely important for Kampala City as a water source for livestock and domestic use. In addition the wetland is a valuable fisheries ground (Byaruhanga & Kigoolo,

Drivers of Change

Lutembe Bay has been highly affected by industrial and commercial development, urban wastewater input and conversion into agricultural land. Papyrus from Lutembe Bay is cut and sold in local markets often in an unsustainable manner. Water hyacinth infestation also affects the wetland as well as the introduction of Nile perch and Nile tilapia, fish that led to the extinction of several *Haplochromine species* (Byaruhanga & Kigoolo, 2005e).

Siltation is a problem in the wetland. Enchroachment due to industrial and residential development is common. One of the main threats for the wetland is reclamation of Lutembe Bay for horticultural activities and subsequent agrochemical input into the wetland (Byaruhanga & Kigoolo, 2005e).



Introduction	69
Socio-economic context of wetlands in Victoria Nile sub-basin	70
Hydrological context of wetlands in Victoria Nile sub-basin	71
Lake Opeta	72
Kyoga Kwania /Swamn Complex	73

INTRODUCTION

Overview

The seasonal and permanent wetlands in the Victoria Nile Subbasin are connected through a network of lakes and rivers with Lake Kyoga at its centre. From the outlet of Lake Kyoga, the Lower Victoria Nile flows north and west towards Lake Albert passing through a series of rapids.

Climate

The average annual rainfall in the Sub-basin is 1,300 mm, the average annual potential evapotranspiration is 1,550 mm (NBI, 2016a). Almost the entire Victoria Nile Sub-basin lies within the forest-savanna mosaic with the exception of the north easterly part

of the Sub-basin, which belongs to the Sudanian savannah ecoregion.

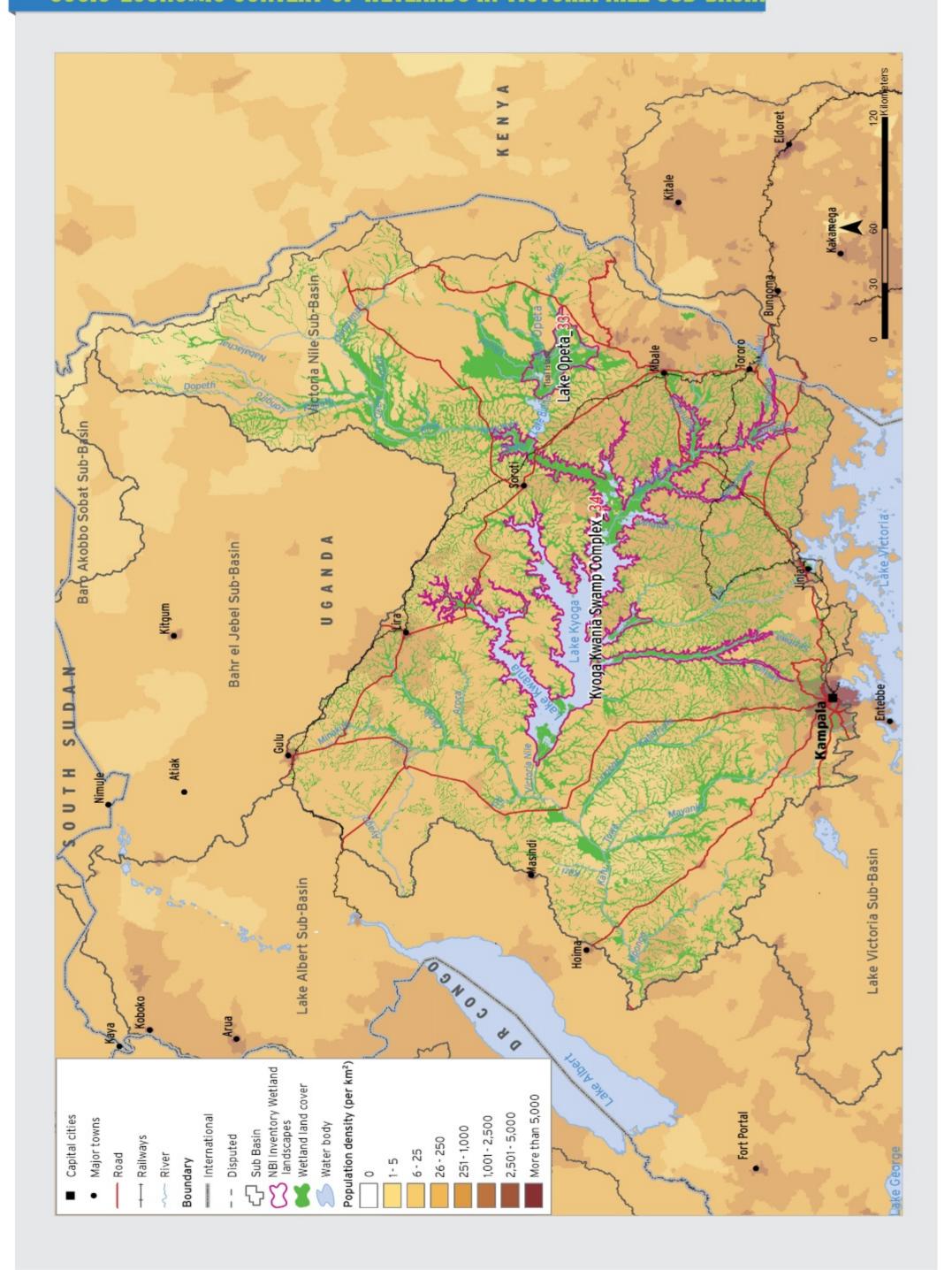
Ecosystem Services

Upon the proposal of degazetting the Mabira Forest Reserve for sugar cane production, Moyini & Masiga (2011) estimated the total economic value (TEV) of conservation to support the conservation efforts and keep the protected area as such. The ecosystem services considered were fresh water, timber and nontimber forest products, medicinal products, water regulating and purification services, carbon sequestration, ecotourism and "option/existence values" (which includes the option of using the forest in the future, the cultural

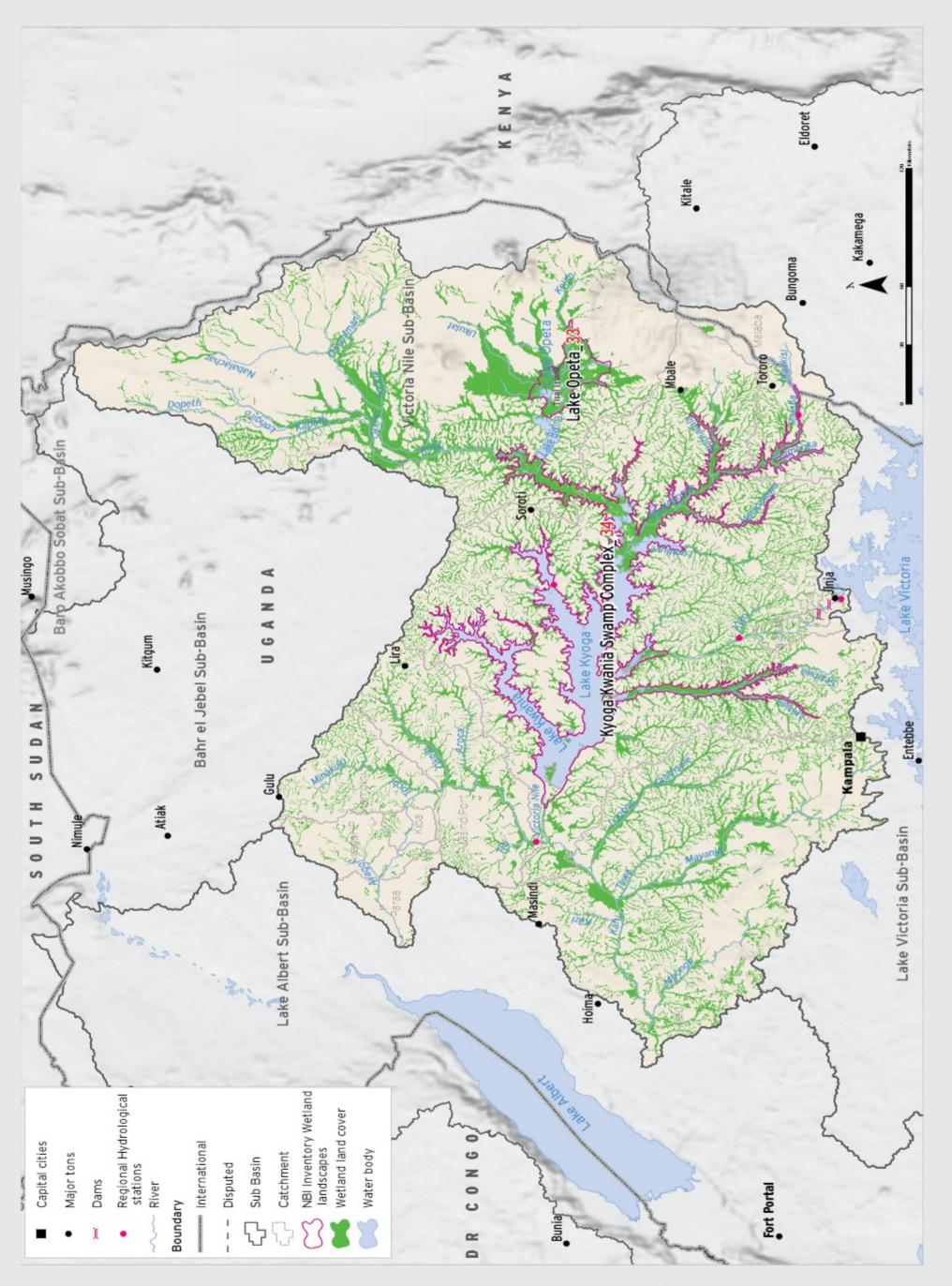
importance, and the intrinsic value of a forest and its wildlife). The TEV of the Reserve conservation was estimated in 45.1 million US\$/ year; in contrast, the sugar cane industry TEV was estimated on 29.9 million US\$/year (Moyini & Masiga, 2011). The ecosystem services identified for the Victoria Nile Basin are further presented in WP 3: Ecosystem Service Assessment.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN VICTORIA NILE SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN VICTORIA NILE SUB-BASIN



LAKE OPETA

Name: Lake Opeta Country: Uganda

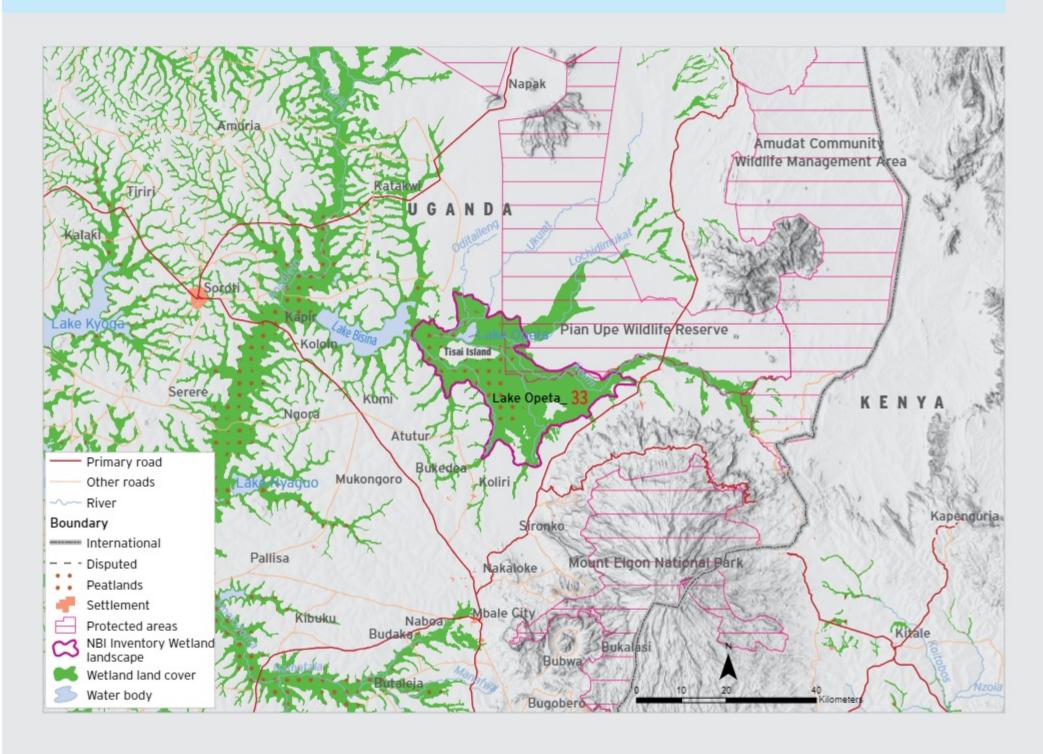
Coordinates: 1°38'30"N / 34°10'50"E

Altitude: 1,045 m a.s.l.

Area: 720 km²

Nearest Towns: Kumi Town, Soroti

International Importance: Ramsar, Important Bird Area



Overview

Lake Opeta is located in the north east of Uganda in the districts of Kumi, Nakapiripirit, Sironko and Katakwi. Lake Opeta drains into Lake Bisina through a marshy wetland area. Lake Opeta and its wetlands are Ramsar sites and Important Bird Areas, however catalogued separately.

Physical Features

Lake Opeta is situated on drainage lines leading from the Karasuk Hills in Kenya, and from Mts. Elgon and Kadam, to the Okere Valley and Lake Kyoga. The Ukutat, Muchilmakat and Kelim Rivers enter Lake Opeta through a zone of permanent swamps east of the lake. Each of the above mentioned rivers has also a seasonal floodplain. Lake Opeta is 10 km long, 5 km wide and has an open water area of 40 km². The entire lake is fringed by wide swamps, except along parts of the southern shore. The Kamirya and Siroko rivers from Mt. Elgon also enter Lake Opeta through the swamps on the southern shore. Water then passes west for 5 km from Lake Opeta through a dense swamp to Lake Bisina (Byaruhanga & Kigoolo, 2005d).

The climate at Lake Bisina Wetland System is tropical and is influenced by the air currents such as the southeast and northeast monsoons. Mean annual minimum temperatures range from 15 to 17.5 °C and mean maximum temperature from 30 -32.5 °C. Higher temperatures are experienced in the westerly plains. Because of this temperature range, the system's evapotranspiration ranges between 1750-1900 mm (NEMA (National Environmental Management Authority), 2017). The basin is largely dominated by wooded savanna interspersed with cultivated gardens and human settlement (Byaruhanga & Kigoolo, 2005a).

Drivers of Change

Over the years a proliferation of firearms has increased insecurity and illegal wildlife hunting in the area. This has resulted in declines in the populations of the wild mammals. There have been also reports of illegal hunting for the endangered shoebill stork. Due to the insecurity, the reserve does not generate any revenue, but has potential for big game viewing as well as bird watching. Overstocking of cattle grazing in the wetlands during dry seasons, as well as low environmental awareness may have a longterm impact on the ecology and character of the area (Byaruhanga & Kigoolo, 2005d).

KYOGA KWANIA /SWAMP COMPLEX

Name: The Kyoga/Kwania Lake/Swamp Complex

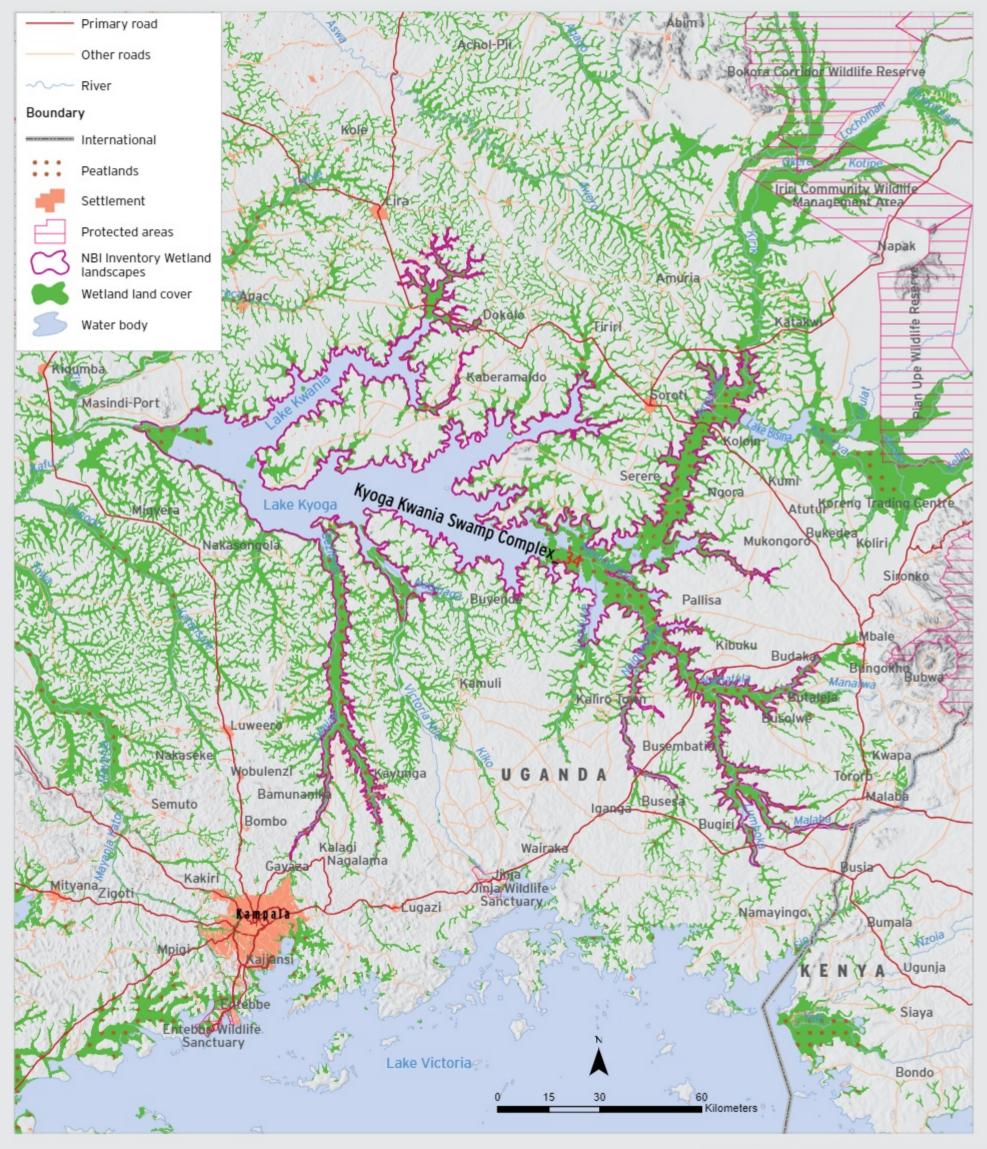
Country: Uganda

Coordinates: 1°28′2.15"N / 32°46′44.52"E Altitude: 1,033-1,060 m a.s.l.

Area: 5,439 km²

Nearest Towns: Nakasongola, Pallisa, Masindi

International Importance: Ramsar, Important Bird Area



Overview

This wetland occupies a shallow dendritic valley system, part of which is permanently flooded to form a series of shallow lakes. The system is tributary to the Victoria Nile which flows through the southwestern end of Lake Kyoga, and then receives the discharge of Lake Kwania 32 km downstream. The system owes its existence to the upwarping of the western edge of the Lake Victoria basin, which has reduced the gradient and rate of flow in rivers flowing west, causing 'ponding' and turning them into sluggish swampy tracts. The Lake Nakuwa Wetland System forms an arm of Lake Kyoga and was designated a Ramsar site in 2005.

Physical Features

Lake Kyoga is the largest lake in the system. The maximum depth is 10.7 m and the mean depth about 3 m. The surface level fluctuates

by as much as 3.8 m during a year. The lake discharges at the western end into the Victoria Nile, and is oriented roughly E-W for 55 km immediately above the confluence, at which point it divides into two arms. The north eastern arm continues up the valley of the Omunyal River for a further 55 km, while the south eastern arm extends up the valley of the Mpologoma River for some 34 km. Many tributaries enter the Omunyal Arm the valley of which carries only minor swamps. By contrast, a vast permanent swamp extends up the Mpologoma Arm for 102 km above the lake head, including many minor lakes, the largest of which are Lakes Adois, Kiando, Naragaga, Nyaguo, Nyasala, Namasajeri, Nakuwa, Nawampasa, Kawi and Lemwa (Hughes & Hughes, 1992).

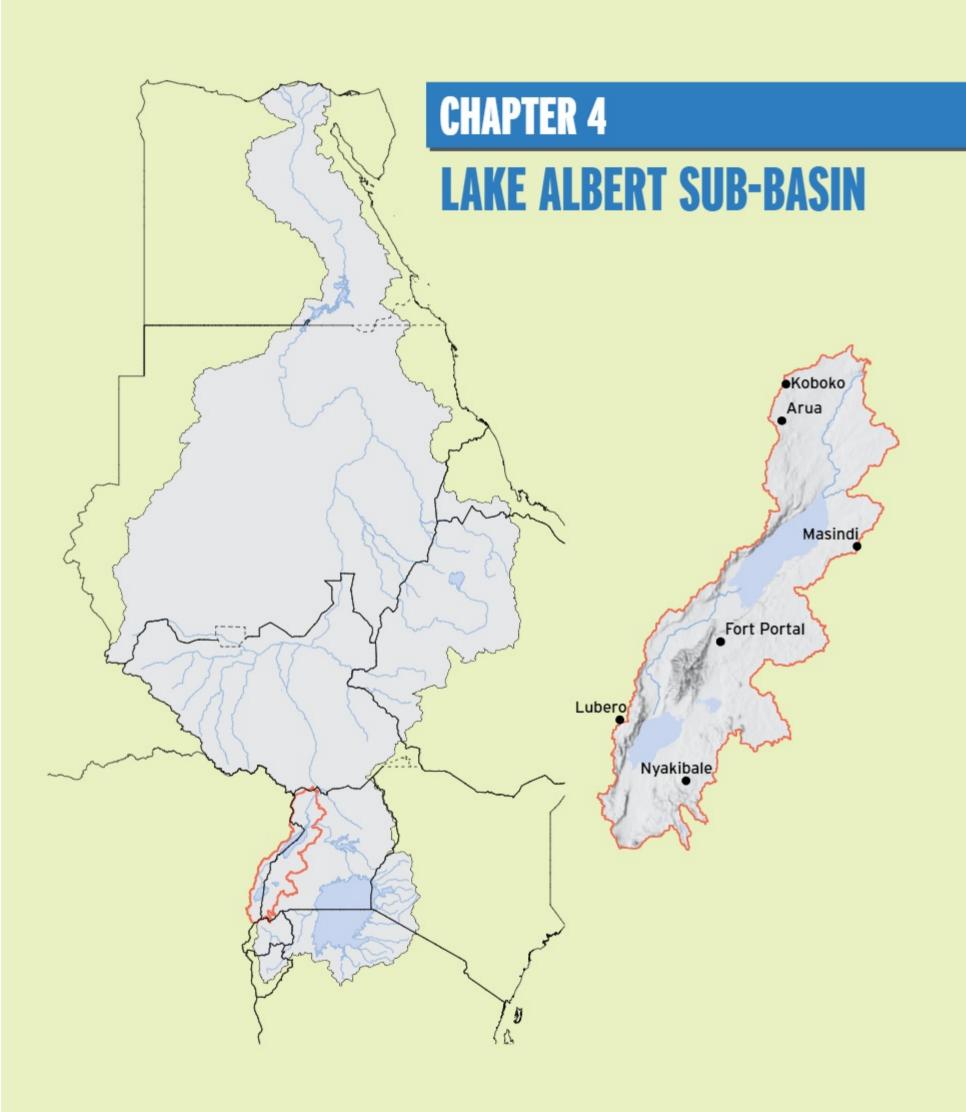
The Victoria Nile enters Lake Kyoga on its southern shore through a swampy valley, with a continuous block of swampland extending upstream for 21 km above the lake, while to the west another large swamp belt extends southwards from the lake, up the valley of the Sezibwa River. Here the swamps are continuous for 80 km above the lake, and thereafter, following the bifurcation of the valley, for a further 25 km SSW up the Lwajali Valley and for 27 km SSE up the Sezibwa. Other extensive swamps occur at the north western end of the lake, between it and Lake Kwania, and also along the south bank of the Victoria Nile between Lakes Kyoga and Kwania, and along the north bank of the effluent channel joining Lake Kwania to the Nile. In addition there are numerous small swamps around the lakeshore, and a seasonal floodplain of some 5000 ha on the Mukate River immediately above its mouth on the southwestern shore of Lake Kyoga. The Ramsar site called Lake Nakuwa Wetland System only covers the permanent wetland, in the eastern swamps of Lake Kyoga.

Lake Kwania (1°35'-1°55'N/32°20'-33°02'E) is situated northwest of Lake Kyoga. It is 66 km long above the 25 km channel which connects it to the Victoria Nile. It is oriented roughly SW-NE and branches into two short arms near its north eastern end. There are several small swamps around the lake margin (Byaruhanga & Kigoolo, 2005c).

The Ramsar site Lake Nakuwa wetland system is a permanent wetland, which covers the eastern swamps of Lake Kyoga. The system is associated to a number of satellite lakes, which include Lakes Nawampasa, Budipa and Nkodokodo, Murlu, and the northern swamps of Lakes Nakuwa and Kyebiseke (Byaruhanga & Kigoolo, 2005c).



Papyrus in Lake Kyoga



Introduction	77
Socio-economic context of wetlands in Lake Albert Sub-basin	78
Hydrological context of wetlands in Lake Albert Sub-Basin	
Wetlands of the Albert Sub-Basin	80
Rwenzori mountains	81
Lake George wetland	83
Semliki Valley Wetlands	84
Lake Albert-Murchison Falls-Albert Delta Wetlands	85

INTRODUCTION

Overview

The distinctive waterbodies in the Lake Albert Basin are the deep Western Rift Valley Lakes, Lake George, Edward and Albert. The Semliki River and its tributaries connect the Rwenzori Mountains and the three Lakes. The majority of the Lake Albert Basin belongs to the Upper Nile Freshwater Ecoregion. On its course from Lake Edward to Lake Albert, the Semliki flows through a series of rapids, which hinders faunal exchange between the two lakes. Therefore Lake Edward and George are placed outside the Upper Nile ecoregion and belong to the Lake Victoria Basin Ecoregion.

Climate

In the Lake Albert Sub basin a bimodal rainfall pattern prevails, with a long rainy season from March to May and a short rainy season in October and November. The mean annual rainfall in the sub basin is over 1,200 mm. In the mountainous regions, the variation of rainfall between individual months is lower compared to other areas. Annual potential evapotranspiration is 1,550 mm (NBI, 2016).

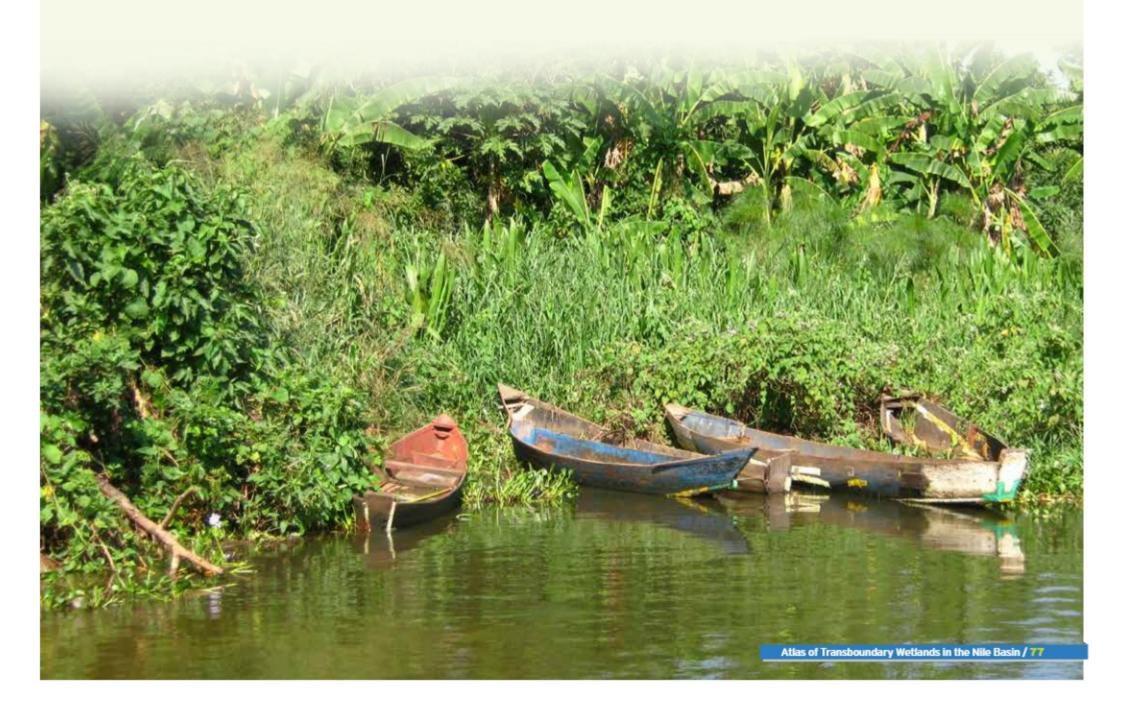
Ecosystem Services

Most of the documents pertaining to this subbasin dealt with biodiversity conservation in protected forest areas in the Albertine Rift Forests, like the Bwindi Impenetrable Forest National Park and Volcanoes National Park (Bush, 2009; Bush et al., 2012). Particularly important for this region is the economic return of biodiversity conservation through mountain gorilla (Gorilla beringei beringei) eco-tourism (Bush 2009).

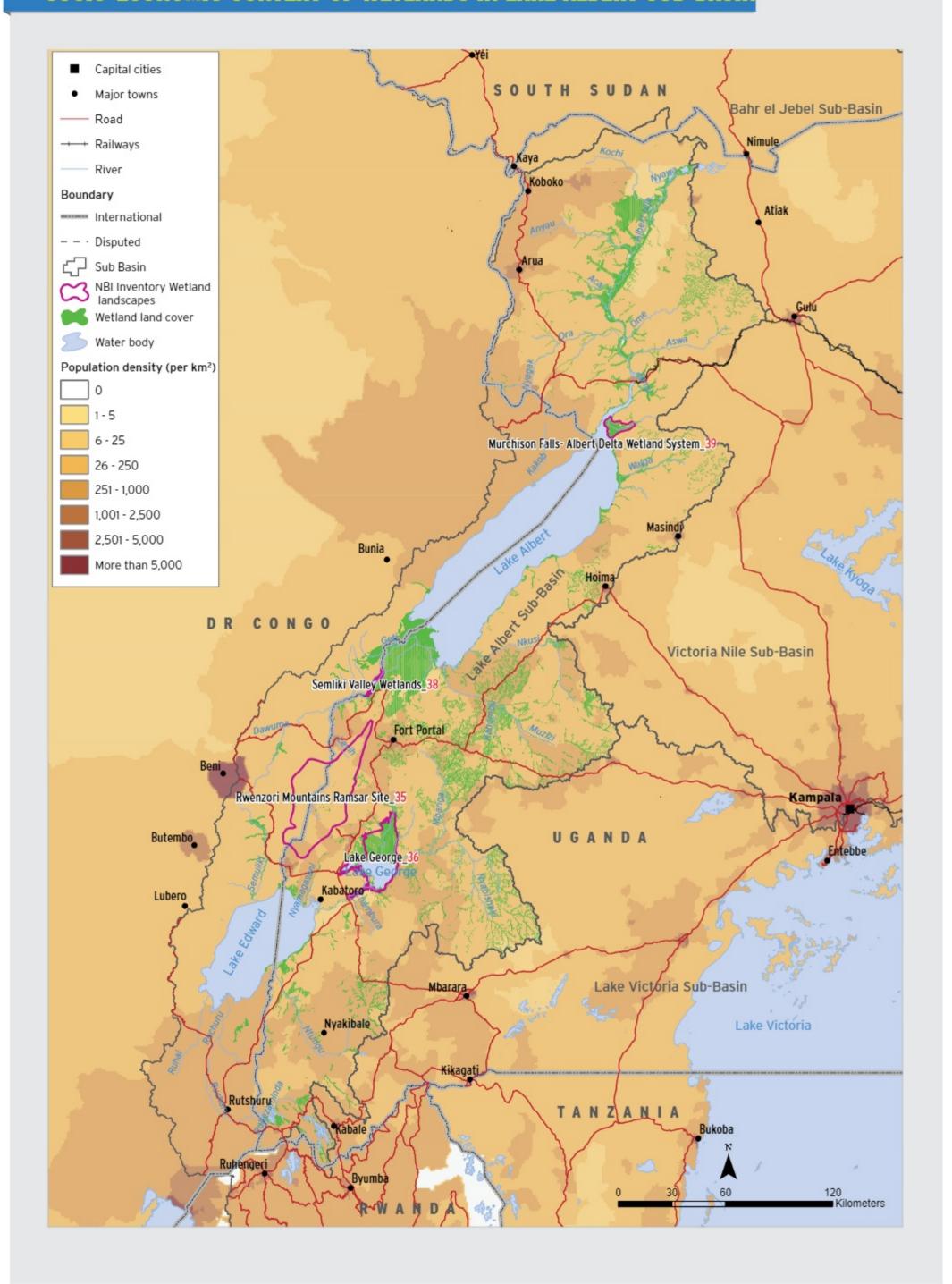
Besides tourism, these forests provide food, fodder for livestock and farmland, fresh water, medicinal products and genetic materials (Bush et al. 2004; Bush 2009; MacLean et al. 2010). Particularly important for the region is the use of wood for domestic energy consumption, so the proper valuation and conservation of forests is key given the regions' role in carbon sequestration and the importance of soil conservation (Maclean et al., 2010). The ecosystem services identified for the Lake Albert Basin are further presented in WP 3: Ecosystem Service Assessment.

Land Cover

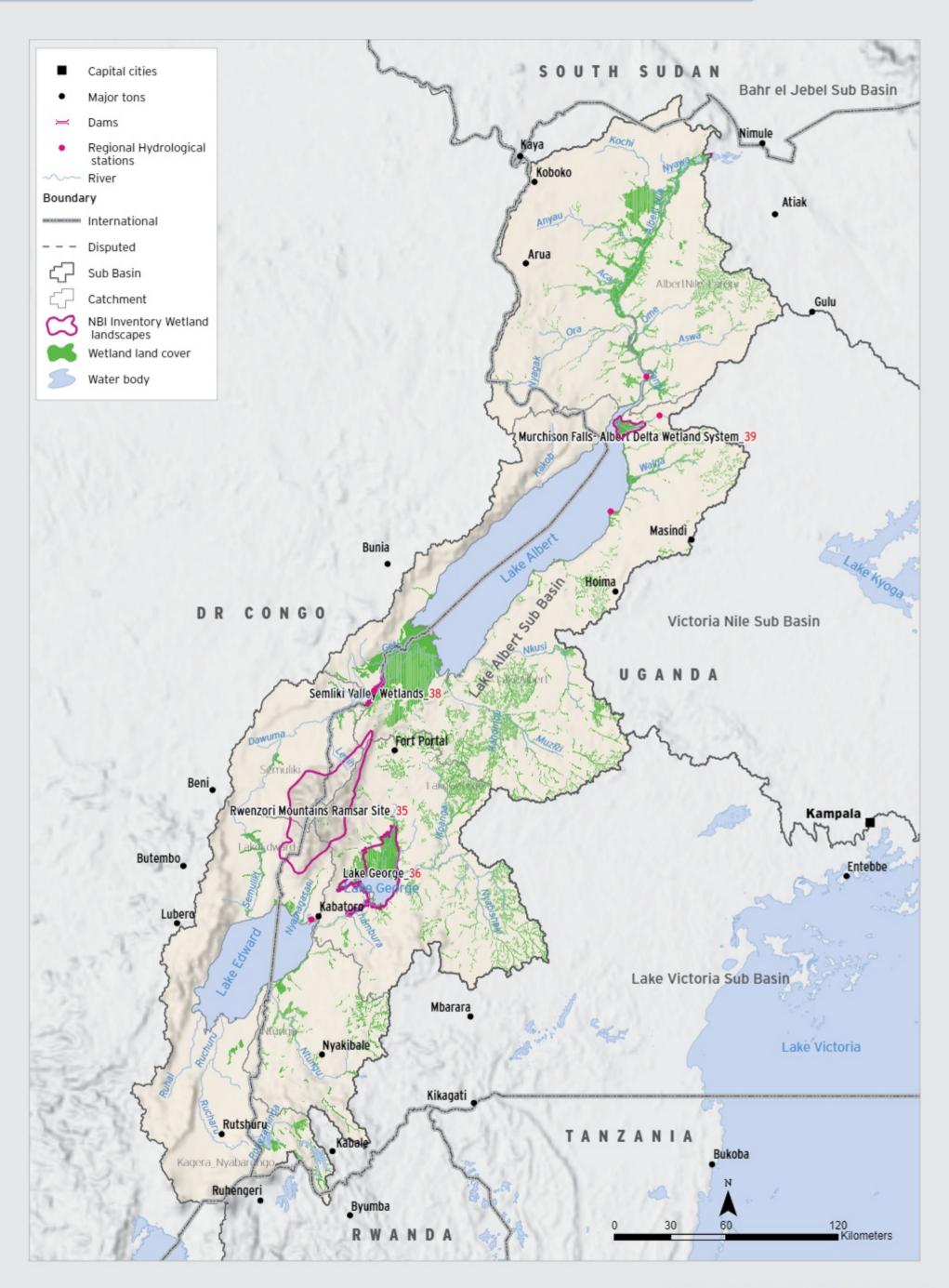
The most dominant land cover in the Lake Albert basin is agriculture, followed by grassland shrubland and bushland. The north western part of the Rwenzori Mountains is forested as well as larger areas east of Lake Albert (Figure 9). Other forested patches are in and around protected sites in the Ugandan side of the Basin, including Kibale National Park and Kigezi Game Reserve.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN LAKE ALBERT SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN LAKE ALBERT SUB-BASIN



WETLANDS OF THE ALBERT SUB-BASIN

Overview

The Lake Albert Sub-basin is one of the hydrological sub-basins in the headwater reaches of the Nile River in the Equatorial Great Lakes region. The sub-basin has an elongated shape straddling the border between the DR Congo and Uganda, and has an area of about 96,807 km2. From north to south, the sub-basin measures about 500 km while from east to west, it measures an average of 120 km. The towering snow-capped. Rwenzori mountain (highest point is 5,109 m amsl) and the escarpments of the western branch of the Great African Rift Valley, are dominant physical features in the basin. Also dominant are the vast plains and great lakes that occupy the floor of the Rift Valley. The major lakes of the Sub-basin are Albert, Edward, George and Bunyonyi, while the major rivers are the Victoria Nile, Semliki, Muzizi, Mpanga, Nyabisheki, Chambura, Ntungu and Nkusi.

Excluding the Victoria Nile system which enters and exists the subbasin in its northern part, the Semliki River is the largest and longest river in the Albert SubBasin. It captures high rainfall on the Ruwenzori mountains, and is a major contributor of water to Lake Albert. The river originates in Lake Edward, flows for 230 km and discharges into the southern end of Lake Albert. Lake Edward is connected to Lake George on its north eastern side by the Kazinga Channel.

Climate

The climate of the Albert Sub-Basin is hot tropical, affected by seasonal movements of the intertropical convergence zone and by altitude and topography. There are two rainy seasons in a year from March to May and from October to November. The mountain range in the Lake Albert Basin exerts a strong influence on rainfall distribution. Most of the plains at the foot of the range lie in a rain shadow and receive low rainfall. The average rainfall at Mubuku station on the eastern foot of the mountains is 700 mm/year, whereas at Rwebitata station close to Fort Portal the mean rainfall is approximately to 1,500 mm/ year (Uganda Wildlife Authority, 2008). The average rainfall in the sub-basin is about 1,180 mm/ year. Average daily temperatures

range from -10°C at the top of Mt. Rwenzori, to 26°C at the floor of the Rift Valley.

Biological features

The Albert Sub-basin is not as well endowed with wetlands as other sub-basins of the Great lakes region, but nevertheless it has some important wetlands. The main wetland systems of the subbasin are the Victoria Nile Delta on the northern edge of Lake Albert; Semliki Valley and Semliki Delta wetlands; Mpanga, Kahombu and Nyabisheki riverine wetlands; and the Lake George wetlands. There are also smaller montane bogs at the top of the Rwenzori mountains, and freshwater wetlands in the Lake Bunyonyi system.

There are 72 taxa in the Albert Sub-basin that have an IUCN threat status of interest. In total there are 36 flagship species that include Balaeniceps rex, Balearica regulorum, Crocodylus niloticus, Hippopotamus amphibius, Nettapus auritus, Phoeniconaias minor and Tragelaphus spekii. Most of the wetlands are dominated by Cyperus papyrus. Azolla nilotica and Pistia stratiotes are important alien species in the sub-basin.

The papyrus swamps of Lakes Edward and George are considered to be biodiversity hotspots due to the high percentage of endemic species, globally important species and threatened species. One such contributing species is the endemic sedge Papyrus hioropetagracilirosiris. Lake George also has a very high concentration of endemic cichlid fish species (USAID, 2015). In Lake Albert Potamogeton schweinfurthii is the dominant submerged macrophyte over most of the lake, by contrast with the other rift valley lakes Lakes Kivu and Edward where P. pectinatus is the most common.

The stretch of river near the Victoria Nile Delta hosts a large population of the Nile crocodile. The vulnerable African elephant can also be found in the parts of the sub-basin that lie in the Kabalega National Park (Murchison Falls National Park). The Kabalega National Park includes more than 460 bird species and is particularly important for Sudan-Guinea bird species. For water birds especially

for Balaeniceps rex, the shallow convergence zone between Lake Albert and the Victoria Nile Delta is an important area for waterfowl (Byaruhanga and Kigoolo, 2005g).

The Queen Elizabeth National Park, another protected area in the Albert Sub-Basin, is one of the most popular National Parks in Uganda for birdwatchers. The park, which covers parts of Lake George and Lake Edward, has more than 600 bird species, the highest number recorded in any IBA in Uganda and probably the highest of any protected area in Africa (Ministry of Environment Protection, Uganda, 1990).

Lake Albert and Lake Victoria share a few common fish species, however in general the fish fauna of Lake Albert is very different from that of Lakes Victoria and Kyoga. This is because the steep Murchison falls form an unscalable barrier for fish. Some of the commercially important indigenous fish species of Lake Albert include Lates albertianus, Citherinus citherius, Tilapia galilaea, Distichodus niloticus, Bagrus bayad, Labeo horie, Alestes baremosa, Hydrocyon forskalii, Synodontis schall and Mormyrus caschive (Byaruhanga and Kigoolo, 2005g) In Lake Edward Citharinus sp., Distichodus sp., Hydrocynus sp., Polypterus sp. and Lates sp. are absent, although both Hydrocynus sp. and Lates sp. are known to have been present in the middle Pleistocene (Ministry of Environment Protection, 1990). There are also wetlands in the Rwenzori mountains, but to the high altitude and temperate climate, the flora and fauna of the mountains differs significantly from that on the low lands.

Ecosystem Services

The riverine forests of the Victoria Nile and Semliki River play an important role in the hydrology of the sub basin. The rivers running down from the Rwenzori Mountains feed the economically important Lakes Edward and George, and constitute a major source of the White Nile through the waters of river Semliki that flows into Lake Albert. Agriculture in the areas surrounding the Rwenzori mountains greatly benefits from the runoff from the range as well as from direct rainfall, which is regulated by the

mountains. There are irrigation schemes, hydro power stations and domestic water supplies, both locally and internationally, that are based on water resources generated within the Albert Sub-Basin. Other regulating and supporting services of the Albert Sub-basin ecosystems include maintenance of soil fertility, and natural hazard and climate regulation (Akwetaireho et al., 2011; Byaruhanga and Kigoolo, 2005g; Uganda Wildlife Authority, 2008).

Furthermore, the wetlands of the Sub-basin provide food in the form of game, fruits, vegetables, grains, fodder for livestock and farmland, timber and non-timber forest products, and genetic materials. The wetlands also support wildlife and maintain genetic diversity. Lake Albert and the Victoria Nile Delta wetlands support important indigenous fish species that differ from the fish of Lake Victoria. The wetlands act as a nursery for fish, which are a source of income for fishermen in the sub-basin (Byaruhanga and Kigoolo, 2005g). The Albert Sub-basin is also important for cultural, recreational and educational values (Akwetaireho et al., 2011). The Victoria Nile Delta, which is part of a national park, is a touristic area and an attractive destination for birdwatchers (Byaruhanga and Kigoolo, 2005g). The ecosystem services identified for the Albert Sub-basin are further presented in WP 3: Ecosystem Service Assessment.

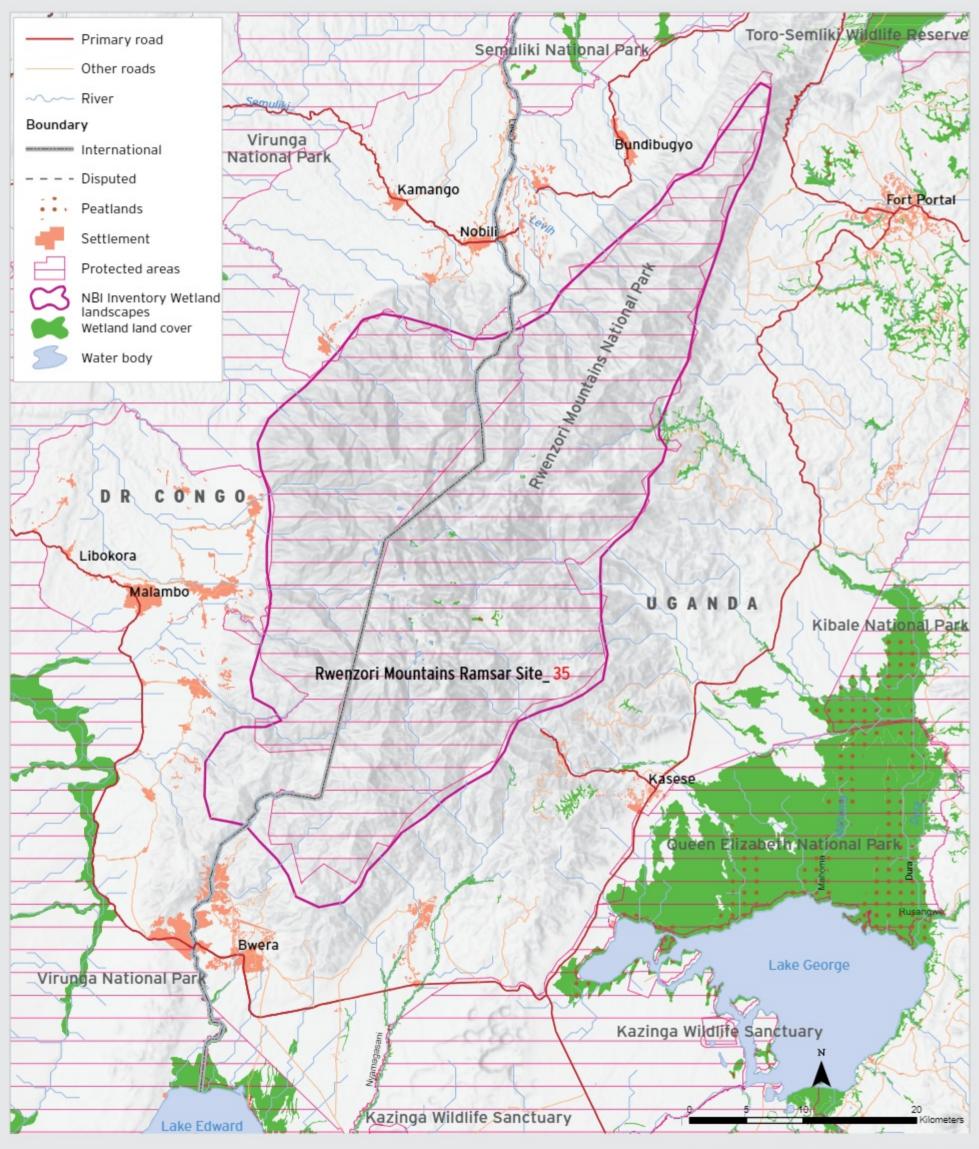
RWENZORI MOUNTAINS

Name: Rwenzori Mountains Country: Uganda, DRC Coordinates: 0°25' N / 30°0' E Altitude: 1,646 - 5,109 m a.s.l.

Area: 1,593 km²

Nearest Towns: Kasese town, Fort-Portal

International Importance: Ramsar, Important Bird Area, Transboundary Wetland



Overview

Rwenzori Mountains are located in the three districts Kasese. Kabarole and Bundibugyo, which are found in western Uganda. The Ramsar site borders the DR Congo in the west. Over 75% of the mountain range is in Uganda and the rest in the DR Congo. In the DR Congo the mountains are part of the Parc National des Virunga, whereas the mountain range in the Ugandan territory is protected as the Rwenzori Mountains National Park. The mountains have a permanent ice cap, which is decreasing in size due to global warming (NEMA, 2017). As a result of the high rainfall (over 2000 mm annually) in most parts of the range and the glacier melts, numerous rivers flow from the mountains. Thus the Rwenzori Mountains contribute a significant flow to the White Nile and are the highest source of the Nile (Uganda Wildlife Authority, 2008)

Physical Features

The Rwenzori basin is one of the basins of the Nile covering an area of approximately 13,900 km². It is one of Uganda's most valuable basins and gives rise to big rivers that feed Lake George, Edward and Albert and later the Nile (Uganda Wildlife Authority, 2008).

The soils from the Precambrian rocks are generally of low fertility, except on the northern parts where there is some soils derived from volcanic ash originating from the craters. The soils show a well-marked altitudinal zonation caused by a combination of age, climate and erosional history. Peat bogs (pH 4) up to 2 m deep are common at altitudes over 3,000 m (Uganda Wildlife Authority, 2008).

Biological features

The distribution of biodiversity in the Rwenzori Mountains is clearly determined by factors related to elevation, hence it follows certain zonation patterns. The vegetation in the Rwenzori Mountains can be categorized into five zones starting with grassland below 2000 m a.s.l followed by montane forest until 3000 m a.s.l. Between 2500 and 3500 m a.s.l. Arundinaria alpina forms a dense stand, characteristic of the bamboo/mimulopsis zone. Bogs in the Heather/Rapanea zone (3000-4000 m a.s.l) are occupied by Carex runssorroensis and other sedges. Above 4000 m a.s.l. The Afro-alpine moorland zone starts, with Helichrysum stuhlmanni as the most abundant plant. The bogy wetlands are well known to contain the tussock forming grass Deschampsia angusta. The most abundant vegetation around the bogs is a tangled thicket of Helichrysum stuhlmanni, with white flowers that open quickly in any sunny period; at the higher altitudes the same species is smaller and covered with white woolly hairs. Thickets of tree groundsels, Senecio adnivalis occupy gullies and other sheltered or well-watered sites. Small brilliant yellow or orange moss bogs occur at the highest levels. Lobelia wollastonii is also common around the bogs of Rwenzori Mountains.

Three endemic mammal subspecies are found in the Rwenzori Mountains namely: Rwenzori colobus monkey (Colobus angolenis ruwenzorii), Rwenzori hyrax (Dendrohyrax arboreus ruwenzorii) and the Rwenzori leopard (panthera pardus ruwenzorii). In addition, elephants, buffalos, bushbucks, red forest duikers, the giant foerest hog and blue monkeys are common in

the mountains. In general animal biodiversity decreases with an increase in elevation.

The Rwenzori Mountains are an Important Bird Area and support one of the most important bird communities in Uganda, with a total of 217 species recorded. Bird species found in the Rwenzori Mountains are the Ruwanzori turaco, francolins, the olive pigeon, Archer's robin-chat, and several species of sunbirds, white-necked raven and mountain buzzards. Near threatened birds in the region are Shelley's crimson-wing, Lagden's bush-shrike and the Kivu ground thrush.

The wetlands and rivers in the Rwenzori Mountains support indigenous fish species. The most common Cyprinid species are Varicorhinus rwenzorii, Barbus alluaudi, B, somereni, B. perince and B. Apleurogramma. Other fish species include the fast flowing cat fish, Ampilius jacksonii, swamp catfish Clarias alluaudi various Haplochromine species. The distribution of fish varies with altitude (Uganda Wildlife Authority, 2008).

Management Status

The Rwenzori Mountains National Park is a state owned protected area. According to the 1995 Constitution, the Government holds wetlands in Uganda in trust for the people. The government on behalf of the people therefore owns Rwenzori Mountains and its features. In the surrounding areas land is privately owned by individuals and organizations (Uganda Wildlife Authority, 2008).

Drivers of Change

Since the sixties the mountains have been increasingly threatened by the demands of a growing population. Poachers have removed most of the large animals from the main valleys while cultivation of steeper land below the protected area boundary caused serious soil erosion. Uganda was isolated during the seventies and some of the eighties by internal unrest. The return of stability in the late eighties, and renewed foreign visitation to the country, came at a time of massive international concern for environmental protection. Growing tourism is also a potential threat to the pristine areas of Rwenzori Mountains. However, most tourism is limited to a narrow strip around the central peaks of the mountains (Uganda Wildlife Authority, 2008).

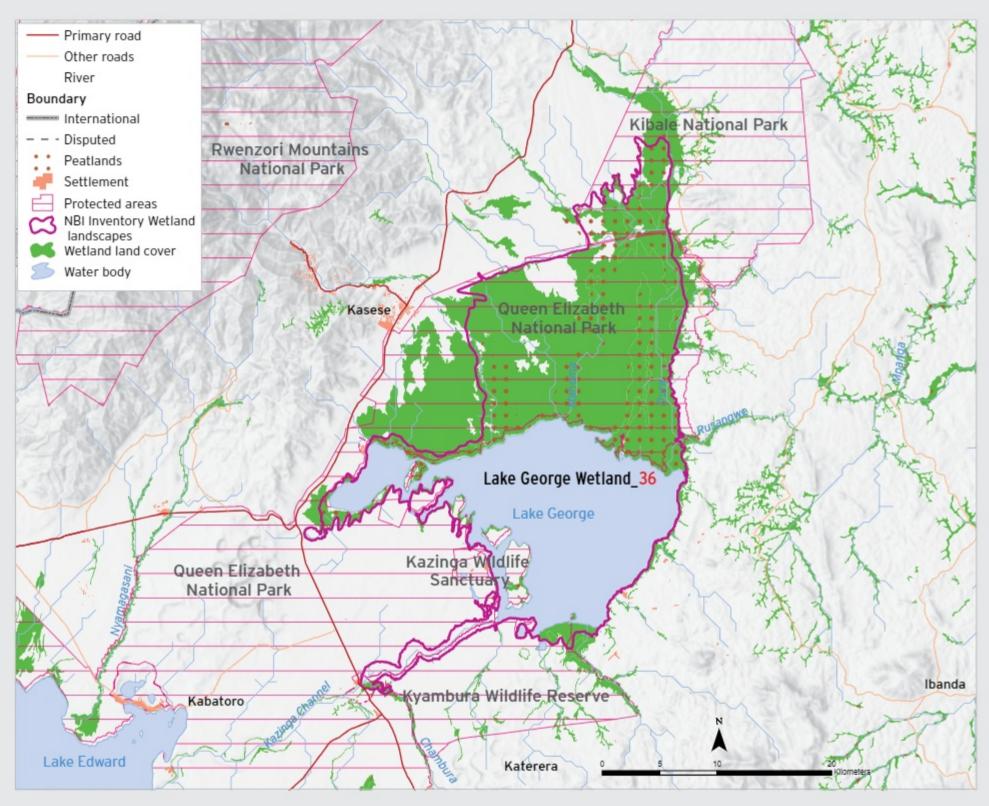
LAKE GEORGE WETLAND

Wetland Name: Lake George, Lake Dweru

Country: Uganda

Coordinates: 0° 0'11 N / 30°12'E Altitude: 915 m a.s.l. Area: 662 km² Nearest Towns: Kasese, Katwe

International Importance: Ramsar, Important Bird Area (Queen Elisabeth National Park)



Overview

Lake George, through which the equator crosses, is situated on the floor of the Western Rift Valley. It has a maximum E-W length of 30 km, N-S width of 16 km, a maximum depth of 7 m and a mean depth of 2.4 m (Hughes & Hughes, 1992). There are extensive swamps dominated by Cyperus papyrus on the northern shore of Lake George. Other swamps occur to north and south of the small western basin of the lake, and another is situated on the central southern lakeshore. There are three large islands close to the

western shore, one of which almost blocks the channel connecting the main basin with a smaller basin in the northwest. The Lake George area has seen much volcanic activity over the past 12,000 years and a small crater lake is connected to the main lake by a narrow channel just south of the beginning of the Kazinga Channel. There are four isolated crater lakes north of the Kazinga Channel and a dozen south of it. Most of the wetland lies within the Queen Elisabeth National Park and a small northern portion of the wetland is in the Kibale Game Corridor. In 1990 Lake George's

swamp was declared a Ramsar site (Ministry of Environment Protection, 1990). Lake George and the wetlands to the north of the lake are part of an Important Bird Area known under the name Queen Elisabeth National Park and Lake George.

Physical Features

The principal affluent streams (Nyamwamba, Rukoki, Mubuku, Ruimi rivers) drain the eastern slopes of the Rwenzori Mountains and enter the lake through extensive swamps on the north shore. The Mpanga also enters

these swamps from the eastern edge of the rift valley escarpment, while two other affluents enter on the southern shore from the Virunga Massif. The westward flowing section of the Katonga River enters the eastern extremity of the lake. The outflow of Lake George is at southwestern end through the Kazinga Channel which leads to Lake Edward. This channel is 36 km long with a mean width of about 1 km. Due to this connection, Lake George can also be considered as a bay of Lake Edward (Simiyu et al., 2018).

SEMLIKI VALLEY WETLANDS

Wetland Name: Semliki (Semuliki) Valley Wetlands

Country: DRC, Uganda

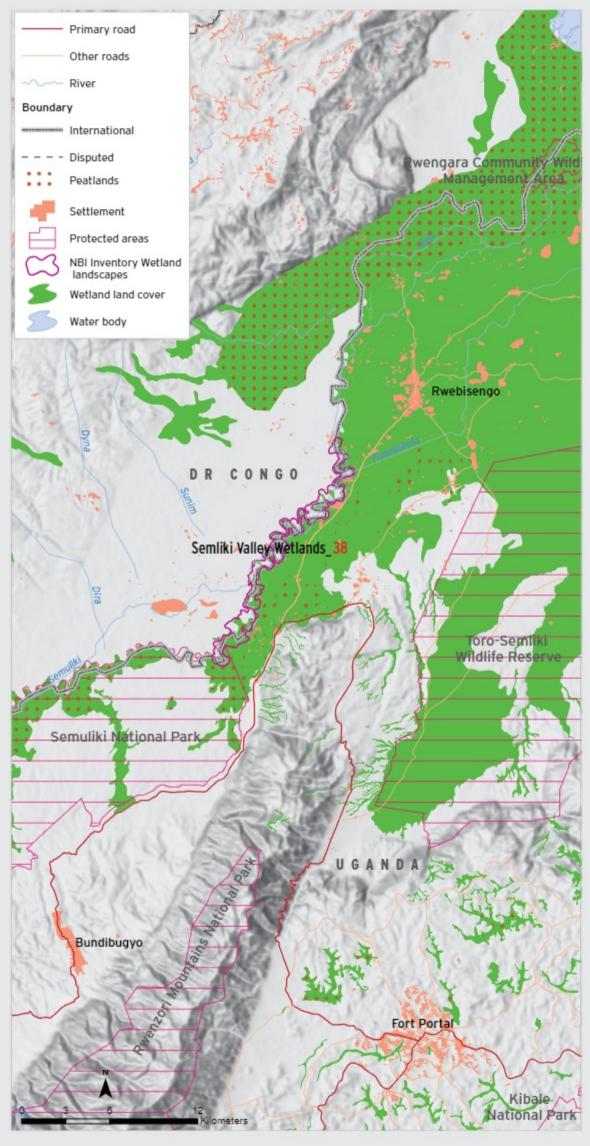
Coordinates: 1°20'N- 0°11' S/29°30' -30°30'E

Altitude: 619-912 m a.s.l.

Area: 17 km²

Nearest Towns: Fort Portal, Bunia

International Importance: Important Bird Area



Overview

The Semliki River connects Lake Edward to Lake Albert and flows west of the Rwenzori Mountains through the DR Congo. It is the largest river in the Lake Albert Basin. The river forms the border between DR Congo and Uganda. The valley is protected as the Semliki National Park, which hosts one of Africa's most ancient and biodiverse forests. During the wet season large parts of the park are flooded. The Semliki River is also part of the Important Bird Area Virunga National Park.

Physical Features

The 140 km long river originates in the Nyamulagira mountains and receives water from rainfall and snowmelt from the Rwenzori Mountains. The upper course is swift, rocky and boulder strewn, 30-40 m wide, and enclosed by the dense Ituri Forest. Most of the descent is made over two rapids sections in this part of the river. In places the river is confined to a narrow channel, 10 m wide, between sheer rock walls. On emerging onto the savanna covered, lower Semliki Plain, the river flows slowly, eventually meandering to its delta in Lake Albert. A chain of oxbow lakes to the west of the present lower course, and deltaic deposits in Lake Albert, indicates that the river bed has been moving eastwards over the lower plain. Swamps occupy an area along the southern shore of Lake Albert astride the delta of the Semliki, which projects a further 3 km into the lake. Upstream, seasonally inundated land extends back from these swamps for many kilometres, and a large area, centred upon the oxbows of the abandoned river course, is poorly drained and comprises hydromorphic soils. Further back upstream, smaller swamps occur along the Semliki at numerous isolated sites, mostly where tributaries enter the main stream (Hughes & Hughes, 1992; NEMA, 2017).

Drivers of Change

Land along the Semliki river is in high demand as the population density is high, but the communities are enclosed between the Semliki National Park to the south, Toro Wildlife Reserve to the east, Semliki River to the west and Lake Albert to the North.

The river has high erosive power and undercuts the river banks as it flows. Extensive erosion caused by heavy runoff from the mountains coupled with deforestation and overgrazing along the river banks leads to siling of the river. As a result, the river has changed course over the years, advancing on the Ugandan side of the river valley. The river course change is accompanied with the loss of infrastructure, border disputes and clashes over ownership. Extensive soil erosion and subsequent deterioration of water quality resulted in the proliferation of invasive species such as water hyacinth (Eichhornia crassipes) or Kariba weed (Salvinia molesta) (NEMA,

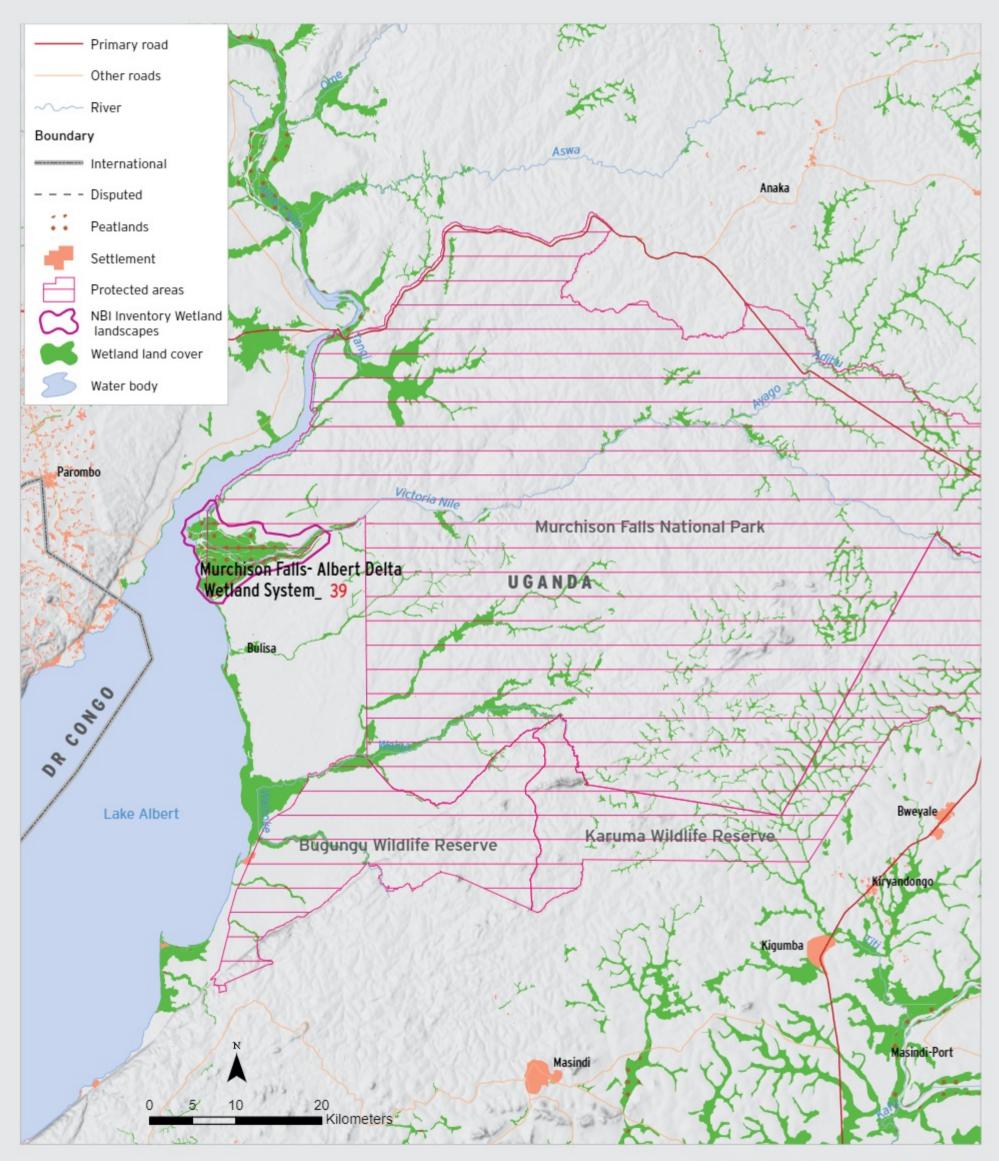
LAKE ALBERT-MURCHISON FALLS-ALBERT DELTA WETLANDS

Wetland Name: Lake Albert-Murchison Falls-Albert Delta Wetland System, Mwitanzige

Country: Uganda, DRC Coordinates: 1°39'N / 30°55'E Altitude: 619 m a.s.l. Area: 172.93 km²

Nearest Towns: Masindi, Bunia, Pakwach

International Importance: Ramsar, Important Bird Area, Transboundary Wetland



Overview

The Murchison Falls-Albert Delta Wetland System is a Ramsar site, situated in the north west of Uganda, 90 km north of Masindi town. The system is situated in Masindi and Gulu Districts along River Nile towards Lake Albert. This site reaches from the top of Murchison Falls to Lake Albert and the majority of the Ramsar is within the Murchison Falls National Park. The stretch declared as a Ramsar site is part of the Victoria Nile and includes thick papyrus swamp through which over 50 small tributaries flow. The convergence zone between Lake Albert and the Victoria Nile delta

forms a shallow wetland which is also part of an Important Bird Area. On the southern shore, the second largest tributary to Lake Albert, the Semliki River forms a delta dominated by papyrus, however this delta is not a Ramsar site. There are a number of smaller tributaries, with typical wetland vegetation at their confluences with Lake Albert.

Physical Features

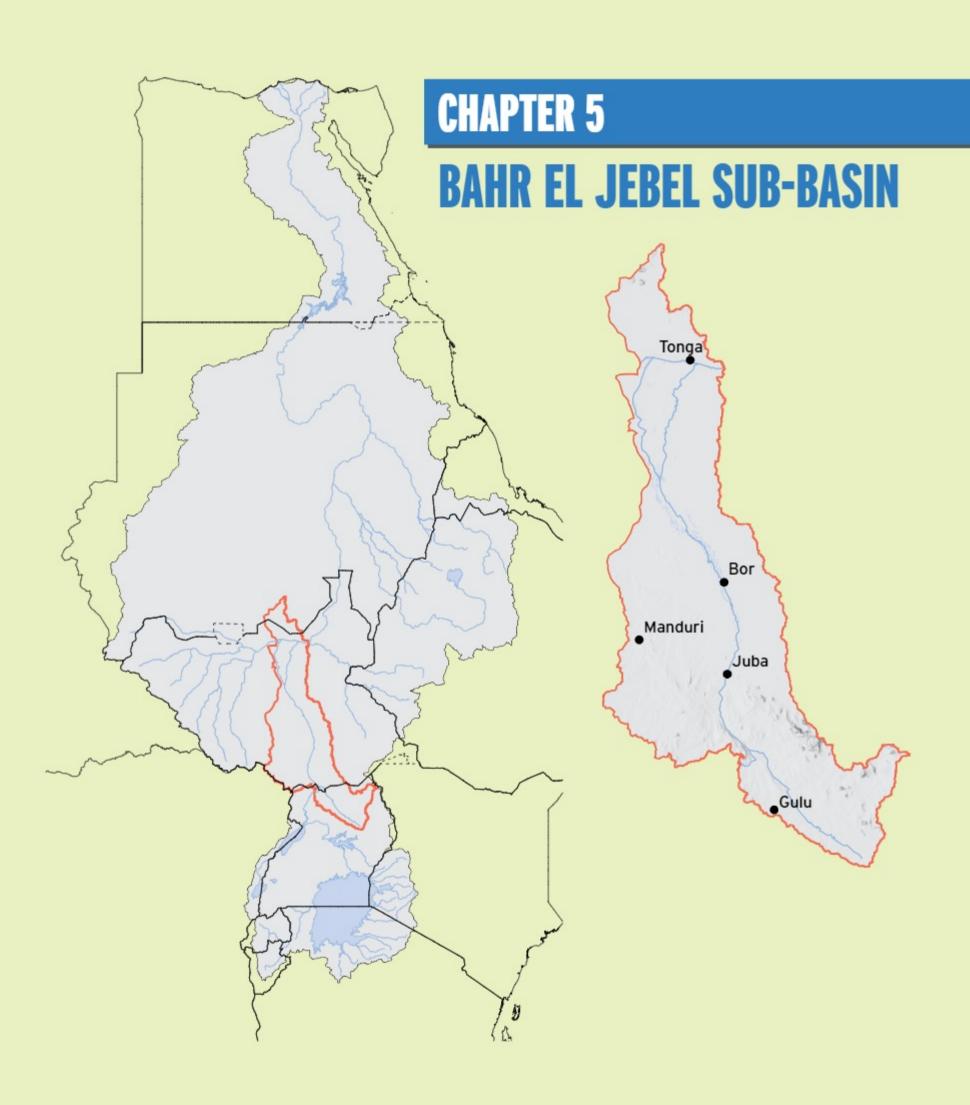
Lake Albert lies between two parallel escarpments in the Western Rift Valley, at an altitude of 619 m, with an extreme length of 180 km and a maximum width of 43 km. Just under 44% of its surface is in DRC and the rest is in Uganda. Its deepest point, 56 m, lies 7 km off the western shore, from where the land rises steeply to a high plateaux more than 2000 m a.s.l.

The principal affluent streams of Lake Albert are the Semliki, which enters at the southern end and the Victoria Nile, which enters very close to the northern end. Both rivers form deltas at the lake confluence. While the Nile carries more water than the Semliki, it has little influence on the ecology of the lake, other than to maintain water levels. Lesser streams enter the lake from DRC are, from south to

north: the Kisege, Ndrigge, Muita, Nyamusiki, Kilowir and Mboge Rivers. Lesser streams entering the lake from Uganda are, from south to north, the Waiga, Waisoke, Wald, Waisembe, Wambabya, Nkusi, Muzizi and Wasa Rivers. However, all these rivers are highly seasonal and of only secondary importance to the two major rivers. Some periodically inundated land occurs around the southern margin of the lake in the vicinity of the Semliki River Delta, and also along the eastern shore at some isolated spots, notably the Victoria Nile Delta (Byaruhanga & Kigoolo, 2005g).



Bull elephant walking near Lake Albert, Murchison Falls National Park, Uganda



Introduction	89
Socio-economic context of wetlands in Bahr El jebel sub-basin	90
Hydrological context of wetlands in Bahr El jebel sub-basin	91
The Sudd wetland	92
Lake Yirol	96
Lake Anyi	97
Lake Nyiropo	98

INTRODUCTION

Overview

After exiting Lake Albert, the Nile flows northwards into South Sudan where it is known as the Bahr el Jebel. The Bahir El Jebel River stretches from Nimule to Malakal and receives various inflows along this stretch. The Bahr el Jebel sub-basin is a relatively narrow elongated area around the Bahr el Jebel River. About three quarters of the sub-basin area lie in central South Sudan while small parts are located in northern Uganda (the Aswa River Catchment), and in Sudan (K. Hagaraf River catchment).

The Sudd wetland, which lies entirely in South Sudan and covers a vast area, is the dominant wetland system of the Bahr El Jebel system. The Sudd is characterized by permanent marsh lands, lakes and swamps, and a braided system of inflowing and draining rivers. The dominant vegetation type in the Sudd area is grassland. The Aswa River Catchment in Uganda also has considerable areas of seasonal and permanent riverine wetlands. The Bahr El Jebel is the largest source of surface water and dominant contributor to water balance of the Sudd

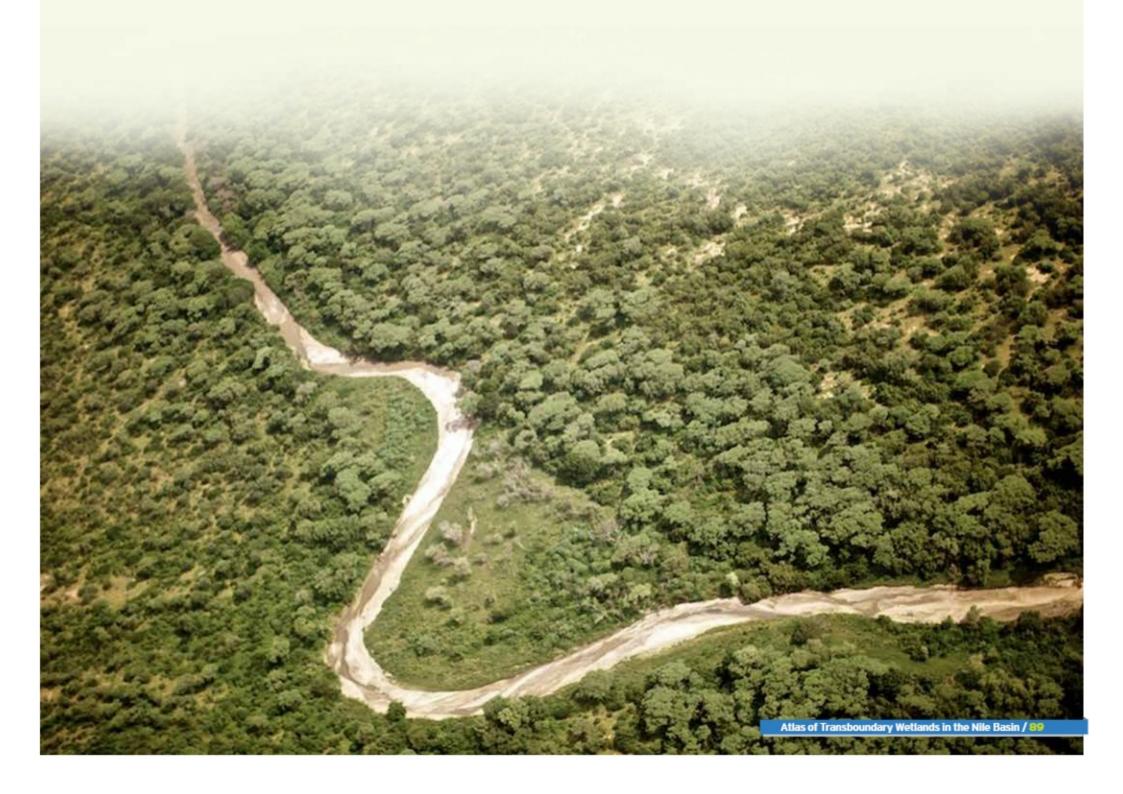
wetland system. Nearly half of the water flowing into the Sudd at Mongala is lost through evaporation. A number of studies have been conducted to try and understand the hydrologic processes of this large and complex wetland. However, to date the Sudd remains one of the least understood wetland systems in the Nile River Basin

Climate

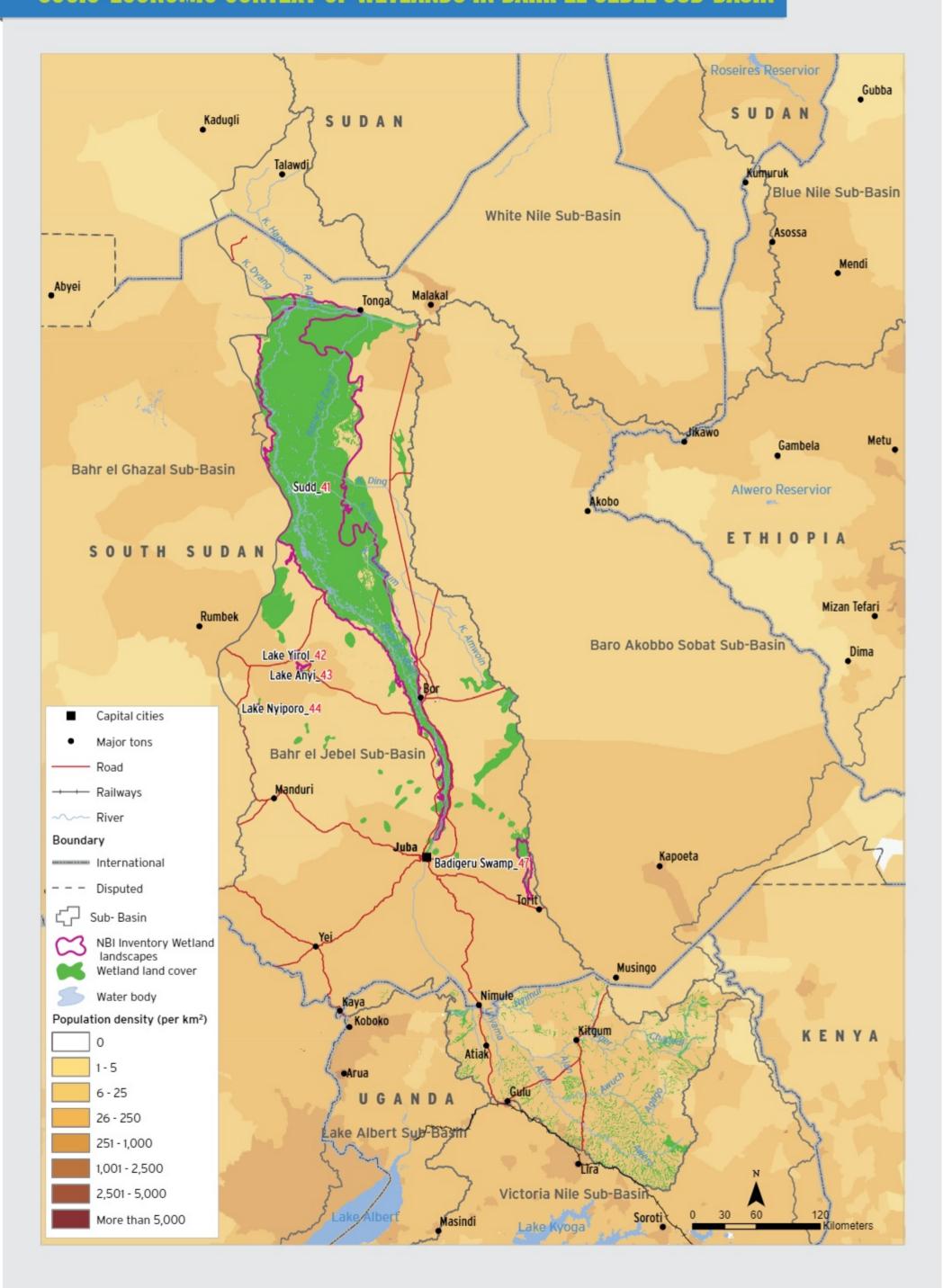
In the majority of the Bahr El Jebel sub basin there is one distinct wet season from April to October. Average precipitation over the upstream part of the sub basin is over 1000 mm/year but reduces to below 1000 mm/year in the downstream parts in South Sudan. Average potential evapotranspiration is 1700 mm/ year (NBI, 2016).

Ecosystem Services

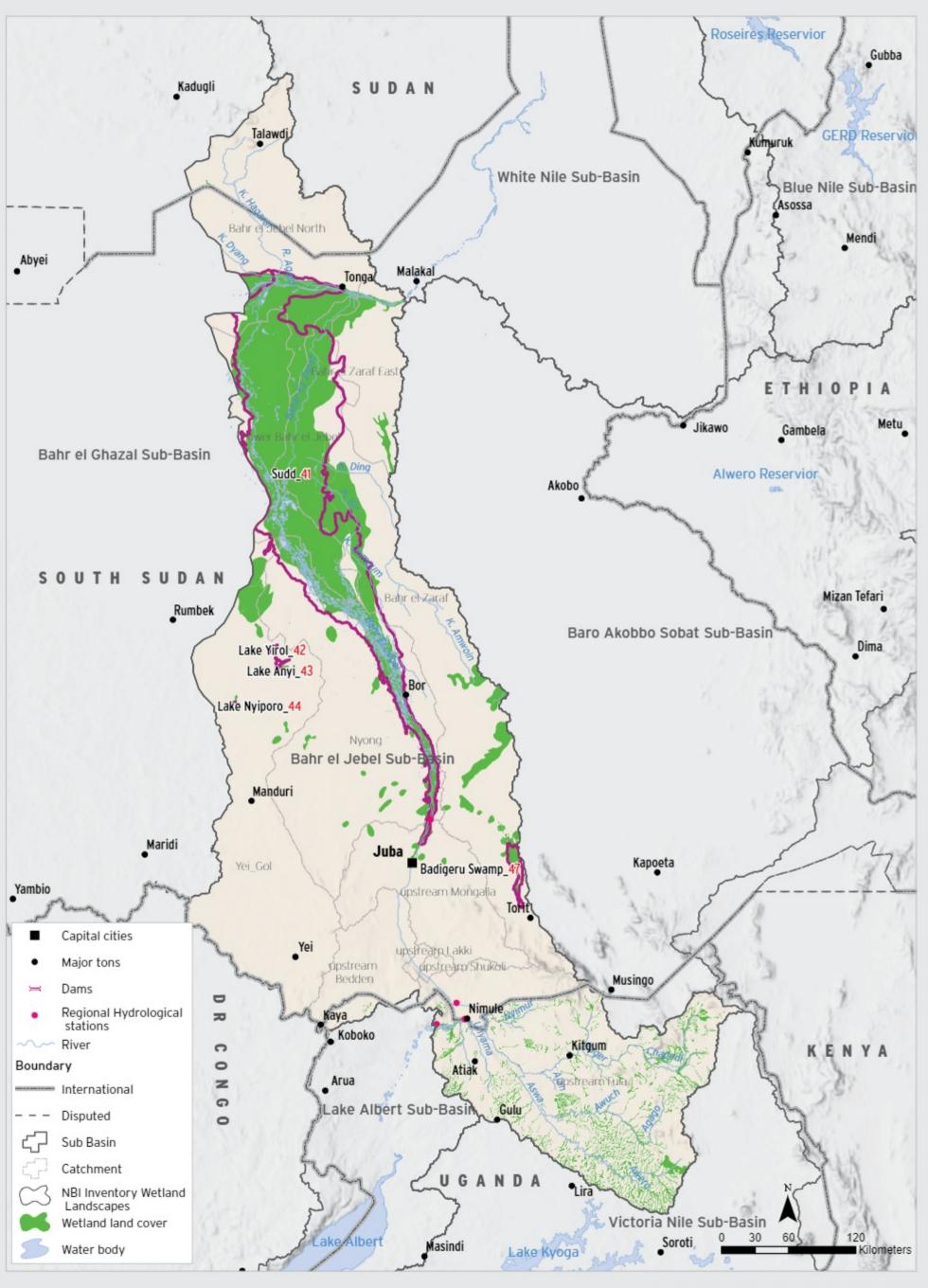
The ecosystem services identified for this sub basin are services related to the Sudd and are further presented in WP 3: Ecosystem Service Assessmentent.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN BAHR EL JEBEL SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN BAHR EL JEBEL SUB-BASIN

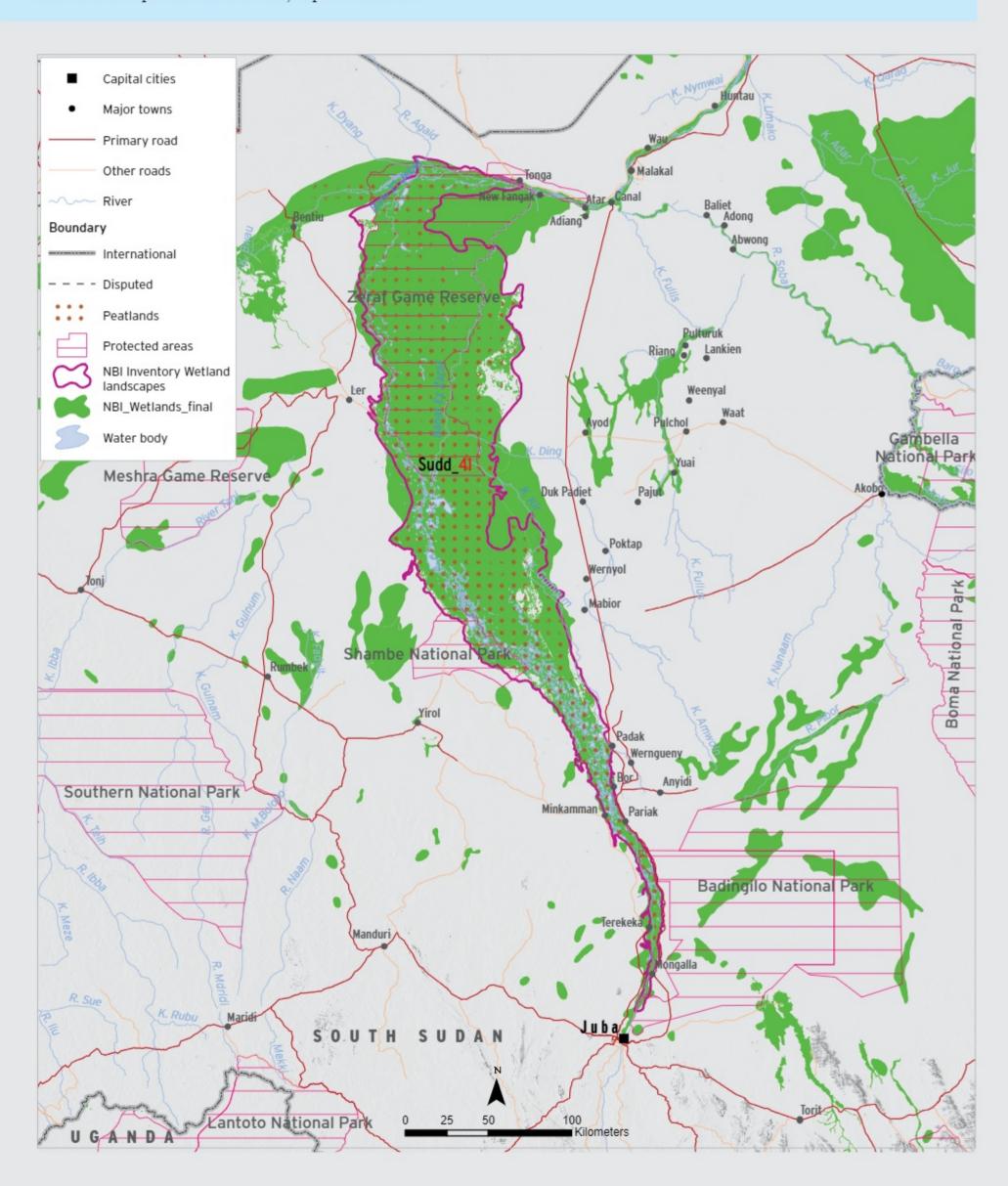


THE SUDD WETLAND

Name: The sudd Country: South Sudan Coordinates: 6°48'14"N / 31°11'51"E

Altitude: 448 – 394 m a.s.l. Area: 23,903 km2

Nearest Towns: Juba, Mongalla, Malakal, Bor and Yirol International Importance: Ramsar Site, Important Bird Area



Overview

The Sudd is the largest wetland on the Nile River system. It lies in South Sudan between latitudes 5°10'N and 9°35'N and longitudes 31° 45' E and 31°4' E. Located downstream of Lake Albert, the wetland covers a vast area that is characterized by permanent marsh lands and swamps, seasonally inundated lands and braided river systems. The swamps and floodplains of the Sudd support a rich ecosystem, which is essential to the pastoral economy of the local population. In addition, the Sudd is a key element of the hydrology of the River Nile. The Bahr el Jebel is the dominant contributor to the water balance of the Sudd. Nearly half of the water that enters the Sudd at Mongalla is lost through evapotranspiration on its course through the wetland system. Several studies have attempted to understand the hydrologic processes of this wetland. Notwithstanding, the complexity and vastness of the system makes it one of the least understood wetlands in the Nile River Basin.

Physical Features

The name "Sudd" is derived from an Arabic word meaning barrier or obstacle and historically it has been an obstacle for exploration. 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. 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.

Climate

The Sudd stretches across two climatic zones. 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.

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 700-1000 mm/year (NBI, 2016). Estimates of rainfall from remote sensing between 2007 and 2011 over the Sudd region show similar precipitation quantities (654-904 mm/year), although year to year variation is significant (Wilusz et al., 2017).

Temperature variations across months increase in the northern part of the Sudd. The hottest months are March and April and the lowest temperatures occur during July and August. In Juba, temperature varies between 19 and 37°C whereas Malakal receives temperatures between 18 and 40°C. Relative humidity ranges from 55 % in January to 80 % in August and September (NBI, 2016).

Evapotranspiration varies spatially and seasonally across the Sudd. Seasonal extremes in evapotranspiration as well as in flooding are common in the north western region of the Sudd. Annual evapotranspiration can be almost twice as high than the annual precipitation, which ranges between 1200 -1500 mm/year compared to 650-900 mm/year of rainfall (Rebelo et al., 2012; Wilusz et al., 2017). The peak evapotranspiration usually occurs right after the rainy season, when vegetation growth is favoured due to low cloud cover and unlimited water availability (Rebelo et al. 2012).

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 has risen by 0.6 °C and minimum temperature by 1.5 °C. Humidity has decreased as well as daily sunshine hours by 10 %, spectively.

Hydrology

The Sudd expands laterally along the Bahr el Jebel from south to north. From Mongalla to Bor the river channel meanders from side to side through an incised trough. From there the water flows in meandering river stretches and various channels and lagoons throughout the dry season. When the flood levels are high enough, the river spills over its alluvial banks and the floodplains consisting of semi-flooded grasslands 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 subdued channels characterize the wetland area between Shambe and Lake No. Just north of Shambe, the Bahr el Zeraf splits from the main river flows in north-north-westerly direction, only to join the White Nile again downstream of Lake

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 neighbouring 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.

The Sudd wetland receives its water from the Bahr el Jebel and from direct rainfall. 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). However, Sosnowski et al. (2016) found that increased precipitation in the downstream regions of the Sudd correlates with larger wetland extents. 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).

Monitoring inflow and outflow into and from the Sudd is a challenge, due to its inaccessibility and extent. 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).

Mohamed and Savenije (2014) analysed long-term trends of Sudd hydrology between 1900 and 2000. During that time period precipitation and evaporation remained comparatively stable. 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 >30,000 106 m³/ 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).

It is estimated, that approximately half of the Bahr al Jebel flow evaporates on its course through the Sudd. In 1961-1983 the average annual inflow and outflow was 49.2 km3 and 20.8 km3, respectively (Sutcliffe & Brown, 2018). Annual evapotranspiration is twice the annual precipitation over the Sudd but deep groundwater recharge in the Sudd is negligible (Sutcliffe & Parks, 1987; Wilusz et al., 2017). An evapotranspiration deficit occurs during the months of the dry season from August to April (Rebelo et al., 2012). As the area of the Sudd increases, right after the rainy season, evapotranspiration reaches a peak.

Water storage volumes are also highly seasonal and driven by flooding. As the Bahr el Jebel enters the wetland, its flow slows down, to average 0.470 m/s in the main channel and 0.003 m/s on average in the papyrus swamps between Bor and Shambe. Along the Bahr el Jebel there are depressions that lead inland from the swamp. These depressions are called khors and play a significant role in carrying floodwater inland, which allows for a richer more grassy vegetation to grow. Indirect flow through the papyrus swamp or other wetland vegetation is relatively small. Only 7% of the Bahr el Jebel flow moves though swamps and lagoons whereas the rest flows in a network of channels (Petersen et al., 2008a).

Wetland Extent

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 the inundated areas in the Sudd corresponds to seasonal rainfall patterns upstream of the Sudd. The wetland area can expand to 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 three months after the water inflow into the Sudd is at its annual peak, the total flooded area of the Sudd is at its maximum extent.

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 km² (Rebelo et al., 2012).

Estimating 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 km² to 90,000 km². 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).

Biological Features

The Sudd is composed of a maze of wetland ecosystems, grading from open water and submerged vegetation to floating fringe vegetation, seasonally inundated woodlands, rain-fed and riverfed grasslands, and floodplain scrubland. There are three swamp types: Vossia cuspidata swamps (which cover 250 km²), Cyperus

papyrus swamps (3,900 km²) and Typha domingensis swamps (13,600 km²). Grassland can be divided into seasonally riverflooded 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 characterized 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. 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 (BirdLife International, 2019; Green & El-Moghraby, 2009).

At times Eichhornia crassipes (Water 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 Oruza longistaminata, wild ricegrass. 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 (Green & El-Moghraby, 2009; Rebelo & El-Moghraby, 2018).

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).

Several endangered animal species are found in the Sudd namely, Acinonyx 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). Other swamp dwelling mammals include Hippopotamus amphibius (hippoptamus), 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; El-Moghraby et al., 2006; Rebelo & El-Moghraby, 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 Shoebill avoids the main channels of the swamp and very tall vegetation. The Shoebill prefers the smaller channels and pools specifically those surrounded by Typha. It mostly eats air-breathing fish which the Shoebill ambushes when they come up for air. (BirdLife International, 2019; Green & El Moghraby, 2009; Rebelo & El-Moghraby, 2018).

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). 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 muriei, 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).

Ecosystem Services

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 grassland, which is the most productive for year-round grazing caused by the high protein content

of the dead grass. Furthermore, 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).

Fishing is also an important seasonal activity and source of food as fish migrate to the nutrient-rich floodplains. It is the second most important occupation of the inhabitants of the wetlands, in particular for the Shilluk and Nuer tribes, and is typically conducted seasonally alternately with crop production and livestock-rearing (Rebelo & McCartney, 2012). Many fish species migrate from the surrounding rivers to the nutrientrich 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 (Riak, 2006).

Subsistence hunting is also important to the Nilotes of the Sudd catchment. Crop production is not a significant occupation although some subsistence agriculture is carried out in the highland areas during the wet season (Rebelo & El-Moghraby 2018). The tree vegetation is an important source of firewood and building poles (Riak 2006). The wetland is used as well for commercial and non-commercial navigation (Rebelo & El-Moghraby 2018).

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 socioeconomic benefits of the wetland to the communities living in its catchment are considered as immense (Rebelo & El-Moghraby 2016).

Ultimately, the Sudd has very important cultural values for the local tribes, from sacred wildlife species (e.g. Nile lechwe (Ontragus 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 properly managed, the Sudd wetland can greatly contribute to the sustainable economic development of South Sudan.

Drivers of Change

The civil war in Sudan has put the Sudd under considerable pressure. During the war more people gained access to fire arms and hunting regulations could not be entered. Hence uncontrolled hunting remains a threat to wildlife in the Sudd. The inflow of people with their livestock who were seeking refuge in the Sudd put pressure on the natural resources of the natural resources. This led to competition for grazing land, deforestation, and infrastructure development in the Sudd (Rebelo & El Moghraby, 2018).

The Sudd is potentially interesting for oil exploitation. Mining for oil in the Sudd can threaten the hydrology, water quality, wildlife and biodiversity of the Sudd. Several blocks have already been allocated to oil companies and exploration drilling is underway in the permanent swamps. Oil exploration and extraction can disrupt water flow patterns as a result of seismic testing and diking. Furthermore the wetland will likely get fragmented due to the construction of roads and other infrastructure. Contamination through human waste and oil spills is also a severe threat to the wetland (Rebelo & El Moghraby, 2018).

In 1980 the construction of the Jonglei Canal project started, to divert the inflow of the Sudd. This would create a navigable canal and more importantly would prevent approximately 4.7 109 m³ 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. However, the Sudanese civil war in 1983 put the project on halt, after 260 of 230 km were already completed. 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. 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). The completion of the canal would significantly impact climate, groundwater recharge, sedimentation, and water quality. 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. In 2008, discussions to continue the work were resumed. However, following subsequent civil unrest and recent political instability in South Sudan, plans for the future of the canal are unclear (Lunt et al., 2019; Rebelo & El Moghraby, 2018).

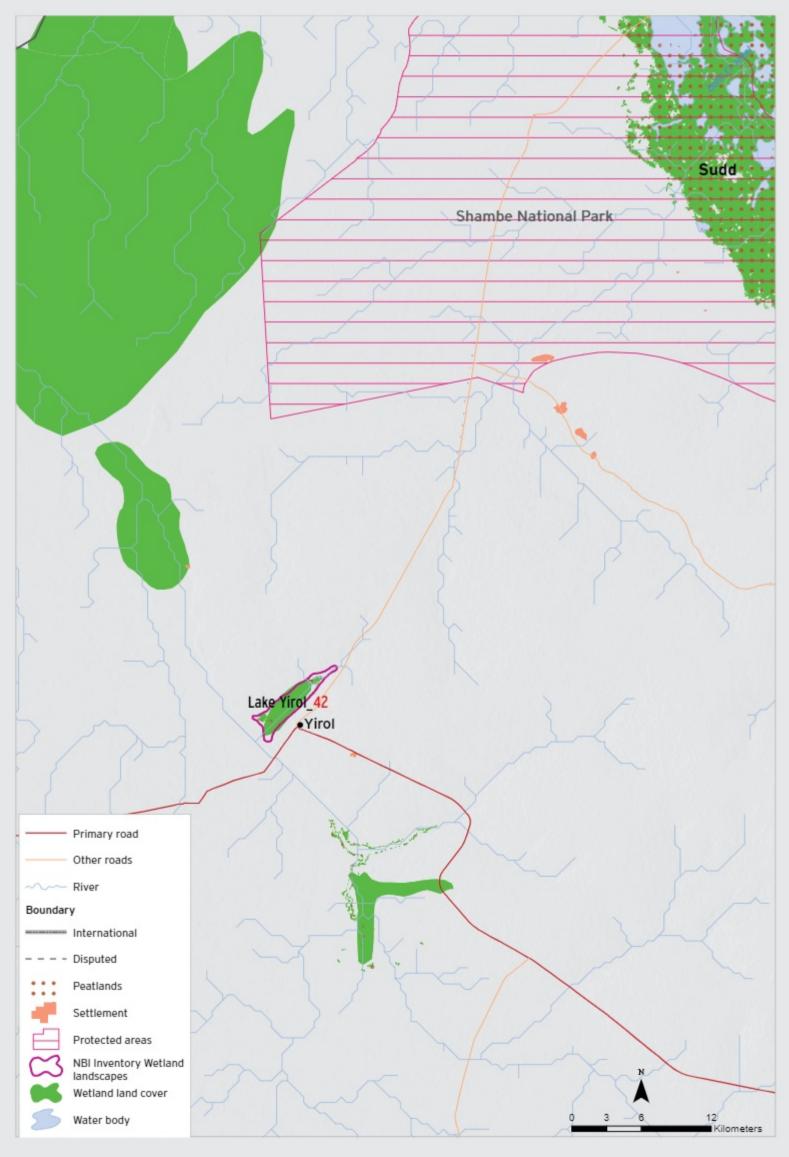
The effect of climate change on the Sudd is unclear. The rainfall in the African Great Lakes region is likely to increase, which in turn could lead to the expansion of the Sudd (Lunt et al., 2019). The effects on the biota of the Sudd are unclear. Invasive species such as water hyacinth already exert pressure on the wetland. Increase of wetland extend in turn can cause a rise in methane emission from the Sudd. Already between 2011 and 2015 a large short-term increase of methane (a potent greenhouse gas) emissions from the Sudd could be proven and correlated with augmented water inflow from the White Nile and a subsequent increase of the flooded area in the Sudd (Lunt et al., 2019).

LAKE YIROL

Name: Lake Yirol Country: South Sudan

Coordinates: 30°29'43" N / 6°34'13"E

Altitude: 428 m a.s.l. Area: 11 km2 Nearest Towns: Bor, Rumbek International Importance:



Overview

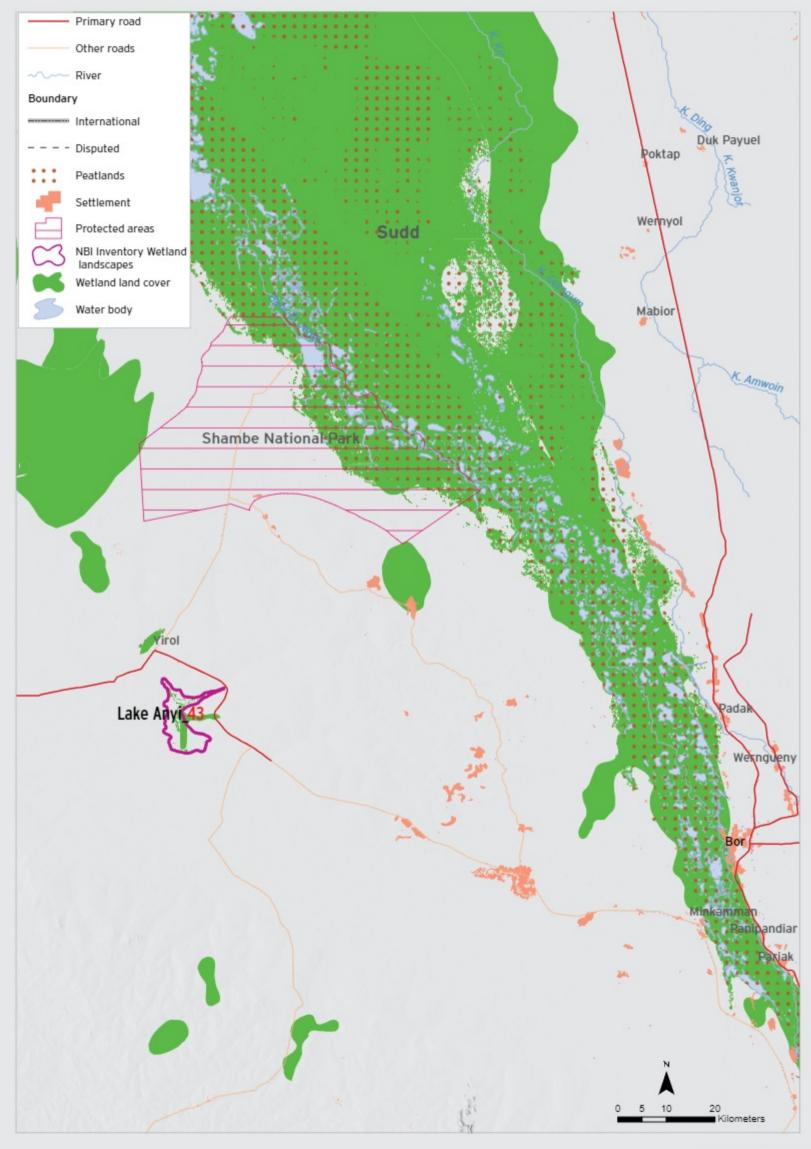
Lake Yirol is 9 km long, 2.5 km wide at maximum, and is fed by a local stream. The lake lies in Yirol County, Eastern Lakes State, next to a small town with the same name. It is shallow, swampfringed, has a peripheral floodplain and drains from its southern end to the Lau or Yei River, which eventually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

LAKE ANYI

Name: Lake Anyi Country: South Sudan

Coordinates: 6°27'37"N / 30°33'28" E

Altitude: 430 m a.s.l. Area: 73 km2 Nearest Towns: Bor, Rumbek International Importance:



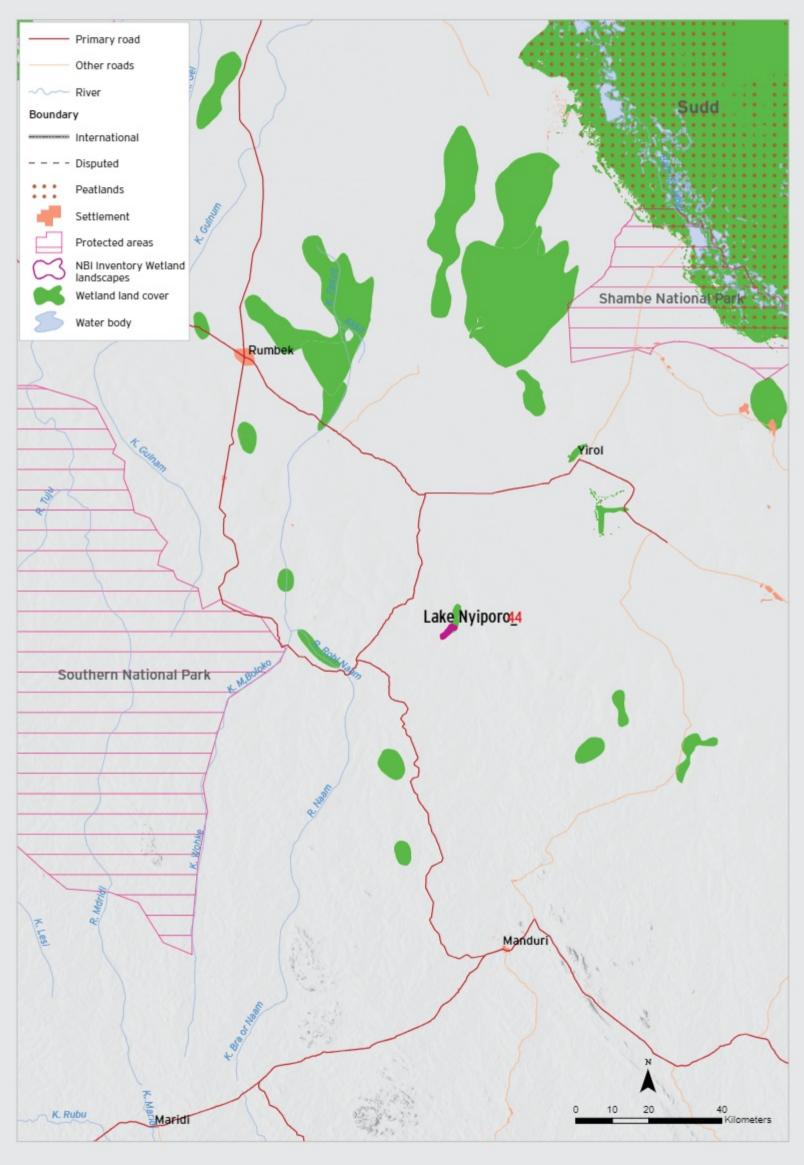
Overview

This lake is shaped like an inverted L, 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 metres higher than the lake. It drains to the Lau or Yei River from the north western end. It is unprotected (Hughes & Hughes, 1992).

LAKE NYIROPO

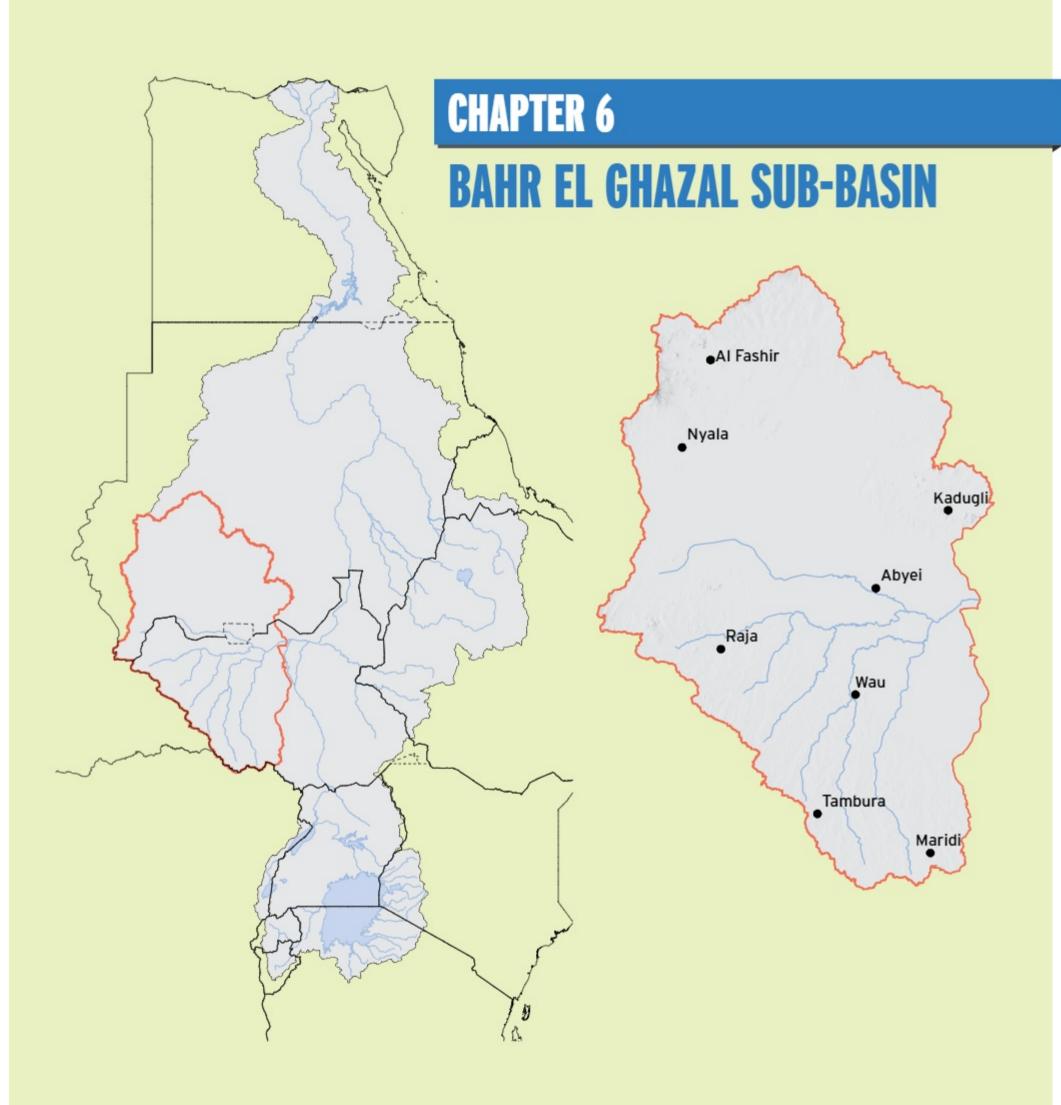
Name: Lake Nyiropo Country: South Sudan Coordinates: 6°8'16" N / 30°10'59" E

Altitude: 450 m a.s.l.
Area: 2 km2
Nearest Towns: Bor, Rumbek
International Importance:



Overview

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).



Introduction	101
Socio-economic context of wetlands in Bahr el Ghazal sub-basin	102
Hydrological context of wetlands in Bahr el Ghazal sub-basin	
The Bahr el Ghazal River Floodplains	
Lake Ambadi	

INTRODUCTION

Overview

The Bahr el Ghazal is one of the three main sources of the Nile. next to the headwater sections of the Equatorial Lakes and the Ethiopian Highlands. There are numerous tributaries to the Ghazal, that flow over the sub basins large area with gentle slope and large floodplains, across which a majority of the discharge evaporates. The Bahr el Ghazal sub basin is shared between South Sudan and Sudan, with headwater streams that originate from the border of the Congo Basin. It combines three ecoregions, Sudanian savanna in the southwest. Sahelian acacia savanna in the North and grassland towards the Sudd.

Climate

Similar to the Sudd, the Bahr el Ghazel basin stretches across two climatic regions. The southern tributaries lie in the tropical wet and dry zone whereas the climate further downstream is influenced by the subtropical dry, semiarid climate. In the southwestern part of the Basin average annual rainfall is over 1,500 mm, which decreases towards the northeast to below 500 mm/year (NBI, 2016). The average annual potential evapotranspiration over the sub basin is 1,800 mm. The air temperature reaches its maximum in March and April and is on average 28°C. Humidity during the dry season is about 20 % and during the wet season 80 % (Y. A. Mohamed et al., 2004; Sutcliffe & Parks, 1999).

Biological Features

The name Bahr el Ghazal translates to 'sea of gazelles' in Arabic. Biodiversity is similar to the Sudd. The vegetation in the Bahr el Ghazal floodplain is the same as in the Sudd. There are 37 taxa in the Bahr el Ghazal Wetland group that have an IUCN threat status of interest. In total there are 28

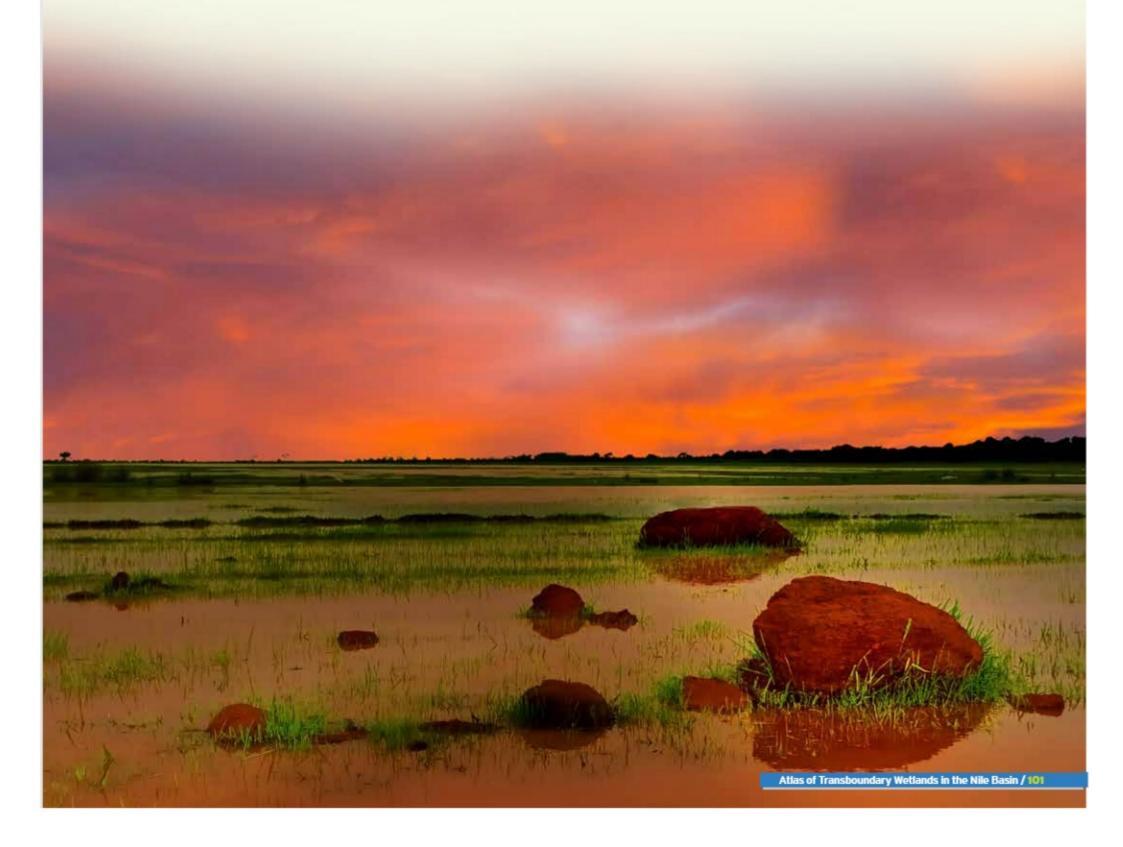
flagship species for example
Balaeniceps rex, Balearica
regulorum, Crocodylus niloticus,
Cyperus papyrus, Hippopotamus
amphibius, Nettapus auritus,
Pan troglodytes schweinfurthii
and Tragelaphus spekii. Pistia
stratiotes is an important alien
species in the wetland group.
Bahr el Ghazal is home to the
endemic Ontragus megaceros.

Ecosystem Services

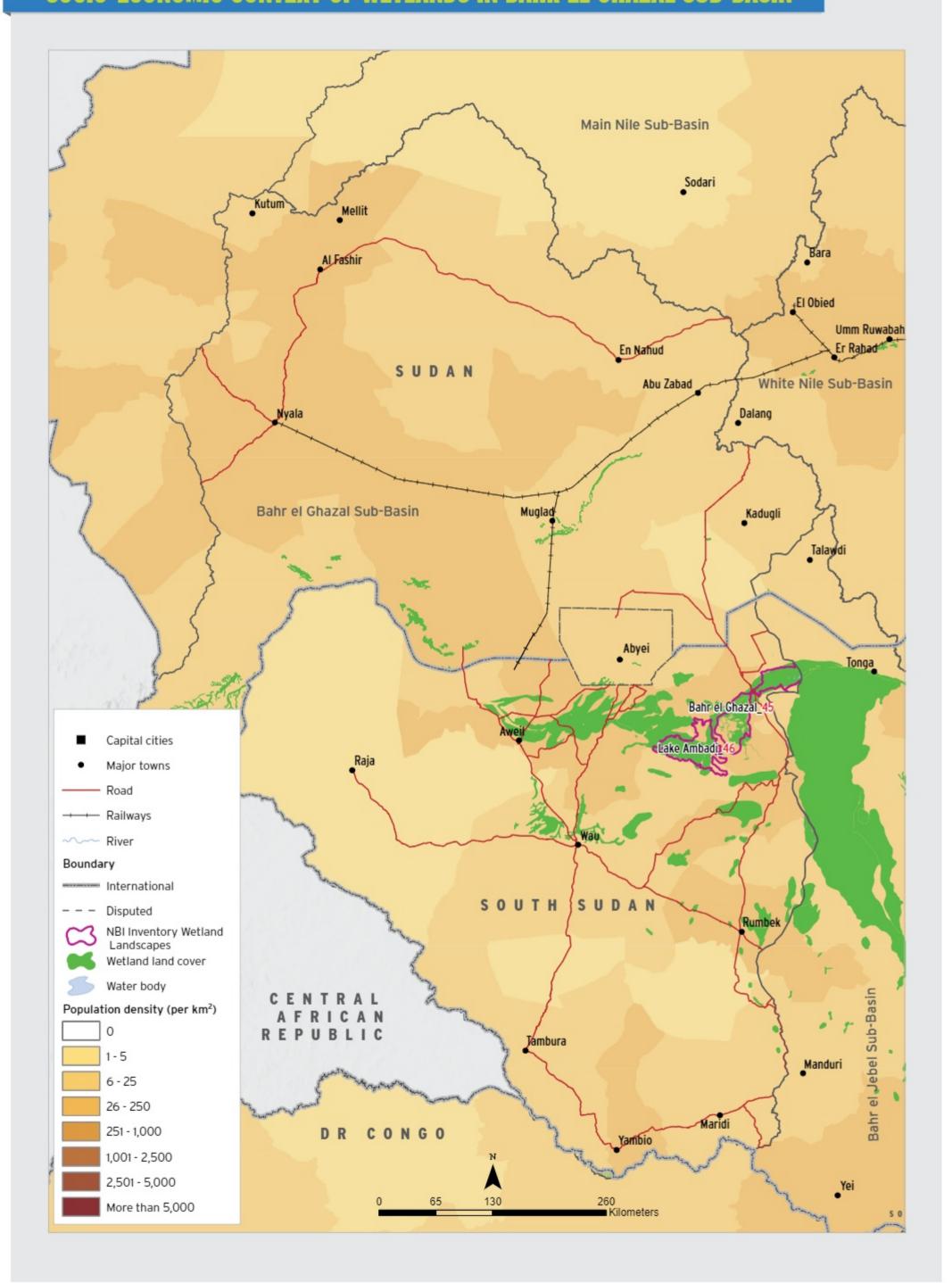
Literature on ecosystem services in the Bahr El Ghazal Basin is scarce. However, there is a report by Ibnaof et al. (2013) that assessed the economic value of ecosystems and biodiversity within Western Bahr El Ghazal State, a State of south Sudan located within the Bahr el Ghazal sub-basin. The main ecosystem uses considered are pastoralism, agriculture, fisheries, fresh water, fuelwood, carbon sequestration, water production, cultural and recreational values. The Gum Arabic (Acacia senegal & Acacia

sayal) extraction and production is of particular interest for the region, with an approximate value of \$65-\$250M (Ibnaof et al., 2013).

Rebelo & McCartney (2012) state that the livelihood activities of Bahr el Ghazal are similar to those of the Sudd. Therefore, potential ecosystem services of these wetlands are fish resources, subsistence hunting, fruits and other food sources, fresh water, fuelwood, building materials and medicinal products. Potential regulating and supporting services include the regulation of water flow, nutrient retention, water purification, natural hazard and climate regulation, and potentially important cultural values of the locals. The ecosystem services identified for the Bahr el Ghazal are further presented in WP 3: Ecosystem Service Assessment.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN BAHR EL GHAZAL SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN BAHR EL GHAZAL SUB-BASIN



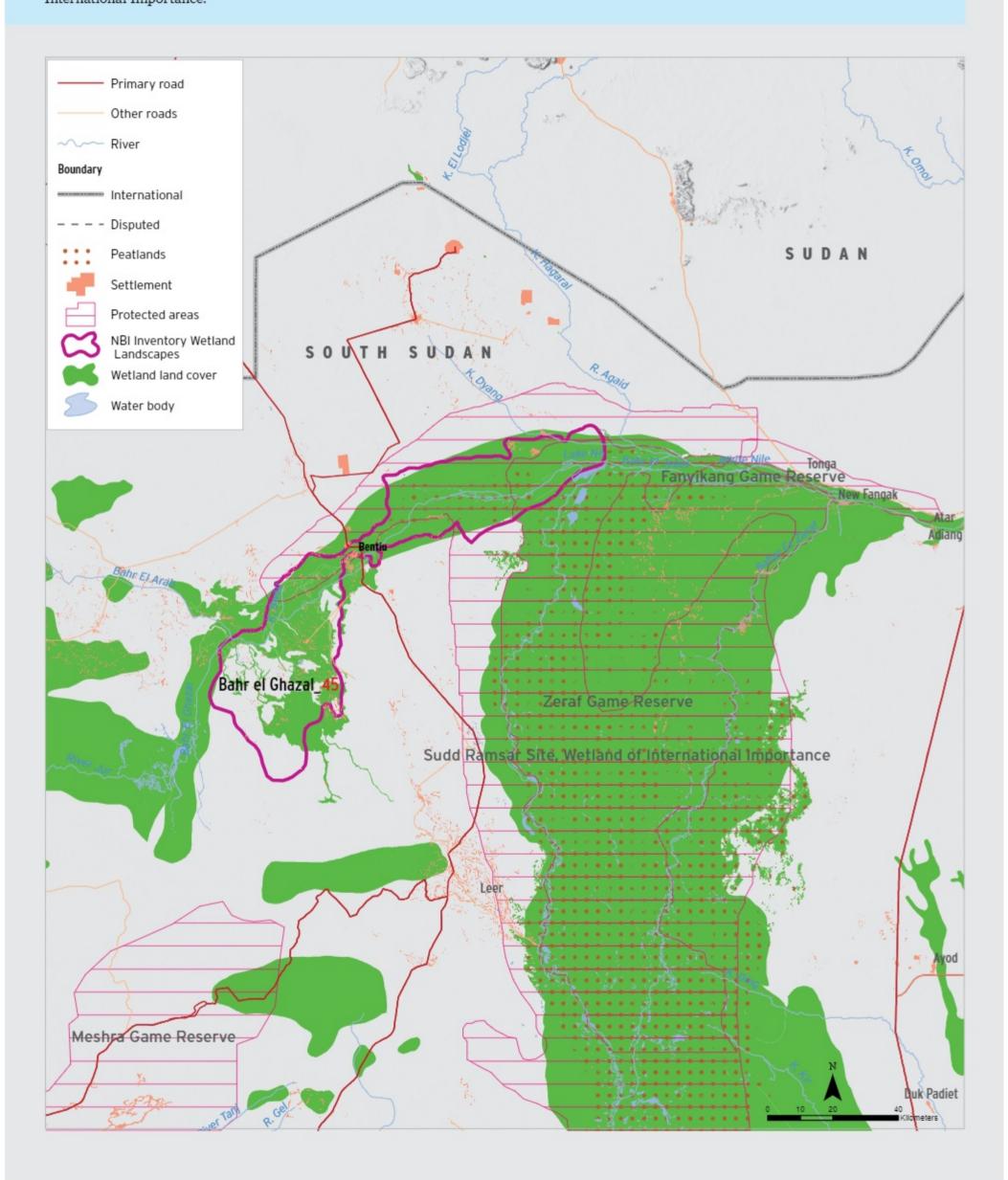
THE BAHR EL GHAZAL RIVER FLOODPLAINS

Name: Bahr el Ghazal River Floodplains

Country: South Sudan

Coordinates: 9°16'52" N / 29°51'30" E

Altitude: 400 m a.s.l. Area: 3,085 km² Nearest Towns: Malakal International Importance:



Overview

Swamps and floodplain accompany the Bahr el Ghazal from Meshra' el Rek (8°26'N/29°16'E) through Lake Ambadi virtually continuously to Lake No and the confluence with the Sudd swamps and the Bahr el Jebel. The flora and fauna of the perennial swamps is similar to that of the Sudd. No part of the Bahr el Ghazal is protected. Artisanal fisheries occur on the river.

Physical Features

Even though the Bahr el Ghazal is one of the main western tributaries of the Nile, the contribution of the Bahr el Ghazal to the White Nile is almost negligible compared to the Bahr el Jebel (Sutcliffe & Brown, 2018). The area of the total Bahr el Ghazal Basin is 59.3 km² of which 10-20% are swamps whose spatial extent follows a seasonal pattern (Mohamed et al., 2004). Between 1942 and 1987 flooded areas ranged between 4,000 and 17,000 km2 (Sutcliffe & Parks, 1999).

There is uncertainty about the connectivity of the Bahr el Jebel to the basin of the Bahr el Ghazal. In Rebelo et al. (2012) the two wetlands are considered as separate systems, whereas Sosnowski et al. (2016) show that the Sudd and Bahr el Ghazal systems are linked even during the dry season. Spill from the Bahr el Jebel into the Ghazal Swamps is mentioned as a possible cause for water losses from the Sudd. Even though there is a continuous slope from the Sudd to the Bahr el Jebel Basin the low gradient and long distance favour evaporation of spillage from the Jebel before it reaches the Bahr el Ghazal Basin (Petersen et al., 2008).

First the tributaries of the Bahr el Ghazal drain across an ironstone peneplain, which transforms into clay grassland plains where the rivers meander between alluvial banks in a widening floodplain. The sediment load of the Bahr el Ghazal tributaries is higher than the lake fed Bahr el Jebel hence alluvial channels are likely to form. Further downstream,

the rivers emerge into a zone of unrestricted flooding over clay plains. The lower courses of the Bahr el Ghazal resemble the Sudd wetland in morphology and in the processes of spilling and drainage of the river (Sutcliffe & Parks, 1999).

The Bahr el Ghazal drains a dry plateau on the South Sudanese border to the DRC, together with a part of Southern Darfur. The basin receives inflow through numerous small streams that originate at an elevation of 700-1000 m a.s.l. High rainfall, steep slopes and rapid runoff characterize these headwater regions. The rivers Lol, Jur and Tonj are the three major tributaries of the Bahr el Ghazal and account for 80 % of the total inflow (Sutcliffe & Parks, 1999). The contribution of water by the Bahr el Arab from the west is minor compared to the streams from the highlands in the south. The total inflow into the Bahr el Ghazal accumulates to 11.3 Gm³/ year. The inflow is likely to be an underestimation, as several tributaries are not gauged or have discontinuous records,

especially during high flows. On its course through the wetland most water evaporates. Only 3 % of the inflow reaches the basin exit just upstream of Lake No. The annual evaporation of the Bahr el Ghazal is 1,500 mm/year and there is a distinct variability in soil moisture storage, which controls evapotranspiration (Y. A. Mohamed et al., 2004).

Drivers of Change

Main issues in the area include potential hazards through oil exploitation and its related infrastructure. Much of the biodiversity and management efforts in the Bahr el Ghazal swamps can be compared with those of the Sudd. The area has been affected by civil war for many years leading to an uncontrolled use of the natural resources including hunting and the return of refugees imposes pressure on the wetland as well. In general the Bahr el Ghazal and the Sudd are confronted with similar threats (NBI, 2009). presented in WP 3: Ecosystem Service Assessment.



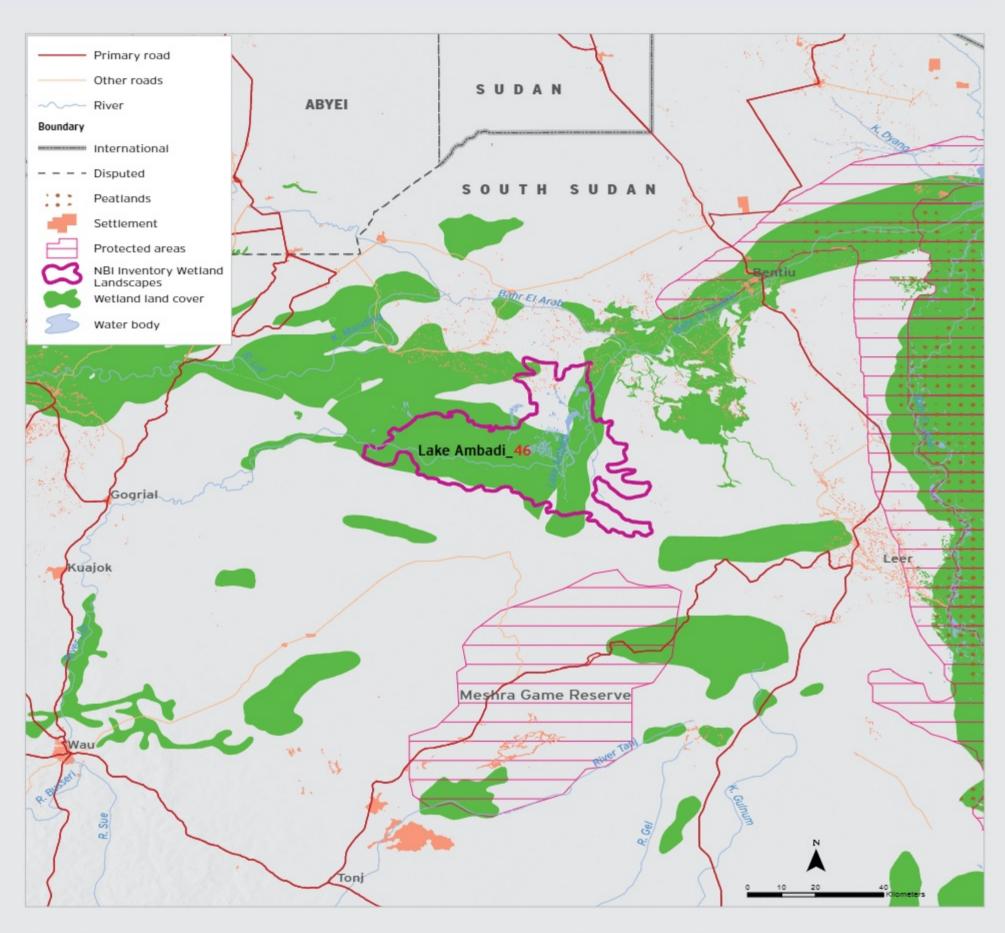
Lake Shambe along river Nile

LAKE AMBADI

Name: Lake Ambadi Country: South Sudan

Coordinates: 8°42'16" N / 29°19'16" E

Altitude: 392 m a.s.l.
Area: 2,228 km²
Nearest Towns: Gogrial, Bentiu
International Importance:



Overview

The lake is formed by a widening of the channel of the Bahr el Ghazal. There is little information on the lake, one of the published descriptions available for the Ambadi is by Hughes and Hughes (1992). The lake is 10 km long, 1-3 km wide, and has a maximum depth of 3 m. It is set in perennial herb swamps on an otherwise

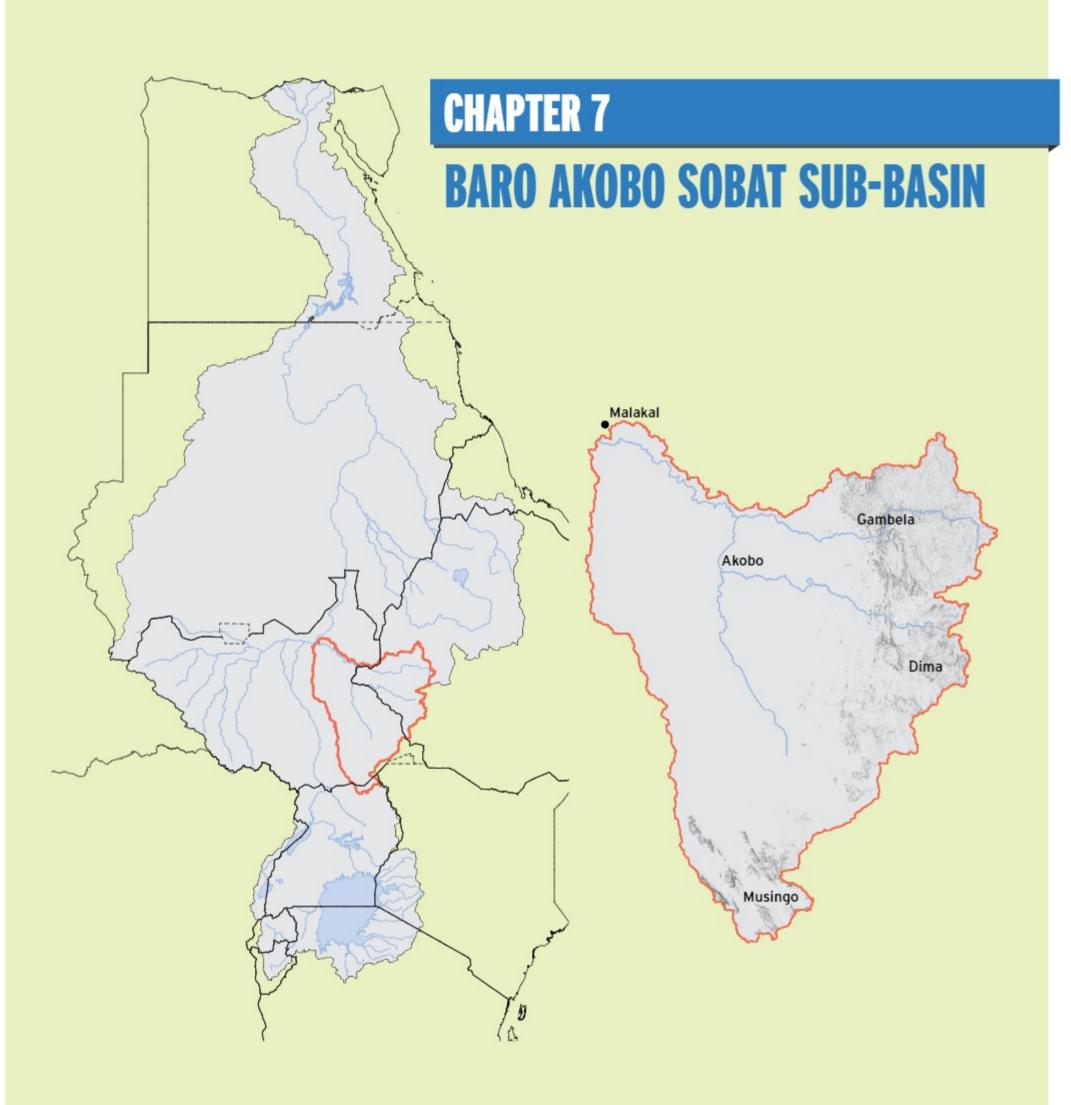
featureless plain. The Bahr el Ghazal flows in at the south and out at the north, then ends in Lake No. The Jur flows into the Ambadi from the west. It is a seasonal stream and the principal input of the lake with a flow rate that may reach 35 million m³/day in September. The water of the lake is generally clear with Secchi depths exceeding 2 m. It is acidic, with a pH range of 6.4-6.8, and

moderately well oxygenated.

Physical Features

The floor is covered by a mat of vegetation dominated by Ceratophyllum demersum, Myriophyllum spicatum, Najas pectinata and Potamogeton pectinatus. The peripheral vegetation is dominated by Vossia cuspidata, with some

Echinochloa, and floating carpets of Eichhornia crassipes. The zooplankton and macroinvertebrate community of the Lake has been described by Green (1984). The macroinvertebrate fauna is sparse but diverse and numerous oligchaetes, dragonflies, snails and caenid mayflies have been found.



Introduction1	109
Socio-economic context of wetlands in Baro Akobo Sobat sub-basin1	110
Hydrological context of wetlands in Baro Akobo Sobat sub-basin	111
Badigeru Swamps 1	112
Kenamuke/ Kobowen Swamp	113
Lotilla River Swamps	114
Veveno/Adiet/Lilebook Swamps	115
Baro Akobo Wetlands1	116

The Baro-Akobo-Sobat (BAS)
System is a vast and complex area containing numerous wetlands stretching over a wide expanse of plains. Little is known about this system and there is inadequate data to construct an accurate water balance for the system.

The River Sobat is the final large tributary of the White Nile. The major tributaries to the Sobat are the Baro, which joins the Pibor. The headwaters of the Pibor originate close to the Ugandan-South Sudanese border. Further upstream the Pibor is joined by the Alwero, the Gilo and the Akobo which flows along the border between Ethiopia and South Sudan. Other tributaries in Ethiopia are Cechi and Chiarini and in Sudan are Neubari and Ajuba, Along its last stretch the Pibor forms the outfall for a number of ephemeral streams which drain a large area of the plain between the Bahr el Jebel and the mountainous areas. All these rivers are accompanied by floodplains.

This network of streams, which regularly overspill, creates an extensive criss-crossed system of wetlands in the lower plains of the BAS sub basin. The major wetlands of the BAS sub-basin are part of a grasslands ecosystem located in the Gambela region in Ethiopia, and are contiguous with adjacent grasslands in South Sudan. The wetlands stretching across the Gambela plains are mostly floodplains from all the main rivers especially the Alwero, the Gilo and the Akobo. The wetlands are fed by several spill channels from the Baro River as well as

The extensive swamps north of the Sobat River are called Machar Marshes. The water retention capacity of the Machar Marshes makes the outflow of the sub basin relatively insensitive to rainfall changes. Due to variations in delineation of sub basins, the Machar Marches are sometimes associated with the White Nile Basin instead of the Baro Akobo Sobat.

Climate

The rivers in the Baro Akobo Sobat Basin drain the Ethiopian highlands, which receive extensive rain that can accumulate to an annual average of 2,000 mm. In the southeast, annual precipitation is only slightly over 300 mm/year and across the whole sub basin average precipitation is 1,340 mm/ vear. Potential evapotranspiration is 1,590 mm/year. Rainfall is highly seasonal and between May and October rivers rapidly rise, overtop their banks and where the slopes of the river valleys flatten out large foodbanks with deep alluvium form. Temperatures range from minimum 20 to maximum 40°C. The warmest months are March and April, actual evapotranspiration is highest in August and September (NBI, 2016).

In years with intensive rainfall, the BAS wetlands may cover an area of up to 3 million ha. There are large complex wetland systems alongside small seasonal wetlands. The Machar Marshes and the Gambella Marshes (here described as Baro-Akobo wetlands) are the among the largest wetland systems in the BAS. The Machar Mashes are associated with the Sobat River and the lower Baro Rover, whereas the Gambella Wetlands

are connected to the Baro-Akobo catchment located mainly in Gambela regional state (Busulwa, 2012).

Ecosystem Services

Literature on ecosystem services in the Baro Akobo Sobat Basin is scarce. However, we can take from Rebelo & McCartney (2012) that the Machar Marshes floodplains are used for grazing, hunting and fishing. The use of these wetlands in Sudan is not so intensive due to the low population density, but they are more utilized in Ethiopia for fresh water, fisheries, construction materials, medicinal plants, grazing and cultivation (Rebelo & McCartney 2012).

Given its dense papyrus areas (Rebelo & McCartney 2012), potentially these wetlands serve regulating purposes like water flow and erosion regulation, water purification, maintenance of soil fertility, natural hazard and climate regulation. Other potential supporting and cultural services might include wildlife habitat and the maintenance of genetic diversity and recreation and educational purposes. The ecosystem services identified for the BAS are further presented in WP 3: Ecosystem Service Assessment.

Biological Features

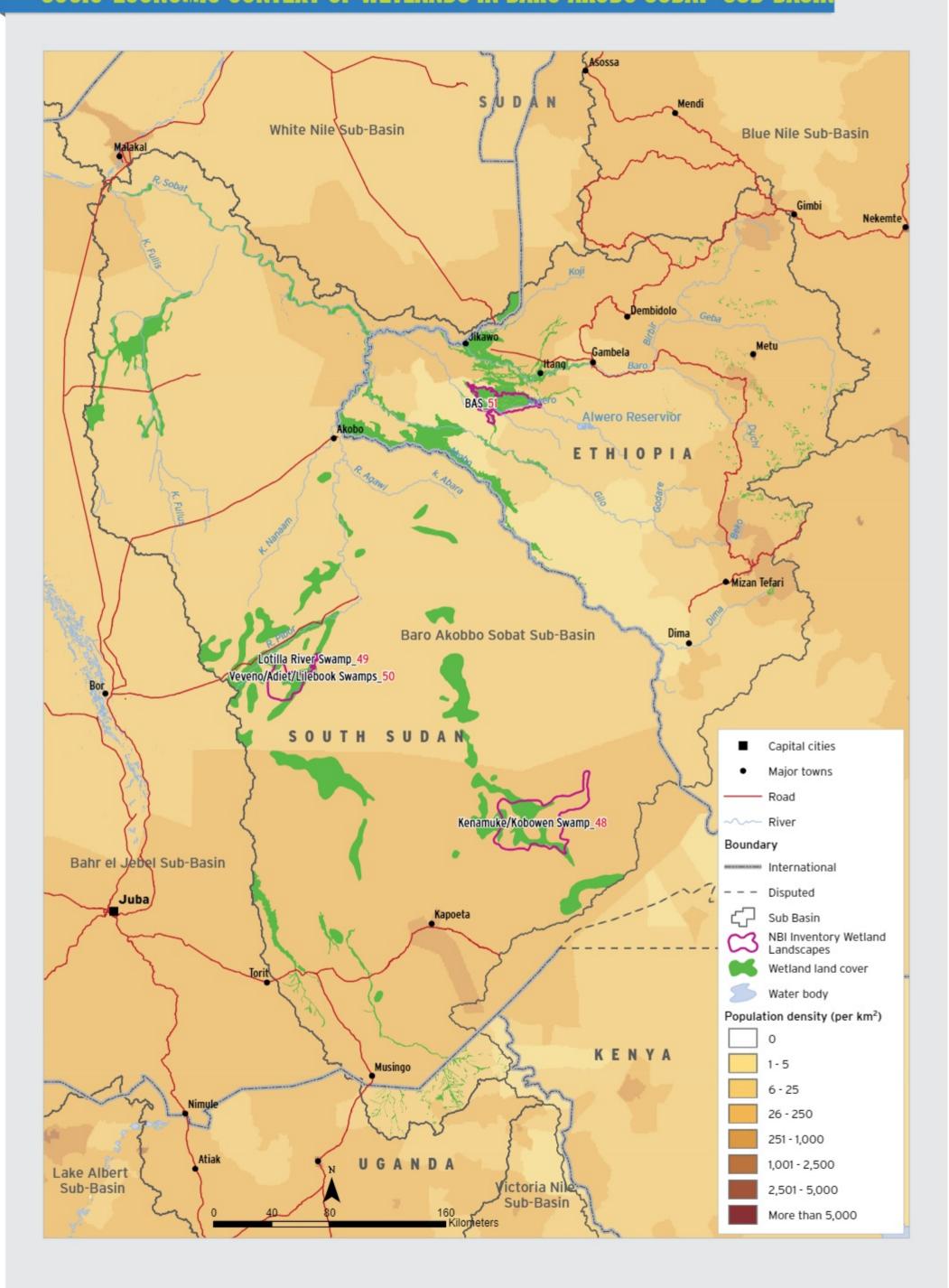
The Machar Marshes have three different land covers namely permanent wetlands with deep water bodies, seasonal flood plains inundated due to river spills and rainfall and dry fringes, which include seepage wetlands. The permanent swamps in the Baro Akobo Sobat wetlands are dominated by Cyprus papyrus, Phragmites and Typha and grassland on the floodplains.

Acacia spp and scattered shrubs occur on the dry areas of the fringes (Y. A. Mohamed, 2018). Some of the mammals occurring in the wetlands include Hippopotamus amphibious (hippopottamus), Tragelaphus spekii (Sitatunga), endemic Kobus megaceros (Nile lechwe), Kobus kob leucotis (white-eared Kob), Damaliscus lunatus (tiang) and Ourebia ourebi (oribi). The Kenamuke swamp is part of the Boma National Park, which covers an area of 20,000 km² of floodplains and grassland and is famous for its annual white-eared kob migration.

There are 43 taxa in the Baro Akobo Sobat Wetland group that have an IUCN threat status of interest. In total there are 31 flagship species for example Balaeniceps rex, Balearica regulorum, Crocodylus niloticus, Cyperus papyrus, Hippopotamus amphibius, Nettapus auritus and Cyclanorbis senegalensis. Invasive weeds found in the wetlands are Mimosa pigra, Eichhornia crassipes and Pistia stratiotes. M. pigra forms impenetrable thickets thus hindering movement and destroying natural biodiversity. Eichhornia crassipes disrupts hydropower generation, increases siltation and evapotranspiration, reduces fish stock and reduces water quality (Bezabih & Mosissa, 2017). The Baro River has a high fish species diversity comprising a mixture of Nilo-sudanic, East African and endemic species.

Flagship bird species for the Baro-Akobo wetland system include Balaeniceps rex (shoebill), Pelecanus onocrotalus (great white pelican), Anastomus lamelligerus (African openbill), Scotopelia peli (Pel's fishing owl), Aythya nyroca (Ferruginous pochard).

SOCIO-ECONOMIC CONTEXT OF WETLANDS IN BARO AKOBO SOBAT SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN BARO AKOBO SOBAT SUB-BASIN



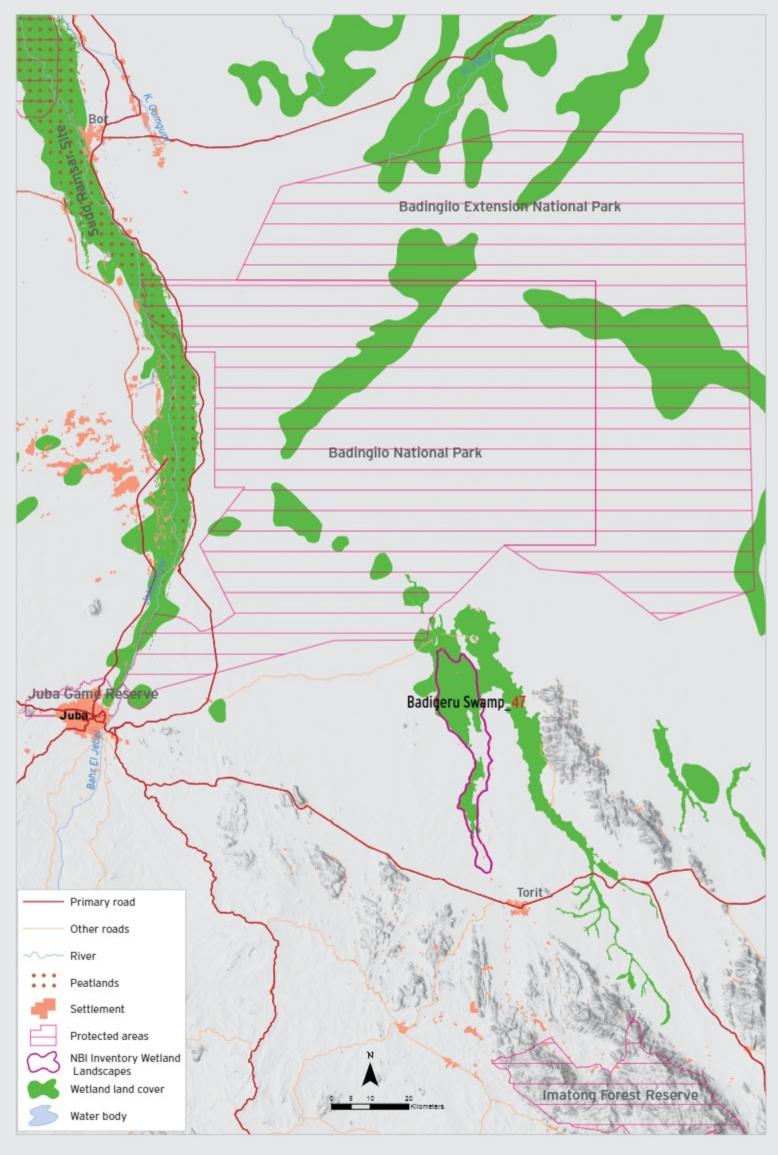
BADIGERU SWAMPS

Name: Badigeru Swamp Country: South Sudan

Coordinates: 4°50'17" N / 32°26'25" E Altitude: 480-700 m a.s.l.

Area: 345 km² Nearest Towns: Juba

International Importance: Important Bird Area (Bandingilo)



Overview

There is little information on the Badigeru Swamp. One of the few published descriptions available for the Badigeru is by Hughes and Hughes (1992). The Badigeru swamp lies in the headwaters of the River Sobat, and is supplied by the Kinyeti River and other streams which drain the northern slopes of the Kinyeti Massif (3187 m) on the South Sudanese/ Ugandan border. The swamps are discontinuous and are oriented SSE-NNW. Water from the northern end of Badigeru Swamp may filter east to the Veveno River basin and thence eventually to the Sobat and White Nile, or west to the Bahr el Jebel above Mongalla (5°12'N/31°46'E). The Badigeru is a valley swamp with papyrus along the river and typical grasses on the floodplain

KENAMUKE/ KOBOWEN SWAMP

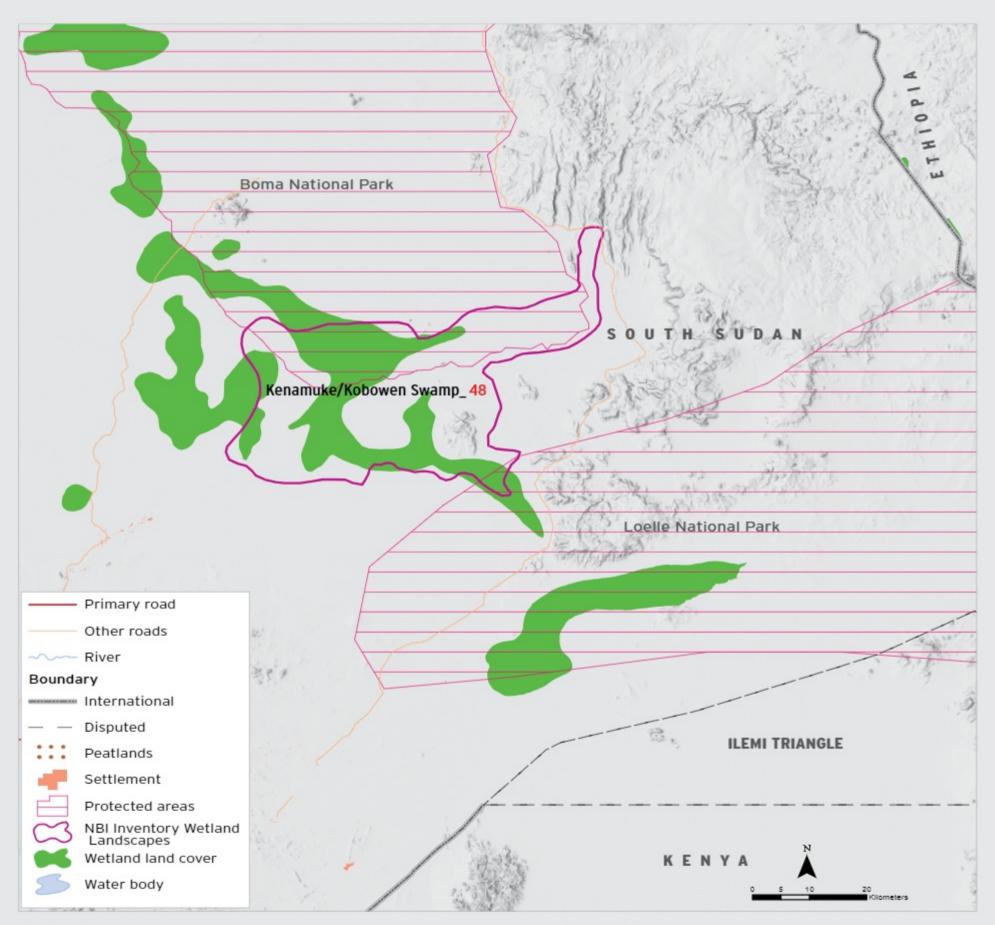
Name: Kenamuke/ Kobowen Swamp

Country: South Sudan

Coordinates: 5°28'11"N / 34°14'34" E

Altitude: 450 m a.s.l. Area: 1,647 km² Nearest Towns: Bor

International Importance: Important Bird Area



Overview

There is little information on the Kenamuke/Kobowen Swamp. One of the few published descriptions available for the Kenamuke/ Kobowen swamp is by Hughes and Hughes (1992). The Kenamuke swamp is a headwater swamp of the Sobat. The Kenamuke/ Kobowen Swamp is approximately 130 km long and varies in width from 5-30 km. It is oriented in a north-to-south direction and is supplied by a number of rivers, the most important ones rising either in the Didinga Hills to the south or the Ethiopian Highlands to the east.

Physical Features

The long narrow swamp occupies the floor of a valley system and drains from the northernmost end by the Kangen River to the Sobat River, and thence to the White Nile. A south eastern outlier at the head of the system is a SE-NW oriented depression, lying immediately below the western side of the Moru Agippi plateau at an altitude close to 700 m a.s.l.
After heavy rainfalls this latter
area floods. The main tributary
streams to the wetland system
are the Gerra, Lomen, Chilmun,
Chalbono and Nakua Rivers. The
Kenamuke/ Kobowen is a broad
floodplain grassland swamp in
Sudanian savanna zone. It contains
black-cotton soils.

LOTILLA RIVER SWAMPS

Name: Badigeru Swamp Country: South Sudan

Coordinates: 6°25′27" N / 32°52′11" E Altitude: 415-620 m a.s.l.

Altitude: 415-620 m Area: 22 km² Nearest Towns: Bor International Importance:



Overview

There is little information on the Lotilla River Swamp. One of the few published descriptions available for the Lotilla River swamp is by Hughes and Hughes (1992). This typical floodplain system is situated in the valley of the Lotilla River which has its headwaters in the Didinga Hills and flows north to join the Kangen River at Pibor Post (6°49'N/33°08'E). The swamps comprise two major blocks, a southern block 140 km long and up to 27 km wide, which contains patches of swamp forest on the plateau at about 600 m a.s.l. and a smaller northern block of 665 km², which ends some 30 km above Pibor. The course of the river is not always clear in the upper swamp, but it is well defined where it meanders through the lower northern swamp. Typical floodplain grasslands occur in the swamp such as Cyperus papyrus, Miscanthidiunz violaceum, Phragnzites mauritianus and Typha domingensis in the wettest sites.

VEVENO/ADIET/LILEBOOK SWAMPS

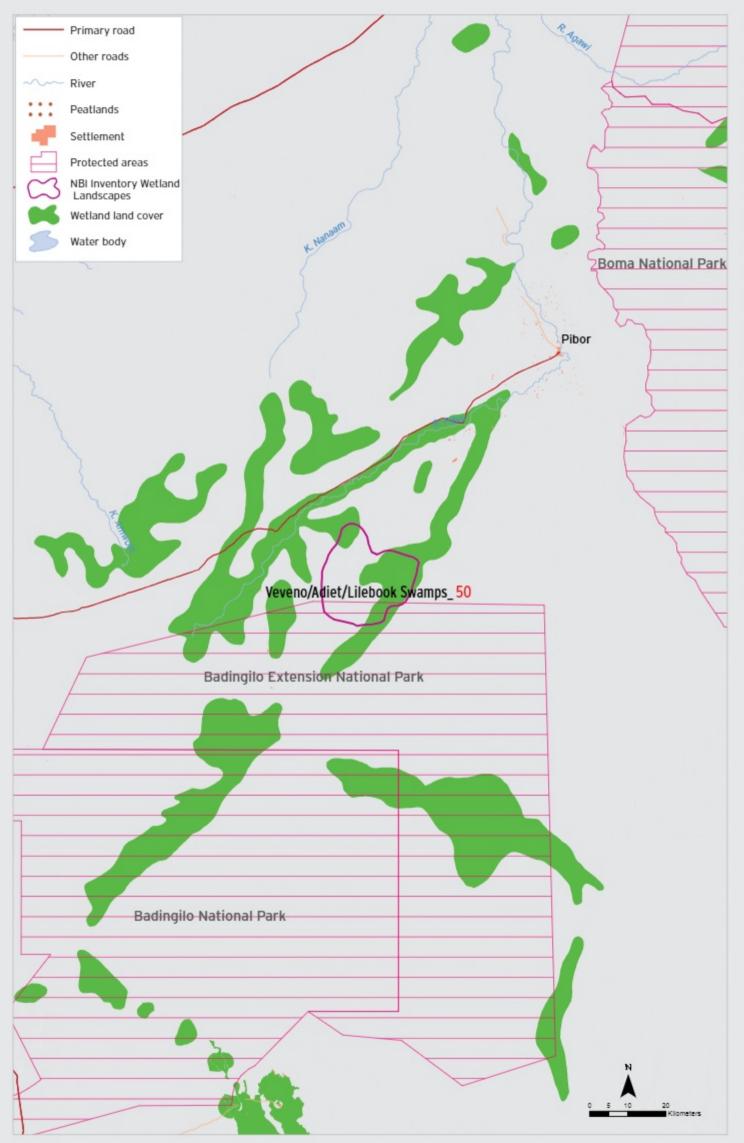
Name: The Veveno/Adiet/Lilebook Swamps

Country: South Sudan

Coordinates: 5°27'-7°04'N/32°00'-33°03'E

Altitude: 400-500 m a.s.l. Area: 442 km² Nearest Towns: Bor

International Importance:



Overview

This vast area of seasonal swampland lies to the east of the Sudd and is oriented SW-NE. It is 215 km long and up to 60 km wide. Run-off from the highlands to the south and southeast, flows north westwards until it meets the Veveno River which crosses its path from SW to NE. The Veveno leaves the swamp at the north eastern end, to join the Lotilla River, and thereafter the combined stream joins the Pibor River. North of the Veveno, water drains north or north westwards until it collects into tributaries of the Adiet (Manaam) River, which flows outside the swamp, on the northern side, parallel with the Veveno. The Lilebook River drains the far north eastern end of the swamp, flowing north eastwards between, and in parallel with, the Adiet and Veveno Rivers. Like them, it enters the Pibor River en route to the Sobat and the White Nile. Broad belts of permanent swampland occur along all these rivers (Hughes & Hughes, 1992).

BARO AKOBO WETLANDS

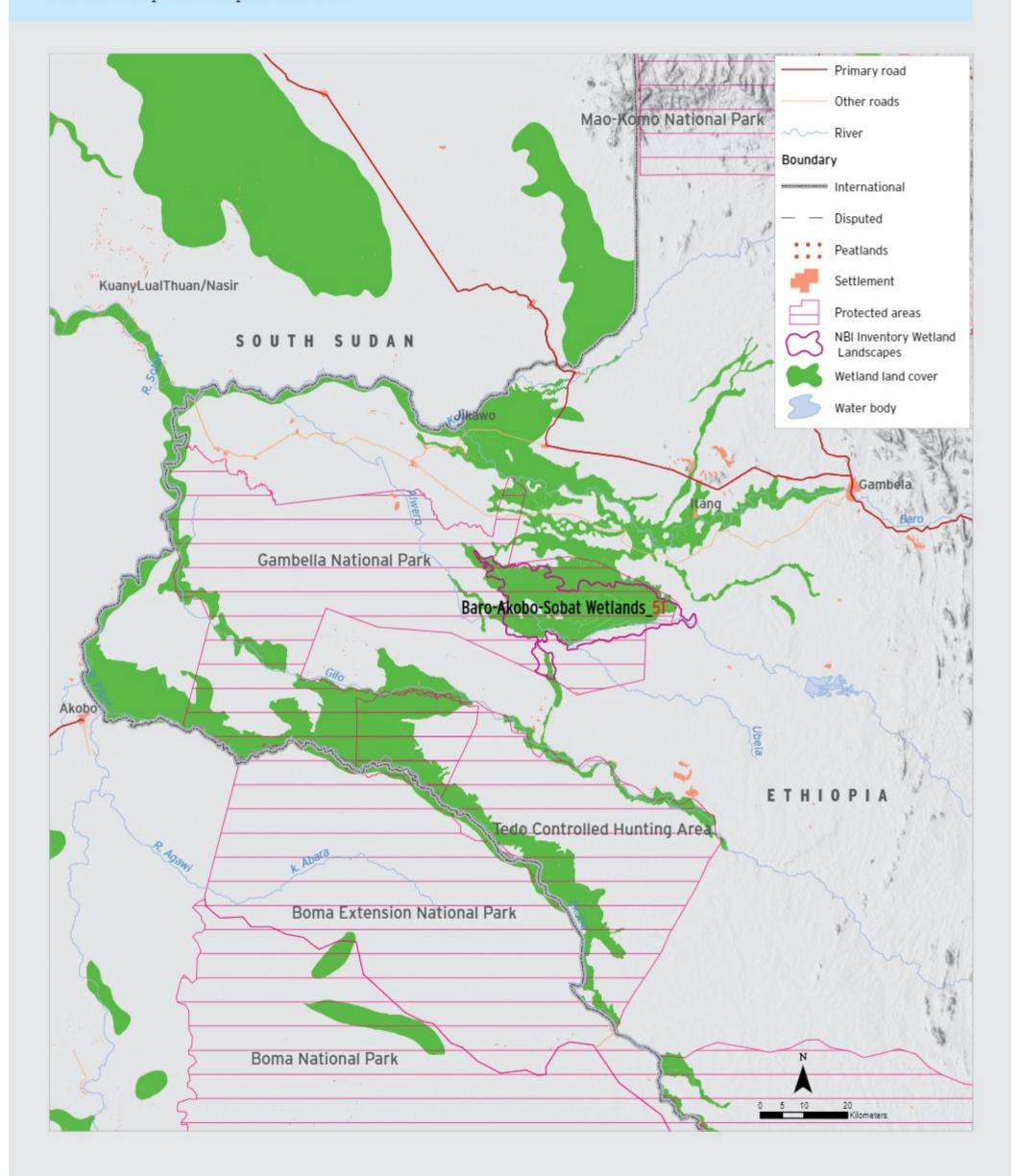
Name: Baro Akobo Wetlands (Duma Wetland, Gambela Marshes)

Country: Ethiopia

Coordinates: 8° 3'35" N/ 34° 6'27" E Altitude: 425 m a.s.l.

Altitude: 425 m a.s.l. Area: 516 km² Nearest Towns: Dembi Dolo, Nasir

International Importance: Important Bird Area



In the lowlands of the Baro Akobo Sobat sub basin there are numerous wetlands across the wide expanse of the Gambella Plains. The concentration of wetlands and the subsequent variety of habitats in and around these wetlands support a very distinctive flora and fauna. As a result, a large part of this plain is covered within the Gambella National Park. One of the largest papyrus wetlands in the park is the Duma Wetland, which is very distinctly visible through the remote sensing analysis.

Physical features

Most rivers in the Baro Akobo Sobat sub basin rise in the Ethiopian highlands at about 1,500 to 3,100 m a.s.l. They flow in a westernly direction over steep gradients until they reach the Gambella Lowland Plains, where they meander, overspill and form seasonal and permanent wetlands. The major wetlands are associated with the Baro-Akobo sub-basin and are located in Gambella regional state in the grassland ecoregion. The wetlands stretching across the Gambella plains are mostly floodplains from all the main rivers especially the Alwero, Gilo, Baro and the Akobo which are the main rivers crossing the Gambella region (Henry Ssebuliba Busulwa, 2012; Wood et al., 2018).

The Duma Wetland is one of the largest papyrus wetlands in the regions, clearly detectable in the remote sensing analysis. The Duma Wetland is situated within the Gambella National Park, south west of Gambella Town and south

of the Baro River. The wetland is mainly fed by the overspill of the Ubela and Alwero rivers, which ultimately discharge into the Sobat River (Busulwa, 2012; NBI, 2016). About thirty kilometres upstream of the Duma Wetland, the Alwero River is dammed as part of the only ongoing large scale irrigation scheme in the Baro-Akobo Basin (Citeau & Crerar, 2017), Large-scale farming activities by investors such as Saudi Star and Ruchi PLC (Degife & Mauser, 2017) take place upstream of the Duma Wetland and impact the wetland habitat.

The areas has a hot and humid climate that is influenced by the tropical monsoon from the Indian Ocean with high rainfall from May to October and a dry period from November to April. The Gambella plain is mostly covered with black coloured vertisols (ENTRO (Eastern Nile Technical Regional Office), 2008a). The Gambella National park is said to be one of the least disturbed and intact ecosystems in Ethiopia, with large grasslands and extensive swamp systems. The National Park is also an Important Bird Area. The wetlands in the Gambella National Park provide a number of habitats that host several large wildlife species, particularly the Nile lechwe (Kobus megaceros) and the white-eared kob (K. kob) (Wood et al., 2018). Each year large numbers of the white-eared kob migrate between the Sudd and the Gambella marshes, a wildlife movement comparable to the wildebeest migration between Maasai Mara and the Serengeti. Between 1990 and 2010 in Gambella National Park more than 100,000 ha or 24.2 % of forested land was converted into other land

covers. In that period land covered by grassland increased by 24.4 % (Aneseyee, 2016).

The Gambella Region is home to the ethnic groups Nuer and Anuak, who both depend on wetlands for their livelihoods. The combined fish vield from the Alwero, Baro and Gilo rivers make up the largest fisheries in Ethiopia (Busulwa, 2012). The Anuak practice flood retreat cultivation of maize and sorghum especially along the Baro and its adjoining wetlands, where they also fish. The Nuer are based higher up, a bit to the west of the lowlands. They are agropastoralists grazing their cattle across the seasonally flooded grasslands during the dry season and moving to upland during the rainy season. More extreme floods during the wet season coupled with lower base flows during the dry season have forced some communities to relocate to higher altitudes, creating competition for resources. Reasons for a changing river regime are deforestation, expansion of cultivation and wetland degradation (Wood et al.,

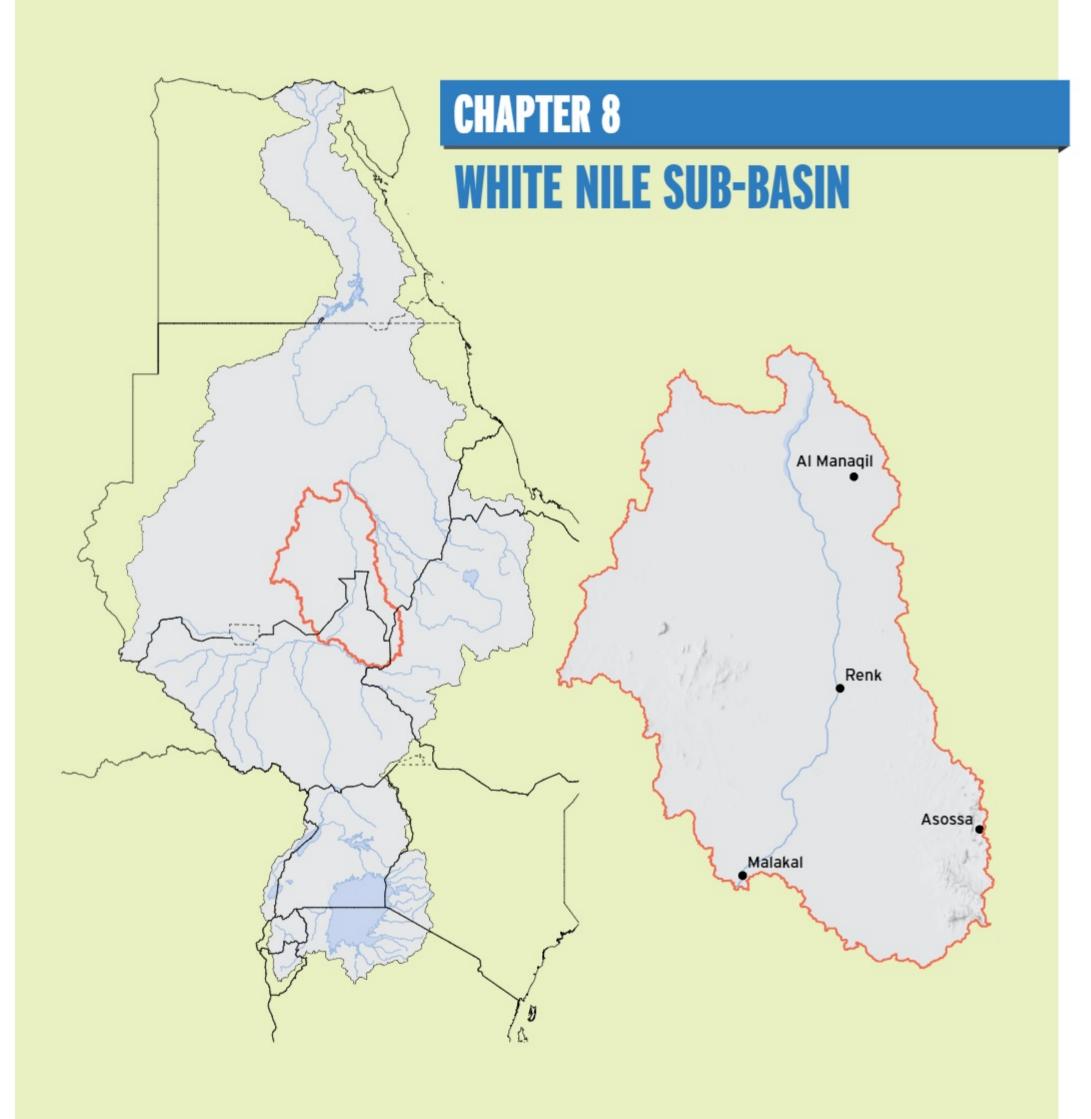
Drivers of Change

The Gambella Region is one of the world's land grabbing hotspots. The Ethiopian government identified the region as one of the most suitable regions for agricultural investment to improve food security. Since the mid- 2000 the government has allowed foreign companies to acquire thousands of hectares of fertile land in the Gambella Region to build large-scale industrialized farms that often produce products for export e.g. cotton, rice, sesame,

etc. (Degife & Mauser, 2017). Hence, peasantry as Ethiopia's agricultural driver was replaced by agricultural investment and tax-exemptions as well as low rents for farmland attracted foreign investors (Degife & Mauser, 2017). Special customs are in place for importing machinery in addition to tax exemptions on profit for five years for foreigners who export 50% or more of their product (Labzae, 2016). However, the government is continuously adapting its policies to also favor Ethiopian investors. Also lands within the Gambella National Park have been affected by this land grabbing trend. In 2011 the boundaries of Gambella National Park were re-delineated, reducing the park from 5,061 to 4,575 km² (Labzae, 2016). Areas that were formally part of the National Park have been largely cleared from forest and were transformed into plantations for sugar cane, rice and palm-oil by agri-buisiness ventures (Degife & Mauser, 2017). The rising rate of deforestation in the Baro-Akobo basin has led to an augmented sediment input into the system (Busulwa, 2012). Also wetland areas within the park are now part of large-scale farm companies, however the extend of flooding of these wetlands each year presents itself as a great challenge for agricultural activities (Degife & Mauser, 2017; Labzae, 2016). Wildlife habitat and wildlife population is also under pressure due to land grabbing, and wetland degradation, coupled with wildlife poaching and pressure by increasing human and livestock population (ENTRO, 2008a)



Baro River



Introduction	121
Socio-economic context of wetlands in White Nile sub-basin	122
Hydrological context of wetlands in White Nile sub-basin	123
The Machar Marshes	124
White Nile Floodplain	126
Gebel Auliya	128

INTRODUCTION

Overview

The White Nile Sub-basin is part of the eastern Nile Basin and starts at the confluence of the Bahr el Jebel and the Baro-Akobo-Sobat River. It reaches from the highlands of Ethiopia to the Jebel Aulia Dam near Khartoum, which is in the ecoregion Sahelian acacia savanna. It encompasses territories of Ethiopia, South Sudan and Sudan. The White Nile Sub-basin can be further divided into five major watersheds: the Machar Marshes, the South West White Nile, the Nubia Hills, the East White Nile and the North White Nile. The Baro and the Sobat River mark the southern border of the Sub-basin.

Climate

There is high spatial variation of rainfall in the White Nile Sub-basin. Semi-arid conditions increase moving from upstream to downstream parts of the Subbasin. Rainfall in the southern part of the Sub-basin is greater than 1,000 mm/year but continuously decreases to less than 300 mm towards the northern part of the Sub-basin. Inter annual rainfall variation is high across the Subbasin. The rainy period is from May to October. Precipitation in the whole Sub-basin exceeds potential evapotranspiration only in July. The average maximum monthly actual evapotranspiration occurs in September after the rainy

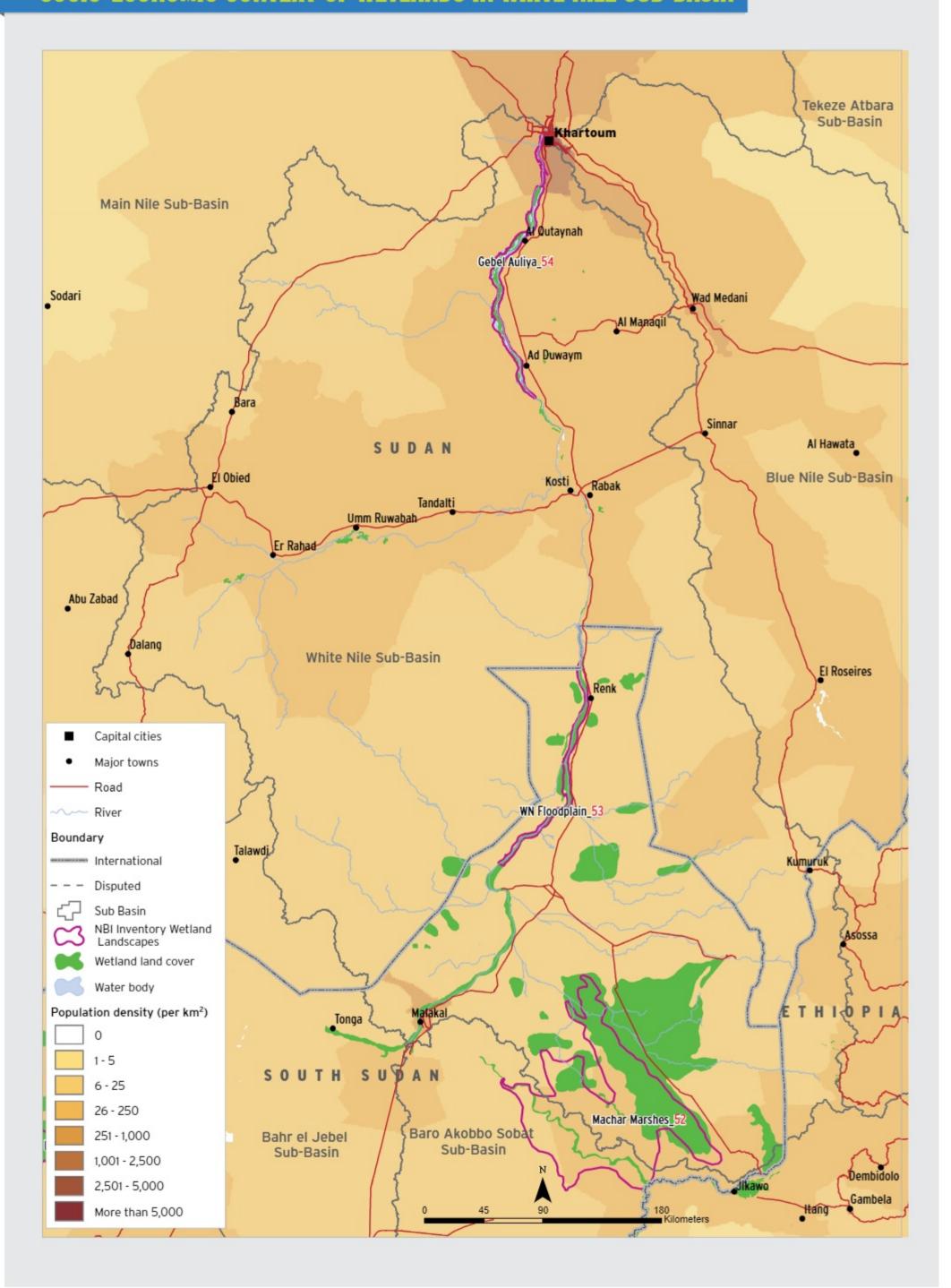
season but does not exceed 80 mm monthly average. The hottest month is May and the coldest is February. Temperature ranges between 15 and 40°C. Relative humidity ranges from 30 % month in January to almost 80 % month in August (NBI, 2016).

Ecosystem Services

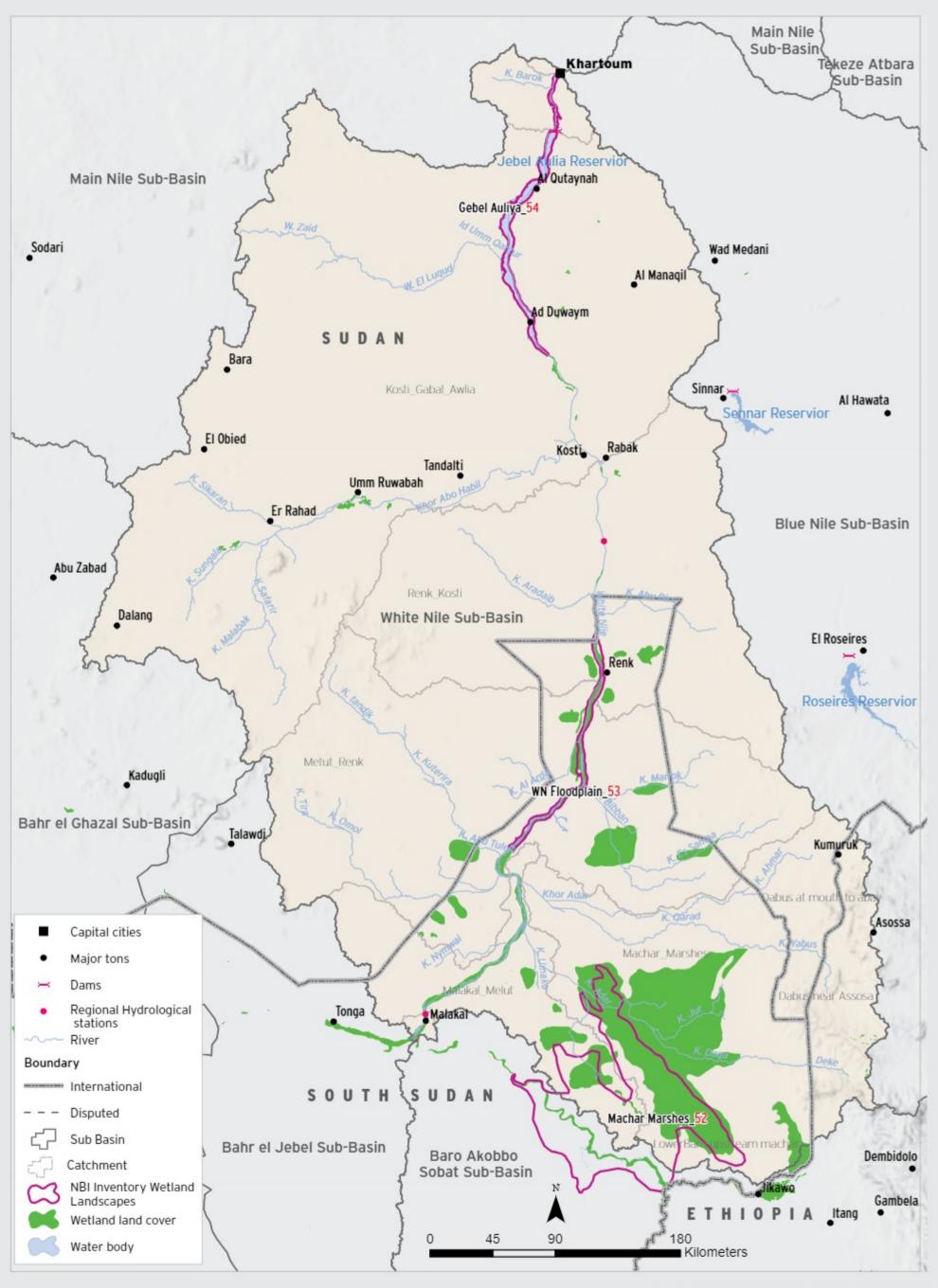
The White Nile provides a long stretch of navigable waters due to the relatively stable flow and flat slope (NBI, 2016b). The ecosystem services identified for White Nile Sub-basin are further presented in WP 3: Ecosystem Service Assessment.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN WHITE NILE SUB-BASIN



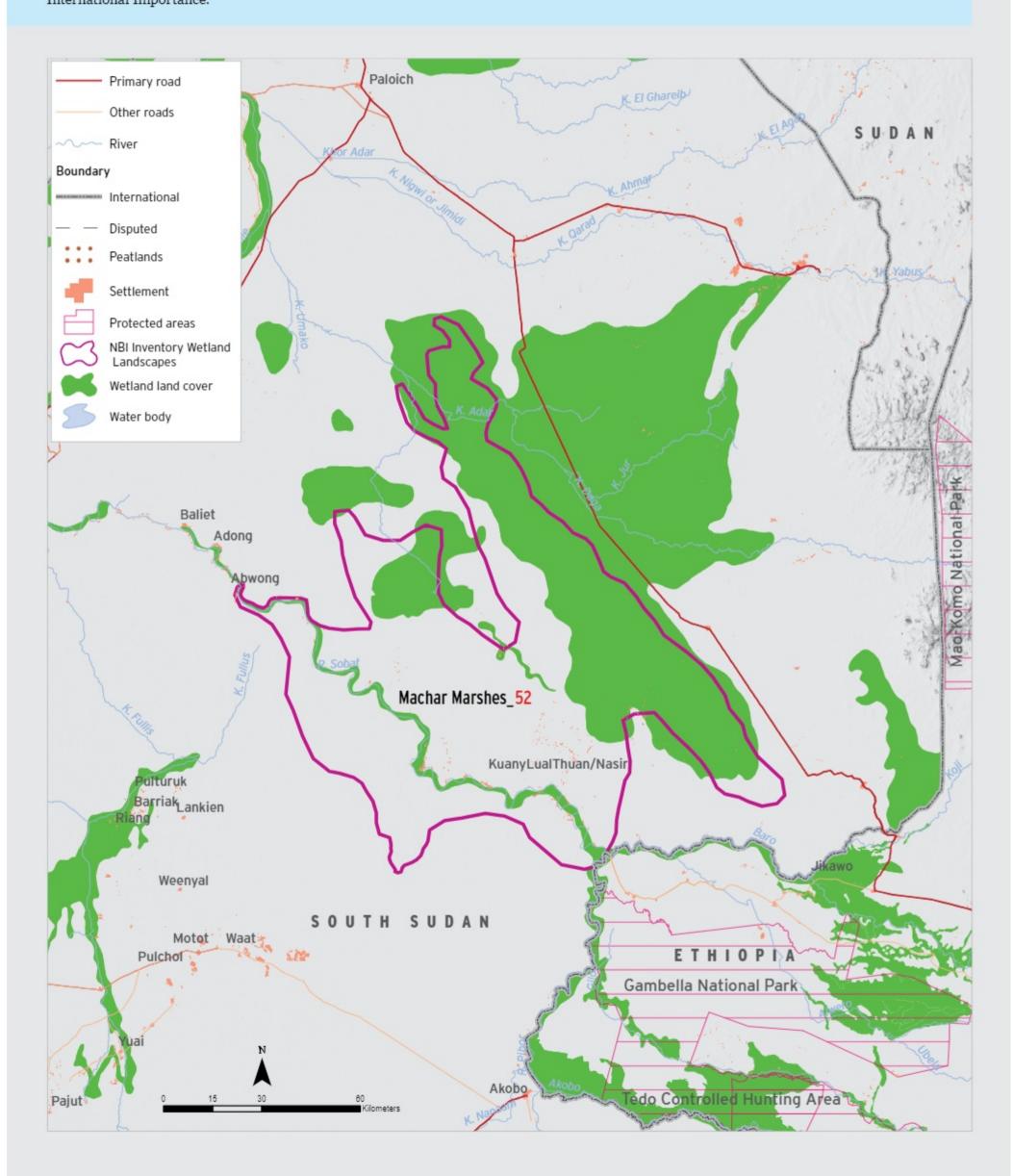
HYDROLOGICAL CONTEXT OF WETLANDS IN WHITE NILE SUB-BASIN



THE MACHAR MARSHES

Name: The Machar Marshes Country: South Sudan

Coordinates: 8°55'11"N / 32°42'55" E Altitude: 290-600 m a.s.l. Area: 9,934 km² Nearest Towns: Malakal International Importance:



The Machar Marshes are comprised of a vast area of swamps and seasonal floodplains interlaced by an intricate reticulate system of watercourses and numerous lakes. The wetland system extends across at least 200 km from north to south and 180 km from east to west and is situated north of the Baro and Sobat River (Hughes & Hughes, 1992). Run-off and drainage from the Ethiopian Highlands flows across the marshes towards the White Nile below Malakal, Similar to the Sudd the area of the marches varies within rainfall season. Even though the Machar Marches supports a rich biodiversity and provides grazing land for Nilotic tribes of South Sudan, it is one of the least monitored and understood wetlands (Y. A. Mohamed, 2018).

Physical Features

The Macha Marches lie on a flat clay plain characterized as vertisol, which form deep cracks during dry periods of the year. The average rainfall over the Machar Marshes is 933 mm/year with a distinct rainfall season between May and September, evapotranspiration significantly drops during the dry season (Y. A. Mohamed et al., 2004).

The Machar Marshes is the largest wetland in the White Nile subbasin. In Hughes and Hughes (1992) the total wetland area is estimated to be 900,000 ha, with 500,000 ha lying in South Sudan and 400,000 ha in Ethiopia in the valley of the Gambela River. Sutcliffe and Parks (1999) estimate the inundated area to be between 150,000 and 600,000 ha depending on the season and rainfall intensity. Mohamed et al. (2004) showed that the Machar Marshes are predominantly seasonal and not permanent swamps. These divergences in wetland area estimates underlines the limited understanding of the

Streams from the Ethiopian Highlands descend quite abruptly to a very flat plain where the rivers break up into the complex of minor watercourses. There are four main routes through which water enters the Machar Marshes. Firstly, water from the Baro River flows into the marshes through overbank spill during high flow between June and November and through spill from the Khor Machar which is a tributary of the Baro River. Secondly, water from eastern highland torrents (the Tombak, Yabus, Daga and other small streams) connects via the Khor Daga, which is the eastern tributary to the Machar Marshes. Thirdly, there is a tributary of the Khor Machar that flows parallel to the Sobat, later becomes the Khor Tiebor and then the Khor Wol. The fourth way the marshes receive water is through rainfall over the marshes.

The Khor Adar and the Khor Wol drain the Machar Marshes and eventually join the White Nile. The Machar Marshes' water balance is described in Sutcliffe and Parks (1999) and in more recent analysis for the Joint Multipurpose Program, commissioned by the Eastern Council of Ministers (Blackmore & Whittington, 2008).

WHITE NILE FLOODPLAIN

White Nile Floodplain (between Malakal and Khartoum) Name:

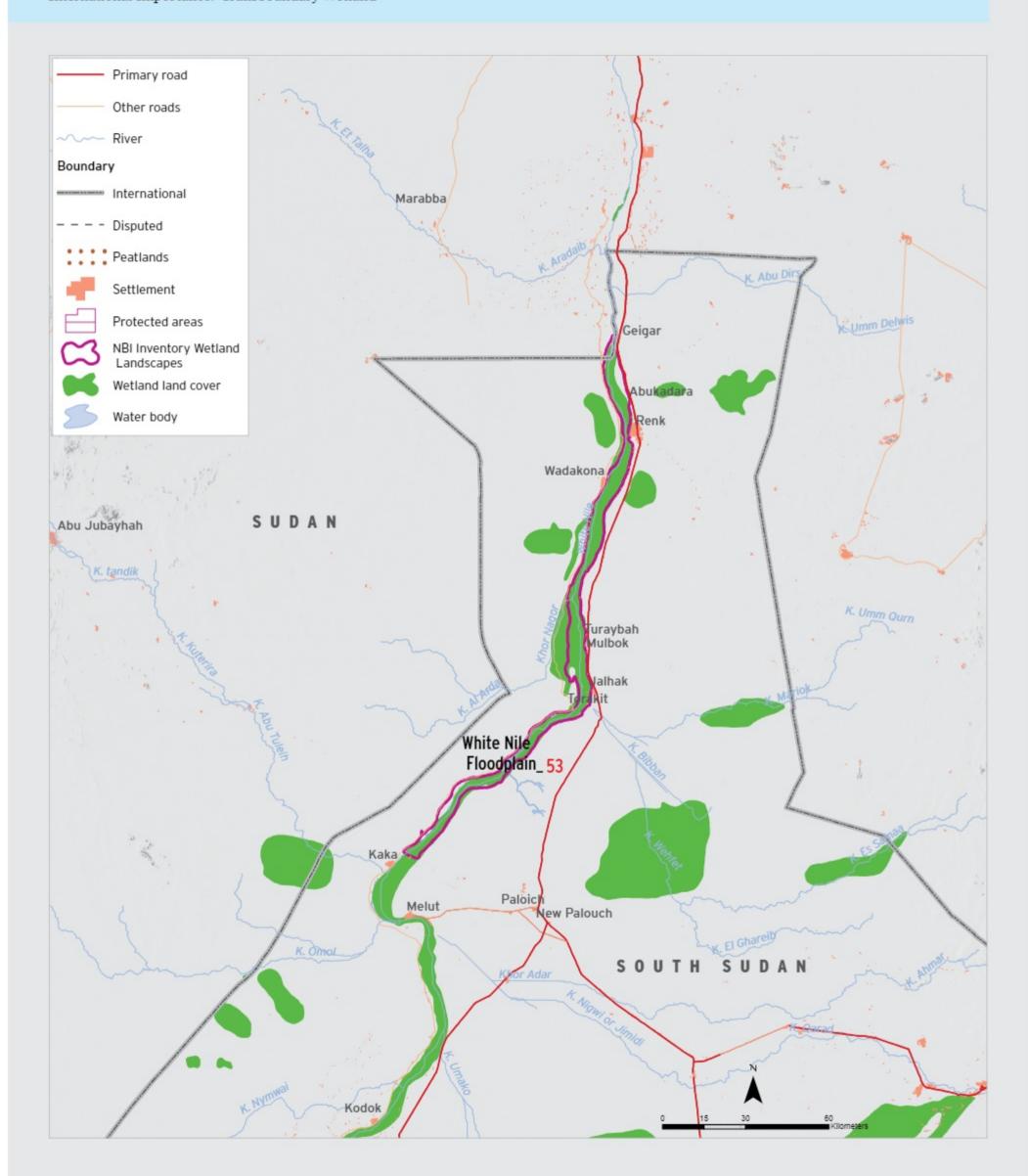
South Sudan, Sudan Country:

Coordinates: $9^{\circ}32'55"-15^{\circ}14'11"$ N / $31^{\circ}38'08"-32^{\circ}28'45"$ E Altitude: 400 m a.s.l.

 $672 \, \mathrm{km}^2$ Area:

Nearest Towns: Malakal, Khartoum

International Importance: Transboundary Wetland



The White Nile between Malakal and Khartoum flows in a relatively confined bed that is fringed by papyrus and reed areas. This stretch of river also includes islands, floodplains, Khors and the shores of the Gebel Auliva Dam

Physical Features

The soil of the White Nile
Floodplain is a black coloured
vertisol, which is crackling in
nature and is challenging for
agriculture. The climate upstream
of Malakal is characterized by high
moisture and longer wet seasons
whereas the wet periods shorten
and the climate becomes arid
tropical.

The White Nile reach between Malakal and Khartoum is about 840 km long. Across this distance the White Nile drops only 13 meters in altitude, to about 400 m a.s.l. at Khartoum. In this stretch tributaries to the White Nile are small and sporadic (ENTRO (Eastern Nile Technical Regional Office), 2008a). During floods the Nile bed is inundated, but in dry season the river is confined to its incised channel. Swamps, 200-300 m wide, line the riverside, but in places these may locally expand to 20 km in width. The channel is island-studded between latitudes 12°30' and 15°00'N, but then bifurcates and even trifurcates. The incised sandy trough flattens and the river develops a floodplain at latitude 13°30'N which persists, 3-10 km wide, to latitude 15°00'N,

after which the river broadens into the lake behind the Gebel Auliya Dam (15°15'N). Below the dam there is another floodplain which leads into Khartoum and the confluence with the Blue Nile. When the latter stream is in flood, water in the White Nile backs up; hence the floodplain above Khartoum. The Gebel Auliya Reservoir contains and regulates the flow of the White Nile. Below Khartoum, the combined White and Blue Niles flows northwards and is joined by the Atbara River on the right bank, the final major tributary of the Nile, and follows a course locally and narrowly fringed with swamps through the desert until it enters Lake Nubia at Ambikol (21°24'N/30°54'E), just above the Egyptian border. (Hughes & Hughes, 1992)

At Malakal the mean annual flow of the White Nile is 30.50 billion m³ and at Gebel Auliya it is 25 billion m³. The difference can be attributed to evaporatiotranspiration losses in the floodplains of the White Nile and the Gebel Auliya Reservoir (ENTRO (Eastern Nile Technical Regional Office), 2008a).

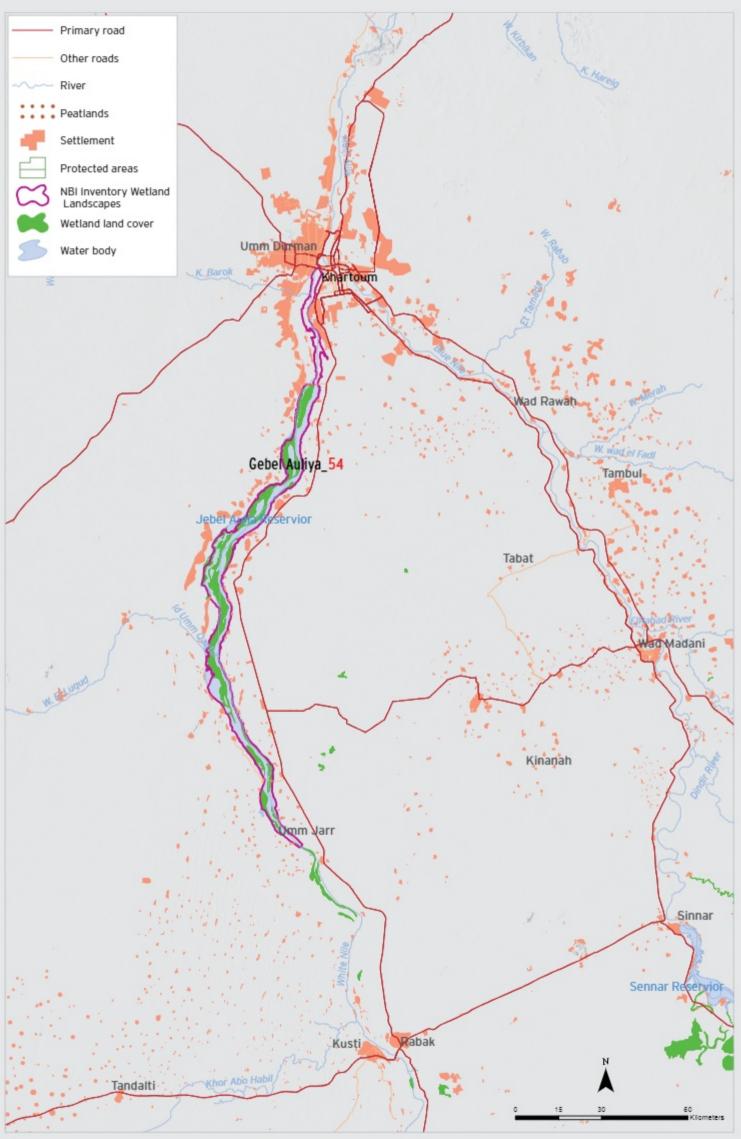
GEBEL AULIYA

Name: Gebel Auliya (Jebel Awlia, Jebel Aulia)

Country: Sudan

Coordinates: 15°14'11" N / 32°28'45" E

Altitude: 380 m a.s.l. Area: 672 km² Nearest Towns: Khartoum International Importance:

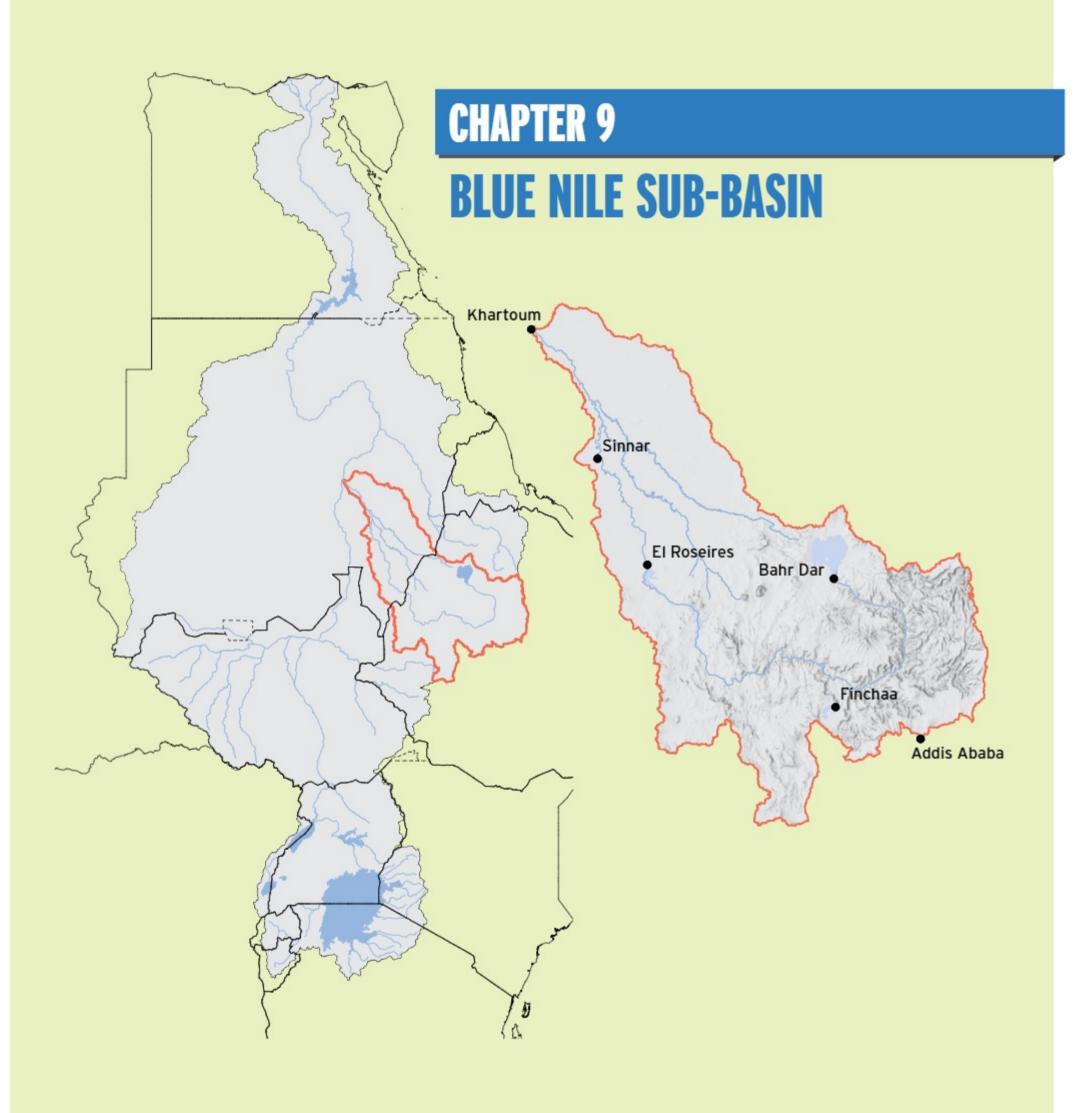


Overview

The Gebel Auliya dam across the White Nile upstream of Khartoum was constructed in 1937 to hold back the flow of the White Nile during the months of July and August, when the Blue Nile floods. The dam has since been equipped with hydro turbines for electrical power generation..

Physical Features

The Gebel Aulia is the second largest reservoir in Sudan. Lacustrine conditions extend a very long way back up the valley of the White Nile. It has a mean depth of 2.3 m and a capacity of $3.5~\mathrm{km^3}$ (Van der Knaap, 1994). The reservoir's maximum water level is reached in September when the rainy season ends and starts to drop in February until the beginning of May. Water is used for irrigation and a commercial fishery operates on the lake (Huges & Hughes, 1992). Sedimentation is not yet a threat for the Gebel Auliya reservoir because the large wetlands upstream (the Sudd, Machar Marshes, Bahr el Ghazal floodplain) serve as filter for the sediment load coming from the highland portions of the Nile Basin (ENTRO (Eastern Nile Technical Regional Office), 2008a)



Introduction	131
Socio-economic context of wetlands in Blue Nile sub-basin	132
Hydrological context of wetlands in Blue Nile sub-basin	133
Dinder Floodplain	134
Lake Tana	136
Fincha'a-Chomen Swamp	138
El Roseires	139
Sennar	141

The little Abbay River, which is the source of the Blue Nile rises in the Ethiopian Highlands. It flows into to Lake Tana, which discharges into the Blue Nile. After receiveing water from various tributaries such as the Dinder, the Dabus and Rahad the Blue Nile connects to the Main Nile close to Khartoum. With 55 billion m³, the Blue Nile contributes 60 % of the combined flows of all Nile tributaries. The discharge of the Blue Nile is highly seasonal, with peak flows in the rainy season between July and September. During this period approximately 70 % of the Blue Nile flow occurs (NBI, 2016).

Climate

The basin stretches south to north, from humid to semi-arid conditions from a Sudanian savanna to the Sahelian acacia savanna ecoregion. In general an uni-modal rainfall pattern predominates with rains between May and November. Maximum rainfall occurs over the southern tributaries of the Blue Nile, in the Ethiopian highlands with more than 2,200 mm/year in the Didesa and Dabus sub-basins. Closer to the confluence of Blue and White Nile the annual rainfall decreases to less than 400 mm. The average annual potential evapotranspiration is 1,760 mm (NBI, 2016)

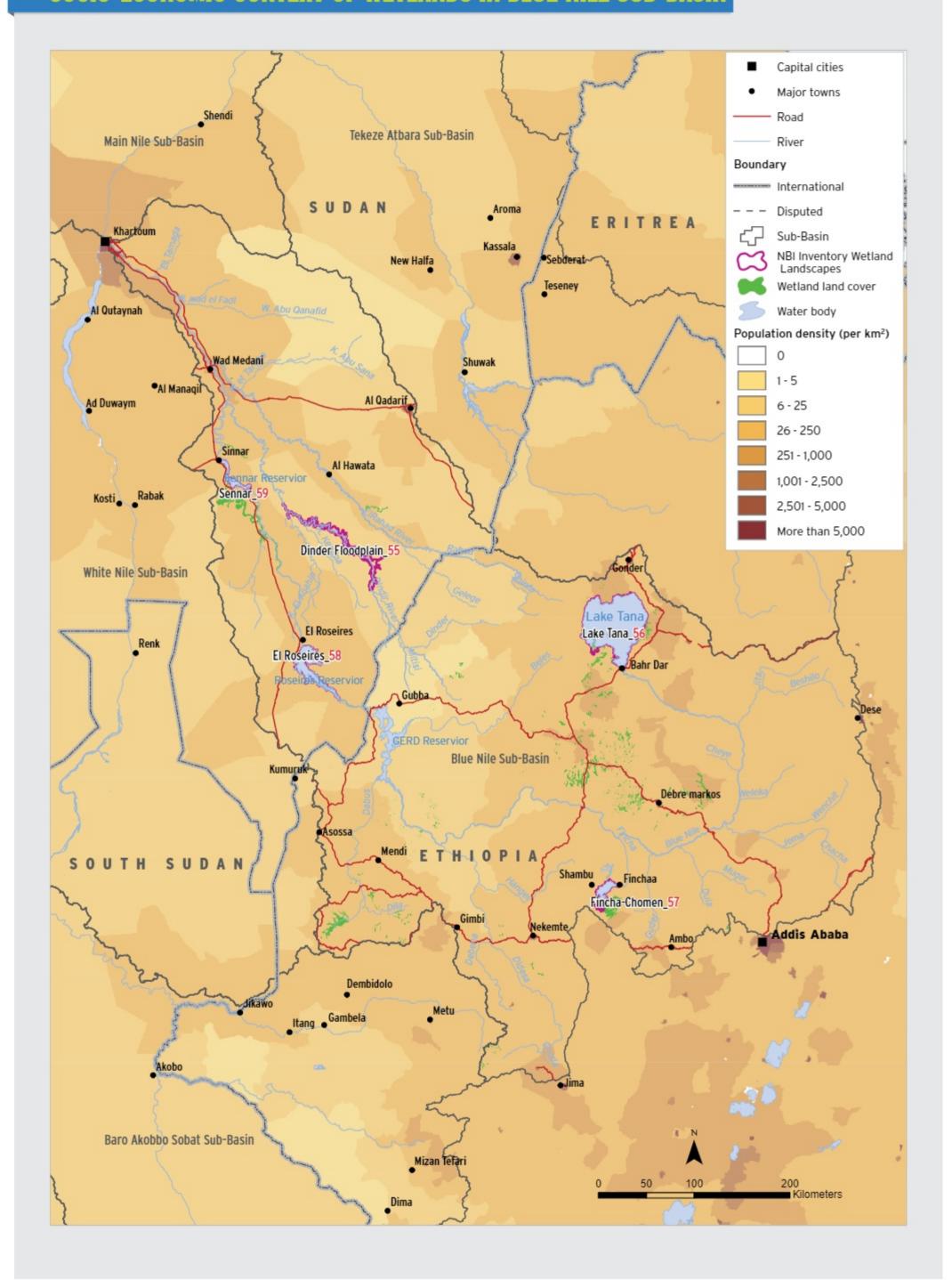
Ecosystem Services

Tesfaye et al. (2016) valued the main ecosystem services of the Blue Nile Basin in Ethiopia (for provisioning and regulating services) at approximately 52 million US\$ for 2011, concluding that this could be higher if proper water resources management was enforced. The ecosystem services included were irrigation water, fisheries resources, energy production and commercial navigation (Tesfaye et al. 2016). The Roseires reservoir supports local activities such as fishery, farming and the collection of wood and fruits (Alrajoula et al., 2016). During the dry season, when the lake water level drops, fertile

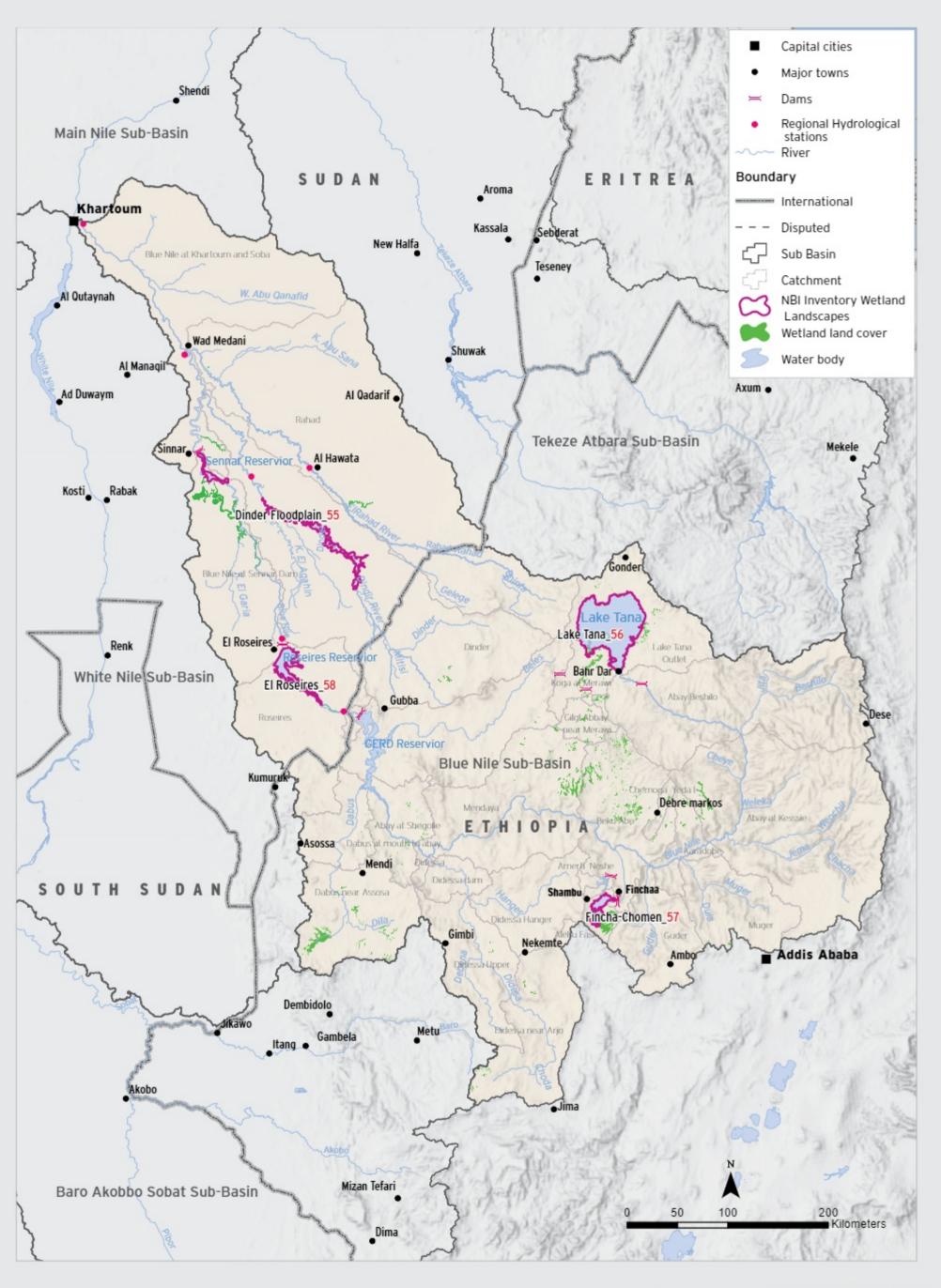
previously inundated soil is used for cultivation. The reservoir is possibly a small scale tourism and recreation attraction (Alrajoula et al., 2016). The ecosystem services identified for Blue Nile Basin are further presented in WP 3: Ecosystem Service Assessment.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN BLUE NILE SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN BLUE NILE SUB-BASIN



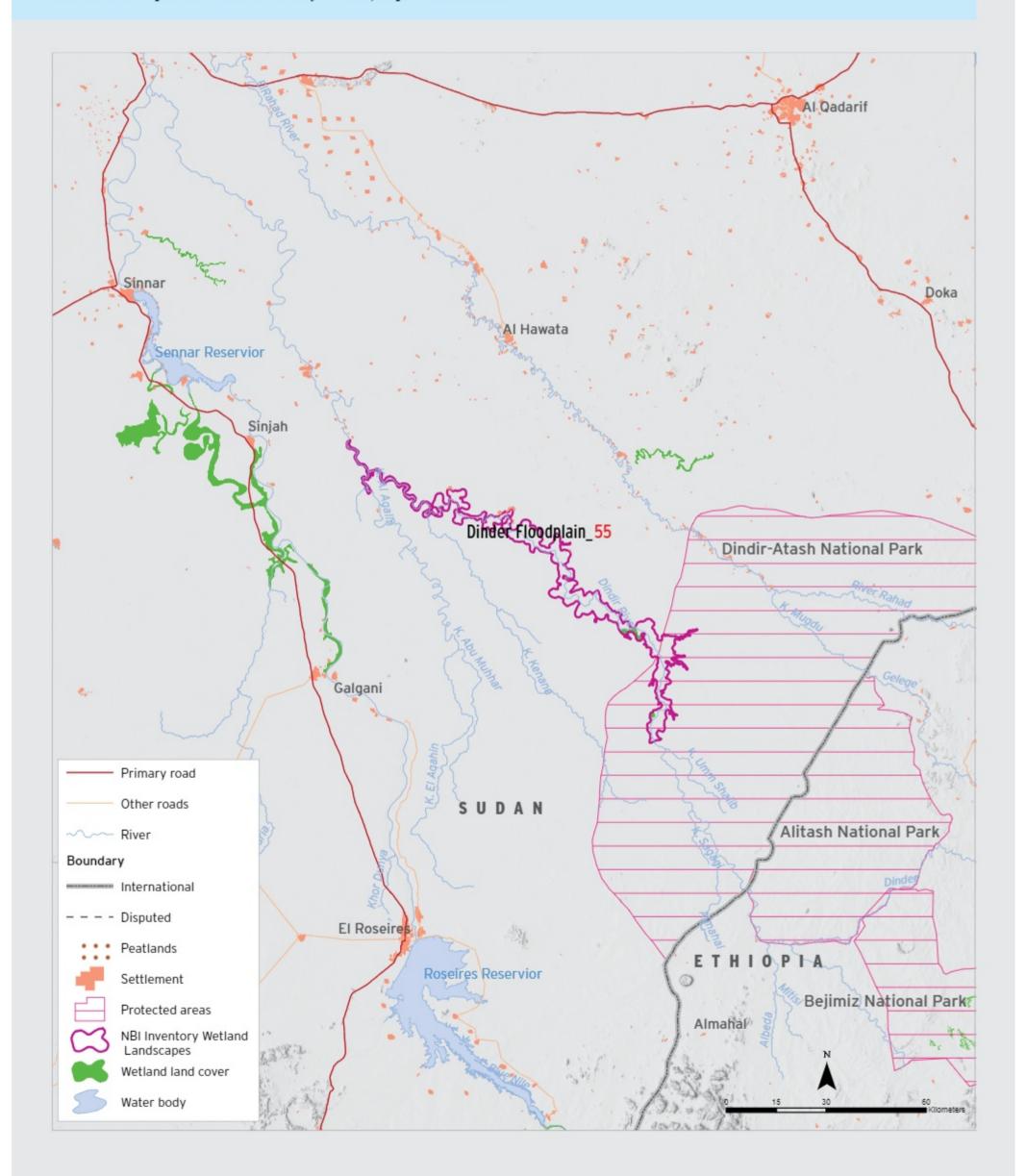
DINDER FLOODPLAIN

Name: Dinder Floodplain, Rahad Floodplain

Country: Sudan, Ethiopia Coordinates: 12°43'9" N / 35°22'13" E Altitude: 700-800 m a.s.l.

Area: 525 km² Nearest Towns: Sennar

International Importance: Transboundary wetland, Important Bird Area



The Dinder floodplain occupies the land between the Dinder and Rahad Rivers flow down from the Ethiopian Highlands to a flat plain, sloping gently north westwards towards the Blue Nile. A number of tributary rivers e.g. the Galegu with numerous oxbow lakes lie between the two major rivers and much of the intervening land may be flooded during the rainy season in the mountains.

Physical Features

The rivers Dinder and Rahad originate to the west of Lake Tana, flow westwards across the Ethiopian-Sudanese border and join the Blue Nile below Sennar. Along both rivers there are riverine wetlands locally called "Mayas". These Mayas are typical features of the Dinder National Park, which is located next to the Sudan-Ethiopian border. The Dinder and Rahad rivers meander through a flat plain in the south eastern part of Sudan, forming a braided river system with a network of small channels and oxbow lakes. Mayas are flat, with slight and/or no clear banks and they may or may not be connected to the main river channel. Some of them dry out completely during the dry season others don't. They also become dry due to groundwater infiltration and water consumption by wildlife. The Dinder floodplains are overlain with vertisols, which are black clays that develop wide cracks during the dry season. These soils are prone to gully erosion (ENTRO, 2008b; Hassaballah et al., 2018).

The Dinder catchment is about 37,600 km². The average flow of the Dinder is about 3 billion m³/year. Rainfall across the Dinder floodplain is uni-modal with 90 percent of total annual rainfall falling between May and November. The rainfall intensity decreases from upstream to downstream. Annual precipitation over the headwaters of the Dinder can be as high as 1,300 mm but decreases to 400-600 mm/year over the main part of

the floodplain. Average annual temperature is around 23°C. Annual evaporation is between 2,300 and 3,400 (ENTRO, 2008b; Hassaballah et al., 2018).

Biological Features

The Dinder floodplain is a protected area as part of the Dinder National Park which is contiguous with the Rahad Game Reserve to the North. This park preserves a natural wildlife migration corridor between Sudan and Ethiopia (ENTRO, 2008b).

The Dinder has three types of ecosystems namely Mayas, Riverine and Acacia seyal -Balinites. The Riverine forest vegetation is characterised by Acacia sieberiana, Ficus spp., Mimosa pigra, Tamarindus indica, Ziziphus abyssinica and Hypaene thebaica. The Acacia seyal-Balanites aegyptiaca woodlands are also subjected to flooding and are characterised by tall grasses such as Sorghum spp., Brachiaria spp. and Combretum spp. The swampy lakes are dominated by Ipomoea aquatica, Echinochloa spp., Leersia hexandra and Nympaea spp. The Mayas are characterised by Hyparrhenia spp., Panicum spp., Themeda triandra, Oryza longistaminata, Sorghum sudanensis and Cynadon dactylon (BirdLife, 2019; Hughes & Hughes, 1992). There are 42 taxa in the Dinder wetland group that have an IUCN threat status of interest. In total there are 27 flagship species.

Flagship bird species for the Dinder include Spatula querquedula (garganey), Spatula clypeata (northern shoveler), Nettapus auritus (African Pygmy goose), Glareola nordmanni (black-winged pratincole), Balearica pavonina (black crowned crane), Rynchops flavirostris (African skimmer), Aythya nyroca (Ferruginous pochard), Pelecanus rufescens (pink-backed pelican). The Dinder occurs within the migration route of the African wintering birds. The world's largest population of

Numida meleagris (tufted Guinea fowl) occurs with the Dinder (Nile-Eco-VWU, 2016).

Flagship mammal species include Aonyx capensis (African clawless otter), Hippopotamus amphibious (hippopotamus), Syncerus caffer (African buffalo), and Hyaena hyaena (striped hyaena). The populations of migrant grazers such as Damaliscus corrigumtiang (Tiang antelope), Hippotragus equinus (Roan antelope), Kobus ellipsiprymnus (waterbuck) and Redunca arundinum (southern reedbuck), are under pressure as land outside the park that they migrate across has been converted to farmland Pistia stratiotes and Lates niloticus are important alien species as well as Azolla niloticus.

Ecosystem Services

The Dinder Floodplain provides habitat for wildlife and the maintenance of genetic diversity. The main provisioning services of the Dinder wetlands are fresh water, farmland along the riverbanks, food (wild fruits like Nabag (Ziziphus spp), timber, and non-timber forest products (particularly Ziziphus leaves for handcrafts for household use and for sale) (Nile-Eco-VWU, 2016). These wetlands are also an important source of water and nutritious grasses for livestock, particularly during the dry season (Rebelo & McCartney, 2012).

They also provide important regulating services like air quality regulation, water purification and regulation, climate and erosion regulation, soil formation, pollination, biological control, and nutrient cycling. There are important cultural aspects that are well rooted in the areas' cultural diversity, and some important species like the Saaf (Ziziphus spp.) which is used in a ritual manner as a protection symbol. There are important archaeological sites, and the DNP is also an important area for recreation and education opportunities (Nile-Eco-VWU, 2016). The ecosystem services identified for the Dinder

Floodplain are further presented in WP 3: Ecosystem Service Assessment.

Management status

The Dinder National Park Authority manages the Mayas' water levels with the objective of supporting wildlife, and some of the dry Mayas are kept artificially wet by pumping groundwater (Hassaballah et al., 2018).

Drivers of Change

Nomadic tribes, move north towards the Dinder during the wet season. Even though the Dinder floodplains lie mostly in the Dinder National Park, where cattle grazing is not allowed, there are considerable incursions of livestock into the park (ENTRO, 2008b).

The hydrology of the mayas has experienced significant changes during recent years. As a result of population increase, more land is needed for agricultural production in the Blue Nile Basin. Hence, forests, woodlands and shrublands are cleared. This kind of land use change can lead to higher runoff, erosion and siltation (ENTRO, 2008b).

Sedimentation due to agricultural loss and gully erosion is one of the main threats to the wetland. River bank erosion, especially along the Blue Nile is accelerated due to excabation of soil for brick making and removal of trees along the banks (ENTRO, 2008b). This has large implications on the ecosystem of the Dinder National Park. The Dinder National Park Authority has been trying to support wetland conservation through engineering solutions such as channelization of the mayas feeder streams and excavation of mayas for removing sediment need to take account of land use and land cover changes and their impacts on runoff (Hassaballah et al., 2018).

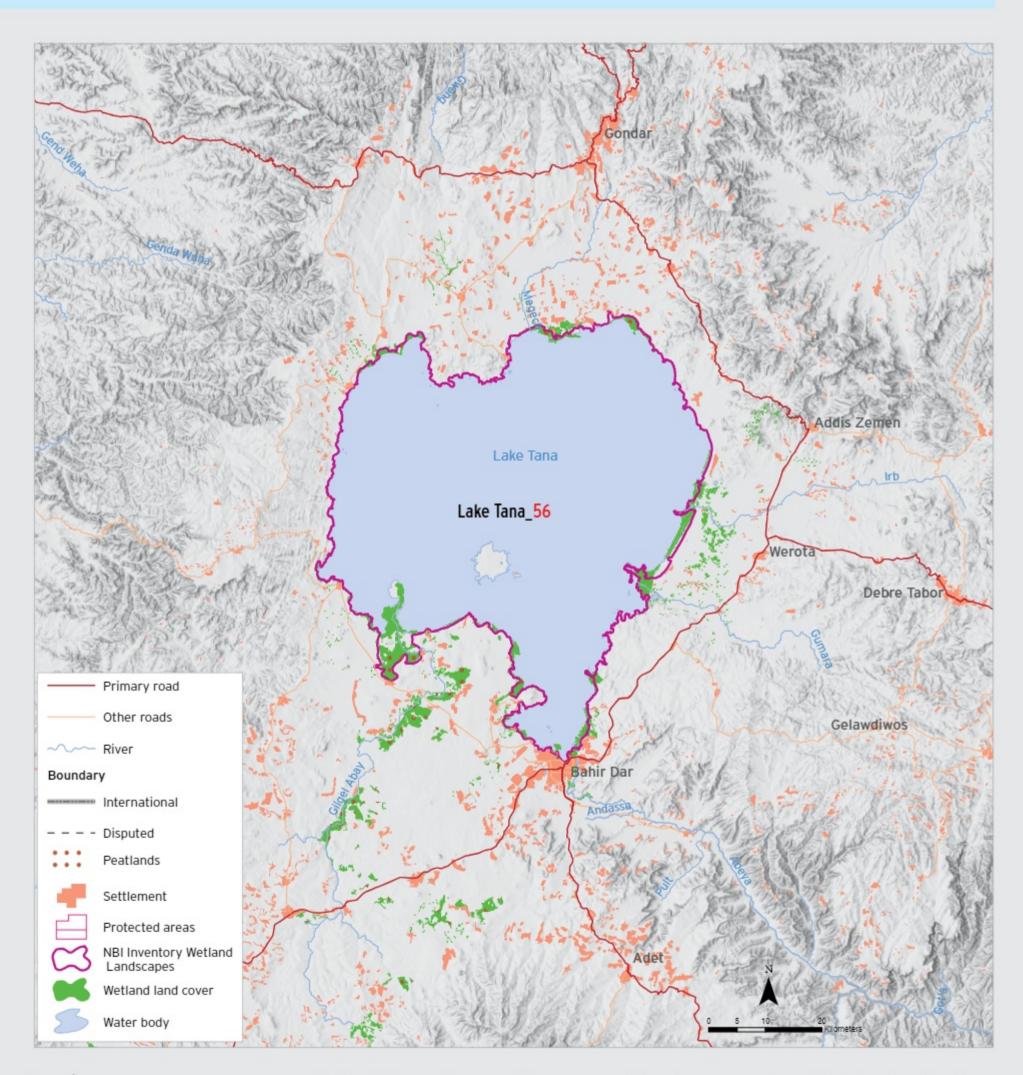
LAKE TANA

Name: Lake Tana Country: Ethiopia

Coordinates: 12°0'13" N / 37°20'8"E

Altitude: 1,788 m a.s.l. Area: 3,201 km² Nearest Towns: Bahir Dar

International Importance: Important Bird Area



Overview

Lake Tana lies in a depression in the north-west corner of the Ethiopian plateau, 350 km northwest of Addis Ababa. It is the largest lake in Ethiopia and the third largest lake in the Nile Basin with a surface area of up to 3,600 km2. There are 37 islands in the lake. On many of them there are ancient churches and monasteries, others support large colonies of birds. Bahir Dar, the capital of Amhara Region, is on the southern shore of the lake, where the Abbey (Blue Nile) flows out. Swampy and seasonally flooded alluvial plains border the lake to the north, east and west. In these regions the lakeshore is flat, elsewhere it is steep and rocky.

Physical Features

Lake Tana occupies a total drainage area of 15, 077 km² (Dessie et al., 2015). The bottom of Lake Tana is made up of volcanic basalt, which is covered with muddy substratum and little organic matter. The lake is relatively shallow, with a maximum depth of 14 m and an average depth of 8.8 m. Its surface area ranges from 3,050 km² during the dry season, to 3,600 km² at the end of the rainy season. The lake is 68 km long and 73 km wide. Its total volumes varies between the seasons and is on average of 28,000 km3 (Mengistou et al., 2009).

The climate around Lake Tana is semi-arid with high diurnal temperature variation. The mean temperature is 18.5°C with daytime extremes of 30°C and night time lows of 6°C. The surface water temperature ranges between 20 to 27°C (Mengistou et al., 2009). The rainfall is characterized by a unimodal rainfall pattern with a long rainy season from March/ April to October/November. Peak rainfall is in July and August average rainfall is 1,450 mm per year (Mengistou et al., 2009). The lake is exposed to wind as it is protected forest only on the southwest. From January to July winds are predominantly from the south and from August to November they blow from the north. These winds can cause strong wave actions and move high masses of floating papyrus and typha islands.

The water balance of Lake Tana is relatively well studied. The lake is replenished by five large permanent rivers as well as many small seasonal rivers in addition to surface diffuse run-off. The main tributary to the lake are the Gilgel Abay which contributes nearly 60 % of the total inflow (Dessie et al., 2015). Other large tributaries are the Gelda River and Gumara River from the east, the Megache River from the northern region and the Rib River from the north east. In total more than 40 seasonal and perennial rivers drain into the lake, predominantly form the west. Lake Tana shows an annual lake water level fluctuation of about 1.6 m (Dessie et al. 2015).

The outflow to the Blue Nile is situate at the southern shore of the lake. This surface outflow is manually controlled by gates to regulate the discharge to the Tis Abay II Hydroelectric Power Plant. On the southwestern side of the lake, there is an artificial tunnel hydropower outlet (Tana-Beles). The average annual evaporation from the lake is 1,835 mm (Dessie et al. 2015) with lowest values in December and highest in April.

There are several wetlands located all around the lake, with the exception of the north- east. Together, these wetlands are the largest in the country and comprise integral parts of the complex Lake Tana ecosystem. Consisting of permanent swamps, seasonal swamps and areas subjected to inundation, during the rainy period these wetlands are connected to the lake (Mengistou et al., 2009). Dessie et al. (2015) emphasise the impact of the extensive floodplains on the water balance of the lake, as 6 % of the total inflow to Lake Tana is lost through evaporation in the floodplains.

On the eastern shore of Lake Tana, the Gumara and the Rib River overflows their banks to form the Fogera Floodplain, an agricultural floodplain wetland. These seasonal floodplains have an estimated area of 28,000 hectares. The wetlands are thought to have been part of the lake but have changed into the present land forms because of high sediment loads from inflowing rivers to Lake Tana. The soils are alluvial and very fertile, therefore they have been used for agriculture for several thousands of years. On the northern shore a large floodplain area called Dembia is seasonally inundated and drained by the Megech and Dirma and other streams. This area is highly degraded. Intensive agriculture uses with further development are being considered (NBI, 2009).

Originating from the south western mountains the Little Abay River (Gilgel Abay) flows through an open valley and enters the lake at its south western end along a stretched deltaic arm. This is the longest of all feeder streams which drain the largest of Lake Tana's sub-catchments and contribute a high sediments loads into Lake Tana (NBI, 2009).

Other floodplains connected to Lake Tana are, the Bahir Dar Zuria Wetlands (Kunzila Floodplain) in the south-west, the Delgi-Takusa Wetlands, the Gelda River Floodplain and the Zegie Wetlands (Mengistou et al., 2009).

Biological Features

Lake Tana wetlands provide habitat for globally threatened and endangered species and as such is a biodiversity hotspot. The Tisisat Falls, 40 m high and 30 km downstream from the Blue Nile outflow, isolate the freshwater fauna from the rest of the Nile. The wetlands are the home of the Fogera cattle which have broad hoofs as an adaption to moving in marshes.

The shoreline vegetation on the eastern and southern sides of Lake Tana consists of Cyperus papyrus (papyrus), Typha latifolia (common cattail), Phragmites karka (common reed), Persicaria senegalensis, Vossia spp. (hippo grass), Scirpus spp. (bullrush) and Nymphaea lotus. The submersed macrophytes are Ceratophyllum demersum and Vallisneria spiralis. The invasive Eichhornia crassipes was identified in 2011 in Lake Tana and Azolla and Water Lettuce also occur. The papyrus has dramatically declined in its distribution around the lake with some local extinction due to overexploitation (Degaga, 2018; Menbere & Menbere, 2018; Vijverberg et al., 2009).

Some of the 17 endemic fish species of Lake Tana include Garra regressus, G. tana, Barbus tanapelagius, Afronemacheilus abyssinicus and Labeobarbus intermiduis (Shkil et al., 2017). The main commercial fish species are Lates niloticus, Oreochromis niloticus, Labeo hori, Clarias gariepinus and Barbus sp. Fishing at the mouths of the tributaries while fish migration for spawning occurs is a major threat to these fish (Hughes & Hughes, 1992; McKee, 2007).

Lake Tana is an Important Bird Area and provides nesting, breeding, roosting and feedings sites for globally threatened and migratory birds. A winter bird count for just Lake Tana exceeded 150,000 individuals. Some of the important bird species include

Bugeranus carunculatus (wattled crane), Poeniconaias minor (lesser flamingo), Rougetiusrouget (rouget's rail), Circus macrourus (pallid harrier) and Aquila clanga (greater spotted eagle) (Menbere & Menbere, 2018). Mammals occurring around Lake Tana include Cercopithecus aethiops (grivet monkey), Crocuta crocuta (spotted hyena), Erythrocebus poliophaeus (Blue Nile patas monkey), Eudorcas albonotata (Mongalla gazelle), Genetta (Genet), Hippopotamus amphibious (hippopotamus), Hystrix cristata (crested porcupine), Colobus guereza (black-and-white colobus monkey).

There are 39 taxa in the Lake Tana wetland group that have an IUCN threat status of interest. In total there are 22 flagship species. Pistia stratiotes and Lates niloticus are important alien species in the wetland group. Some of the 17 endemic fish species of Lake Tana include Garra regressus, G. tana, Barbus tanapelagius, Afronemacheilus abyssinicus, and Labeobarbus intermiduis (Shkil et al, 2017).

Ecosystem Services

Besides habitat for wildlife, the human population also makes use of the fishing resources for commercial and non-commercial purposes. Some species are preferred over others (like Barbus over catfish) for cultural and religious reasons. This lake also provides area for crop cultivation and fresh water for agriculture and cattle. People also use it as means for transportation (Agimass & Mekonnen, 2011).

Regulating services, like water flow regulation and water purification, are also important and are being lost due to wetland conversion and loss of plant cover, increasing the silt inflow into the lake (Agimass & Mekonnen 2011). Other potential ecosystem services of Lake Tana are natural hazard and climate regulation, soil formation, nutrient cycling, maintenance of genetic diversity, and recreational and educational values. The ecosystem services identified for Lake Tana are further presented in WP 3: Ecosystem Service Assessment.

FINCHA'A-CHOMEN SWAMP

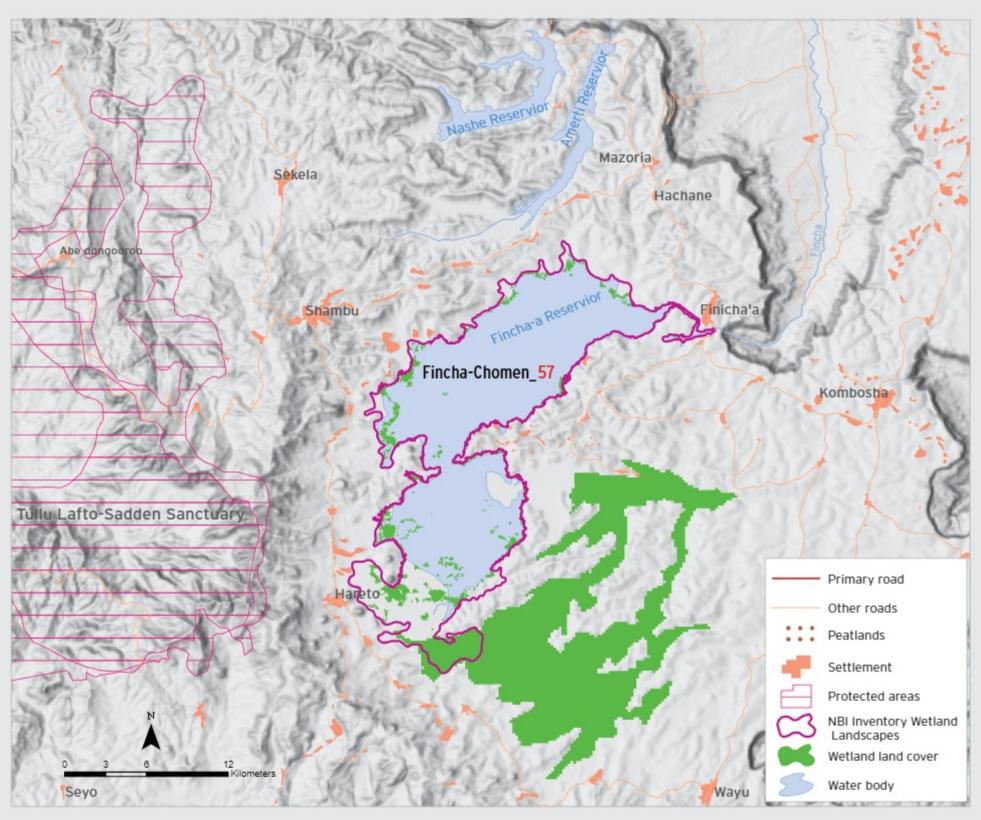
Name: Fincha'a-Chomen marsh, Fincha's Lake

Country: Ethiopia

Coordinates: 9°33'27.40"N / 37°21'54" E Altitude: 2,220-2,250 m a.s.l.

Area: 277 km² Nearest Towns: Fincha Town

International Importance: Important Bird Area



Overview

The Fincha'a-Chomen marsh is one of the largest wetland complexes in Ethiopia. It is found surrounding a man-made reservoir that was constructed in 1972 for hydroelectric power production. The two shallow swamps, Fincha'a and Chomen are separated by a low ridge.

Physical Features

North of Fincha'a a series of small ridges separates the swamp from the Aleltu River and its tributaries. which run parallel from west to east before dropping over the basalt shelf into the Abbay gorge. The western edge of the plateau is delimited by a ridge of highland that runs north-west-south-east and divides the watershed of the Didessa River to the east from the Finchaa and Chomen swamps. A lower ridge on the east separates the swamps from the Guder river basin. The encircling highlands limit the extent of the swamps during the rainy season. The only outlet is at the north-east corner of Fincha'a, where the Fincha'a River falls in a long drop of nearly 500 m into the Abbay gorge. The streams flowing into Fincha'a and Chomen swamps are all short, thus direct rainfall is a vital source of their water. In the dry season the water-level in the swamps is less than 1 m, but in the rainy season the level rises to 2-3 m. Water is released from the swamps at a rate controlled by the Finchaa channel between the swamp outlet and the falls. At the edges of the lakes there are large floating mats of vegetation. These floating mats are dominated by stoloniferous grass (Panicum hygrocharis) and are travelling extensively across the

whole basin. Along the western edge of the reservoir there is a wider mix of grass and sedges.

Drivers of Change

There is no known environmental management measure in place. The wetlands are under constant pressure from agricultural expansion, overgrazing, and various types of land use changes such as the introduction of new crops, eucalyptus plantation among others (ENTRO, 2008b).

EL ROSEIRES

El Roseires artificial impoundment Name:

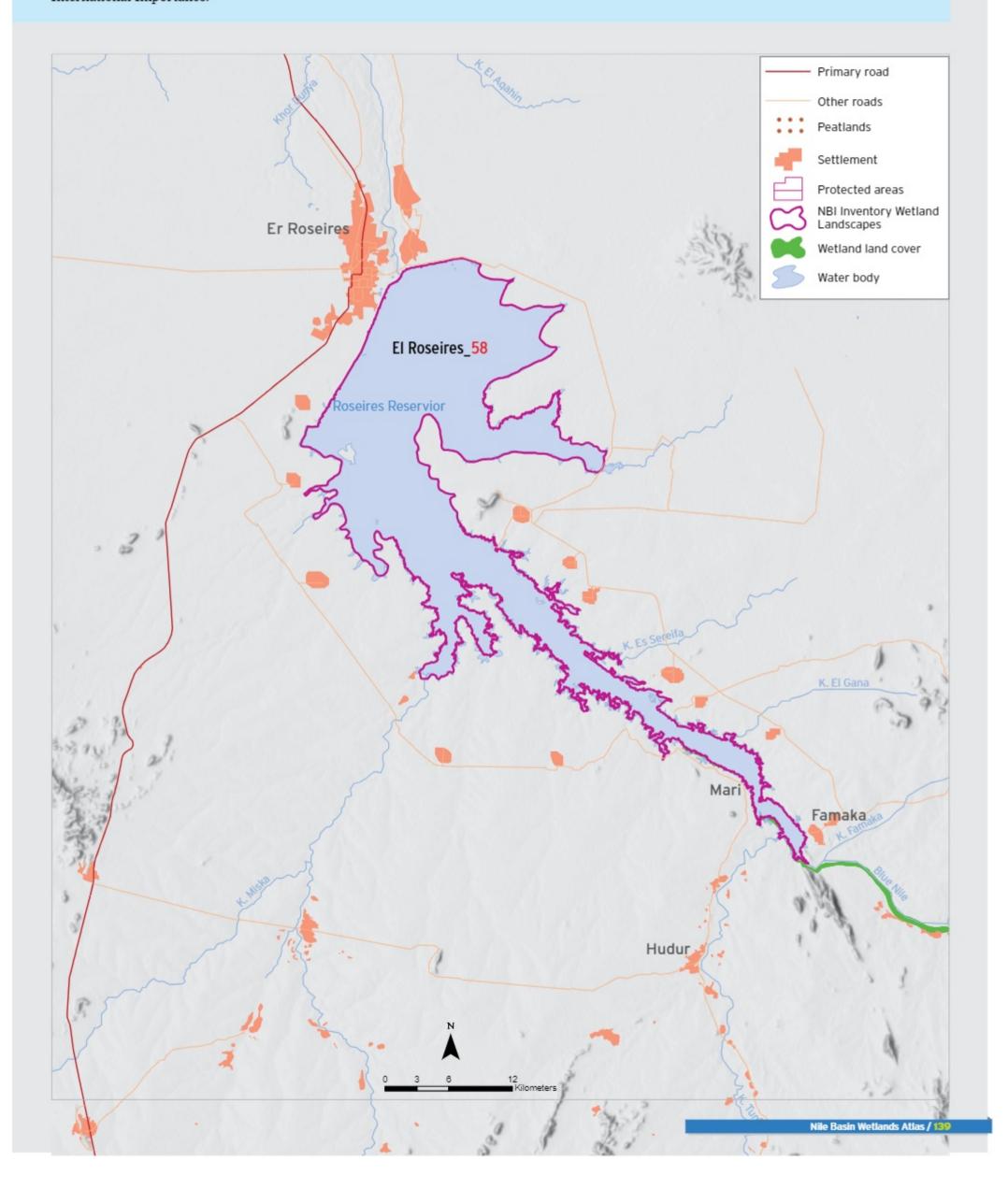
Country: Sudan

11°41'26" N / 34°23'6" E 480 m a.s.l. Coordinates:

Altitude:

Area: 535 km²

Nearest Towns: El Roseires (Khartoum 550 km SE)
International Importance:



The Roseires Reservoir is located iust above Er Roseires some 100 km from the Ethio-Sudanese border on the main stem of the Blue Nile. The dam plays a key role in regulating the flow of the Blue Nile. It was finalised in 1966 to produce hydropower and provide a reservoir for irrigation. The capacity of the power plant is 250 MW. Originally the artificial lake had a volume of 2.4 km3 (ENTRO, 2008b). Due to severe sedimentation in the last forty vears, the reservoir has already lost one third of its storage capacity (Omer et al., 2014).

Physical Features

The temperature within the environment of the El Roseires reservoir ranges between 27 to 46°C (Muala et al., 2014). Rainfall occurs mainly between June and October. The average annual rainfall at the Roseires weather station is slightly above 700 mm/ year with interannual variations (NBI, 2016).

The annual average water inflow at El-deim is 49 billion m³/year (Muala et al., 2014). The high flood season occurs between July and late October. In the beginning of the season, the reservoir is drawn to its minimum level as flood gates are opened to flush inflow water with a high sediment and debris content. In September the reservoir is filled and reaches its maximum level in October. After January, during the dry season the water level drops, as more water is released (Alrajoula et al., 2016; Muala et al., 2014).

Sheet erosion in the Ethiopian Highlands, agricultural soil loss and gully erosion lead to a high sediment load arriving at the El Roseirs impoundment (ENTRO, 2008b). The reservoir is the first trap for sediments coming from the upper Blue Nile Basin. Sediment deposition in the reservoir has led to a storage volume loss of 238 *106 m³ between 1992 and 2007 (Omer et al., 2015). This results in a reduction of hydropower generation and impacts the availability of water for

irrigation. Silt enters the irrigation canals within the Geizera-Managil and Rahad Irrigation Schemes and clogs pumps, as well as the canals themselves (ENTRO, 2008b). As a countermeasure the dam was heightened in 2012 by 10 m to double its storage capacity and increase power production. Since then the total surface area of the reservoir has increased from 203.5 km² in 2011 to 528 km² (Alrajoula et al., 2016). The reservoir is 80 km long and 9 km wide with a mean depth of 50 m and a water volume of 3 km3 (Muala et al., 2014). The bed of the reservoir is cut through by a 10 m deep channel (Omer et al., 2015).

Drivers of Change

Even though wetlands are well known for suspended solids retention (Russi et al., 2013), the high sediment load reaching Roseires can affect soil properties, topography, species richness and composition (Wang et al., 2014).

To limit sedimentation, the flood gates of the dam are kept open

during the wet season, which leads to a drop in water level by 13 m. During this time, the area surrounding the reservoir channel falls dry (Omer et al., 2015). These hydro morphological variations in addition to an increased reservoir area due to the heightening of the dam impact the ecosystem as well as the environment for the population surrounding the reservoir. The large water surface area probably leads to a lower groundwater table and higher evaporation. The high humidity affects the structure of concrete buildings close to the reservoir and possibly affects the health of the local population (Alrajoula et al., 2016). However, this is not yet scientifically proven. Hydrological alterations caused by the construction of the Grand Ethiopian Renaissance Dam, will likely have a great impact on the Roseires Reservoir.

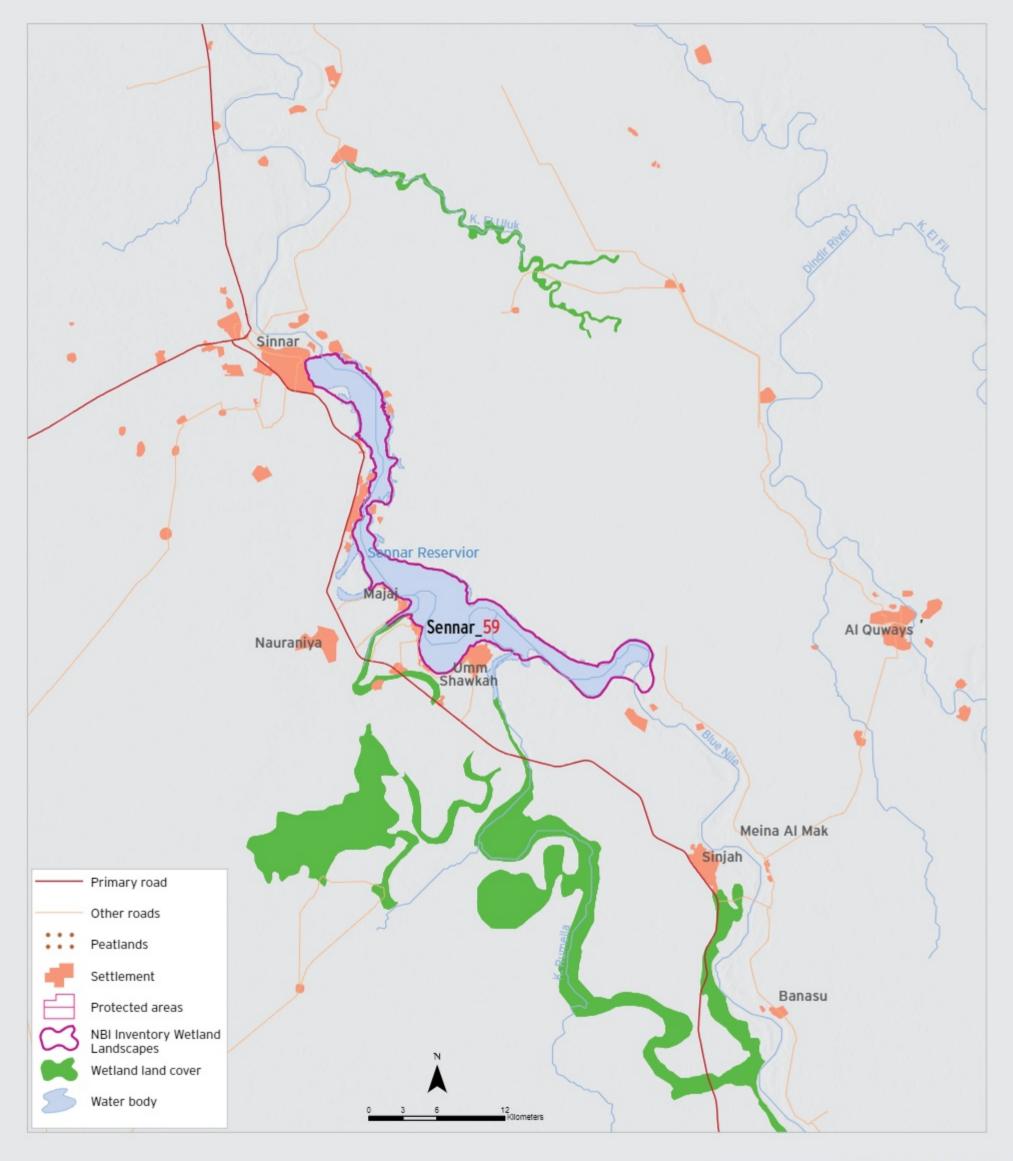
SENNAR

Name: Sennar artificial impoundment, Sinnar dam

Country: Sudan

Coordinates: 13°30′14"N / 33°40′3" E Altitude: 425 m a.s.l.

Altitude: 425 m a.s.l Area: 133 km² Nearest Towns: Sennar International Importance:



The Sennar Dam was completed in 1925 with a storage capacity of 0.93 billion m³. The dam was mainly built for regulation purposes as well as for developing hydropower and irrigation. The hydroelectric production capacity is 15 MW.

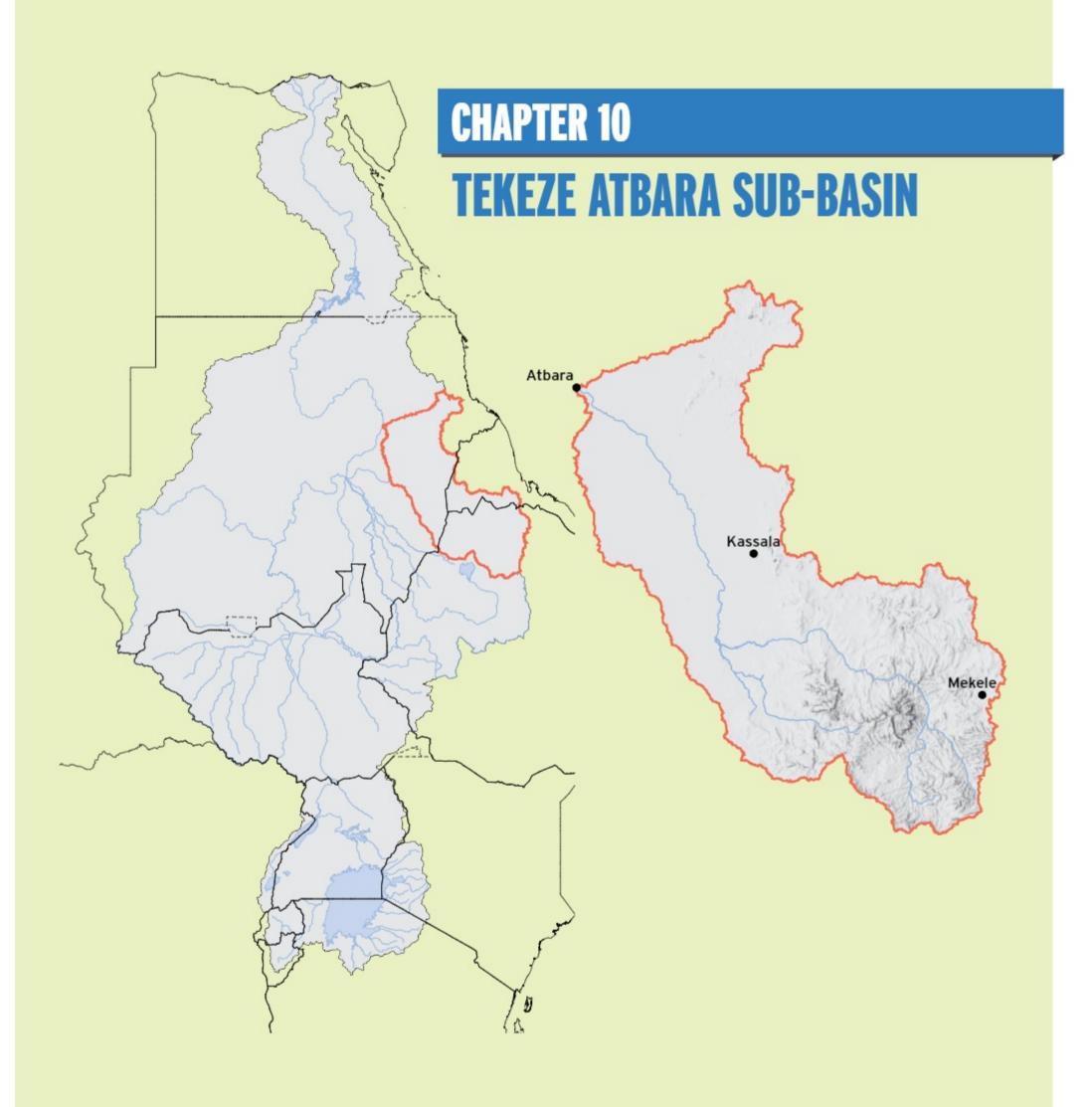
Physical Features

There is no major tributary to the Blue Nile between the Roseires Dam and the Sennar Dam.
Therefore the inflow into the Sennar reservoir is the same as the inflow into the Roseires reservoir (49 billion m³/year) (ENTRO, 2008b; Muala et al., 2014). The two dams are operated in accordance. Even though the Roseires Dam

acts as a first buffer for sediment retention, the Sennar's capacity has also been reduced to 0.37 billion m³.

Drivers of Change

Sheet erosion in the Ethiopian Highlands, agricultural loss and gully erosion lead to a high sediment load arriving at the El Roseirs impoundment (ENTRO, 2008b). Sedimentation in the reservoir can lead to high losses in storage capacity. In wetlands sediment accumulation can impact species richness and composition, influence soil properties and topography (Wang et al., 2014)



Introduction	145
Socio-economic context of wetlands in Tekeze Atbara sub-basin	146
Hydrological context of wetlands in Tekeze Atbara sub-basin	
Khashm el-Girba	

INTRODUCTION

Overview

The Tekeze-Atbara sub basin drains the highlands of centralnorth Ethiopia. Its main rivers are the Tekeze (also known as Setit in its lower reaches), Gwang and Atbara, which constitutes the ultimate downstream river reaches. The long-term average annual water yield of the subbasin is approximately 12 billion m³. The rivers are highly seasonal in their flows and are used to supply water for hydropower generation and irrigation. There are three dams in the sub-basin, the TK5 in Ethiopia, Khashm el Girba in Sudan and the Atbara Dam complex (known as Rumela-Burdana Dam, not yet operational). Sediment loads in the basin are high and water or

sediment retention in wetlands or floodplains is low. An inventory of the Tekeze Atbara Setit sub basin (ENTRO, 2008c) states that there are no significant wetlands in this system.

Climate

The Tekeze Atbara Sub-basin shows a changing topography from south to north and lies mostly in the ecoregion Sahelian acacia savanna. Rainfall is unimodal and concentrated in August and September. The Ethiopian highlands receive more than 800 mm rainfall per year, whereas downstream at the junction of the Atbara River and the Main Nile precipitation decreases to less than 90 mm per year. Potential evapotranspiration in the basin is

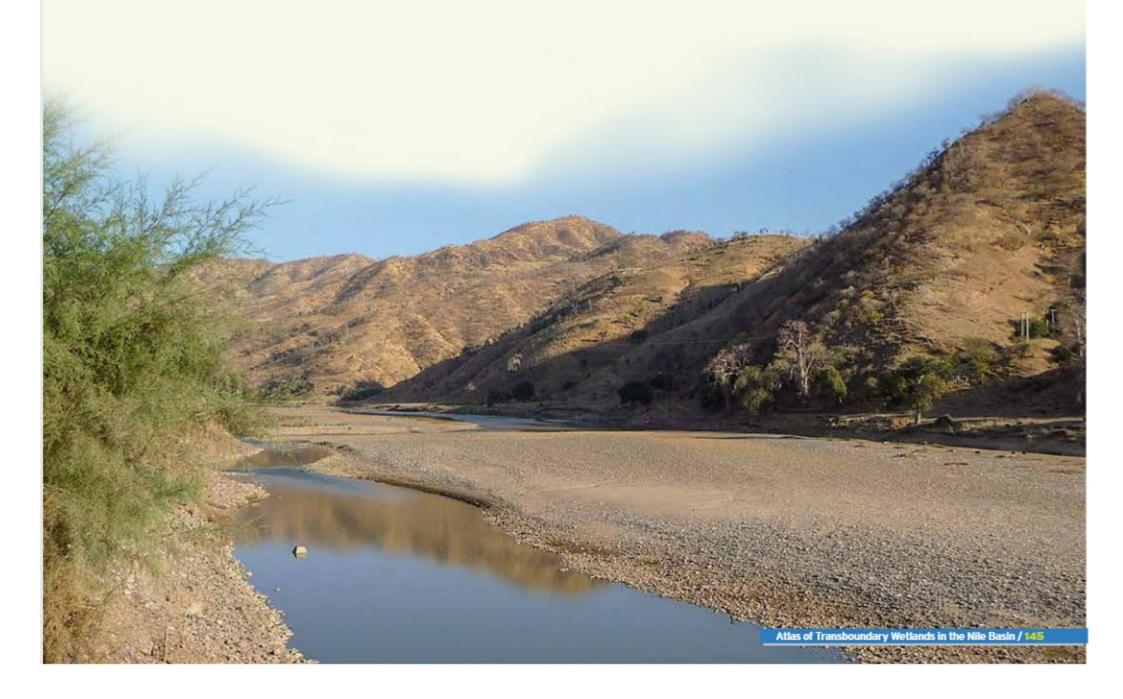
1,780 mm/year (NBI, 2016).

Ecosystem services

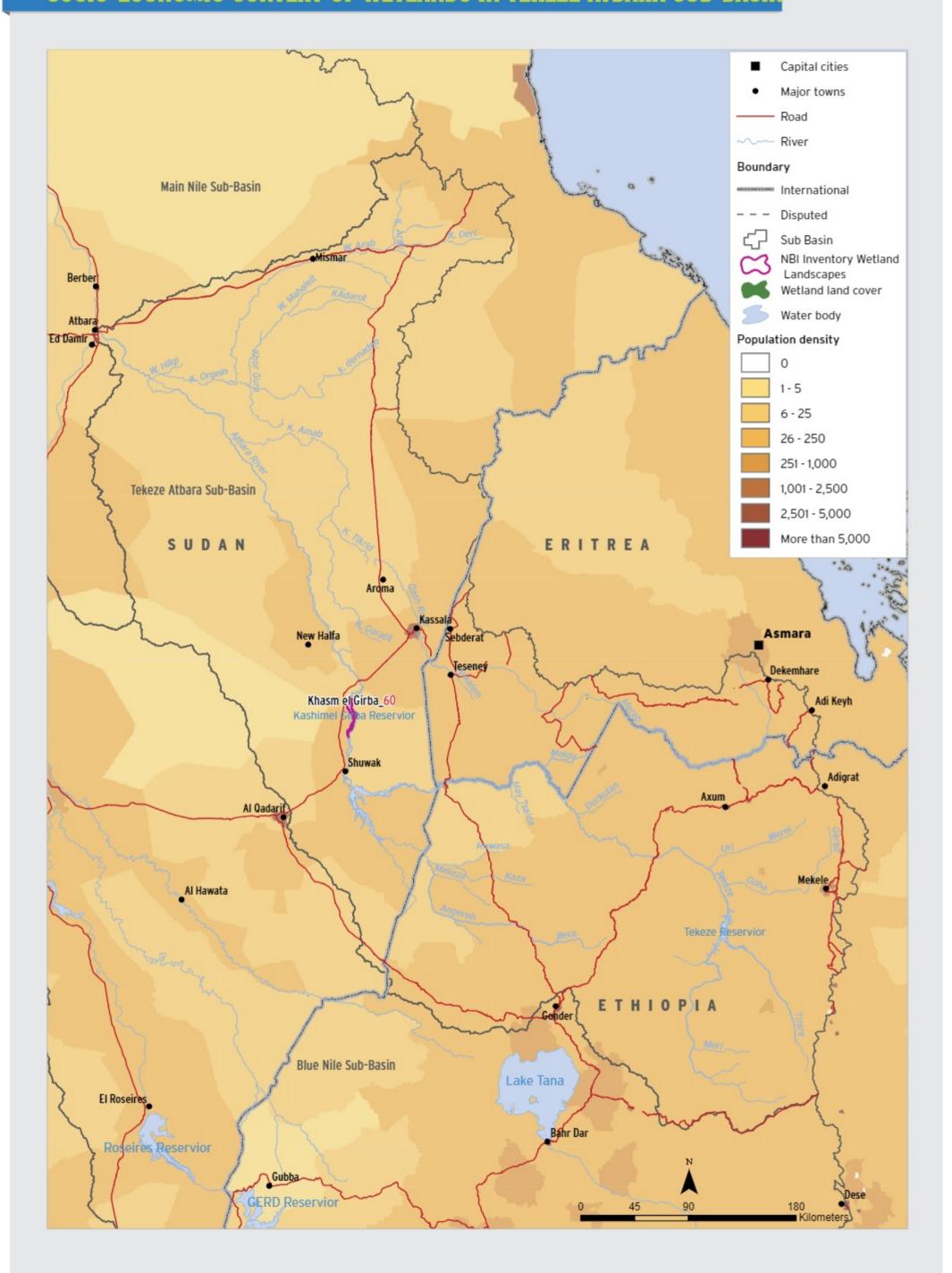
Particularly the administrative sub-zone Dighe (Eritrea) is relevant for its biodiversity richness and socio-economic importance, which is threatened by forest clearings for commercial agriculture and resettlements (Araia, 2005). These forests provide ecosystem products in the form of food like game, fruits, grains, and fodder for livestock and farmland, as well as fresh water, timber and medicinal products. They also provide regulating and supporting services like water flow regulation, water purification, erosion regulation, maintenance of soil fertility, natural hazard

regulation, climate regulation, pollination, nutrient cycling and habitat for species (Araia, 2005; Atnafu, 2014; Aymeric et al., 2014; Mekuria et al., 2011)

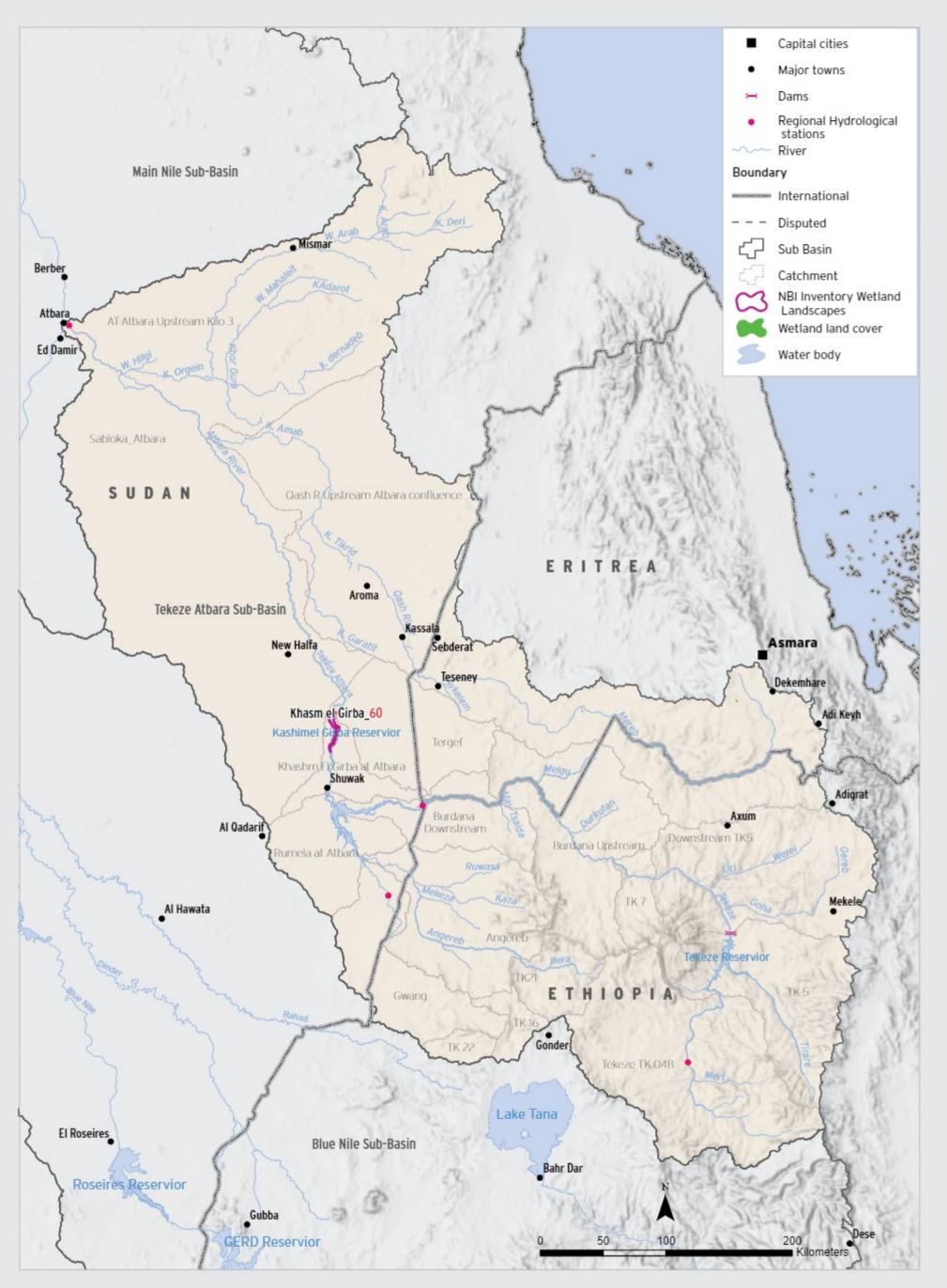
Atnafu (2014) considers specifically the importance of forests in Ethiopia, particularly the Semien Mountains National Park, as an important conservation zone for the Walia ibex (Capra walie). This National Park provides habitat for this and other wildlife species, thus aids in maintaining genetic diversity, and provides recreational opportunities. The ecosystem services identified for the Tekeze Atbara wetlands are further presented in WP 3: Ecosystem Service Assessment.



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN TEKEZE ATBARA SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN TEKEZE ATBARA SUB-BASIN



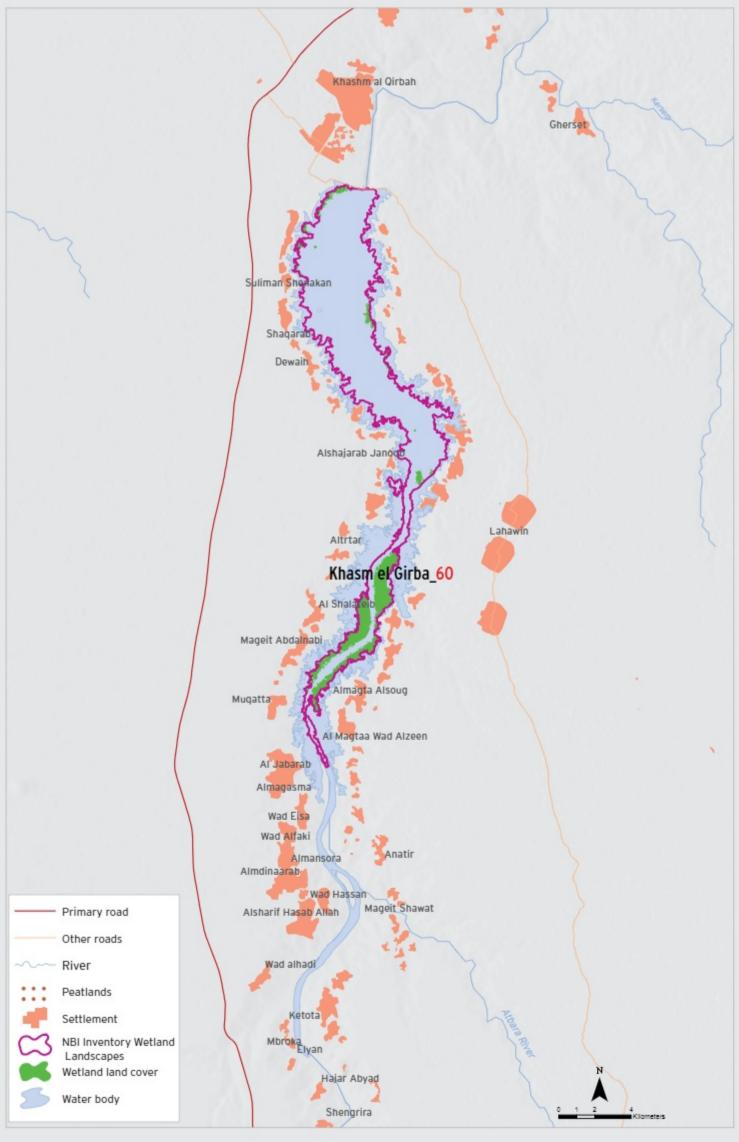
KHASHM EL-GIRBA

Name: Khashm el-Girba

Country: Sudan

Coordinates: 14°54'1" N / 35°53'40" E

Altitude: 420 m a.s.l. Area: 63 km² Nearest Towns: Kassala

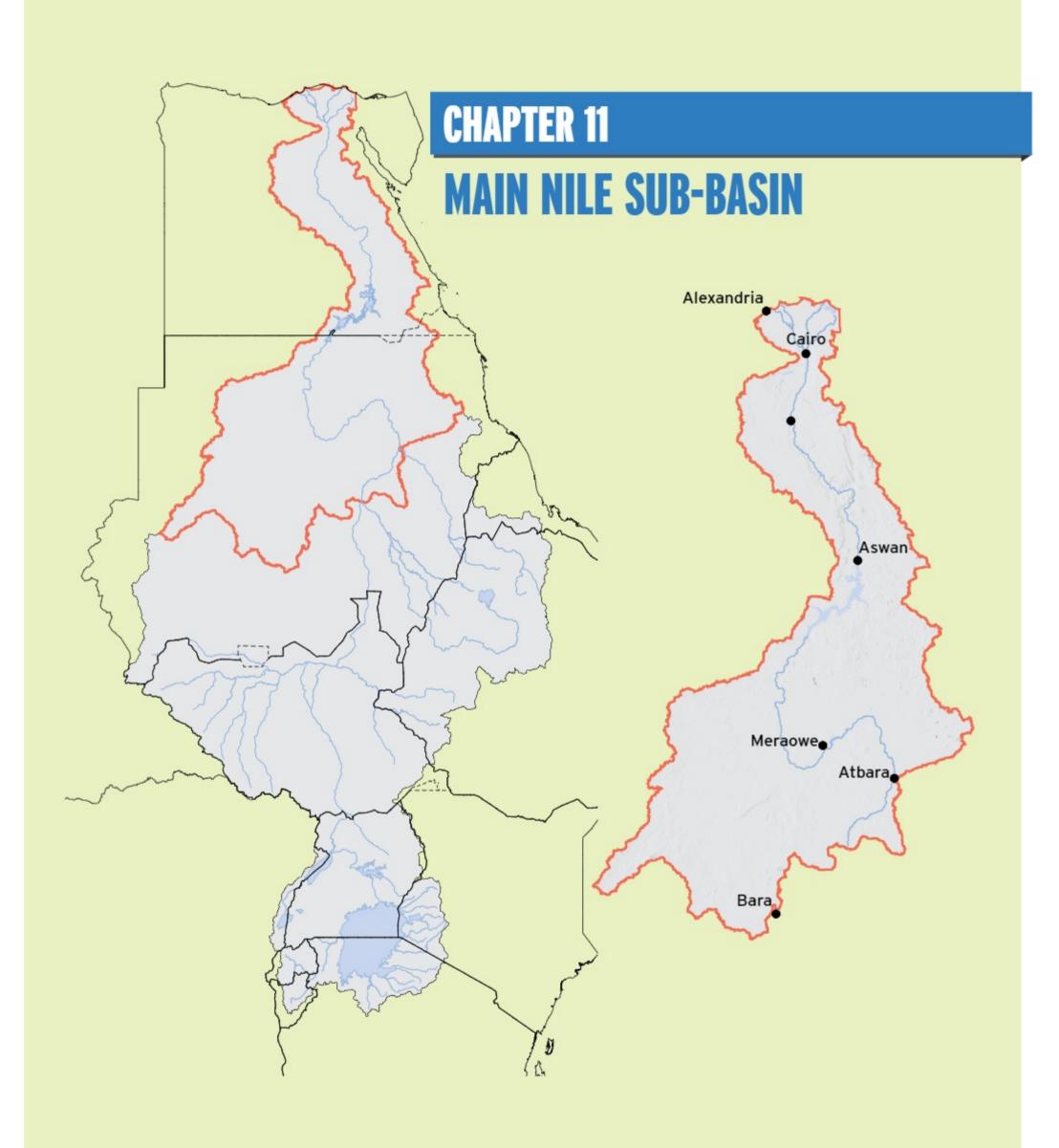


Overview

The Khasm-el-Girba located downstream of the Angereb-Goang-Tekeze confluence in Sudan is the only existing reservoir in the Tekeze-Setit-Atbara system. The dam was built in 1966 in the Atbara main stem at initial storage capacity of 1.3 billion m³ (ENTRO, 2008c).

Physical Features

In general there is not a lot of published literature available on the characteristics of this reservoir, especially data on biodiversity and shoreline wetland morphology is scarce. The watershed of Atbara at this station is estimated at 230,000 km² with mean annual inflow of 11.65 billion m³. The Girba reservoir is built for irrigation and hydropower purposes. Mean annual sediment inflow to the reservoir is in the order of 28.5 million m3 (ENTRO, 2008c). Between 1964 and 2010 the Khashm el-Gibra reservoir has lost 53 % of its original storage capacity due to heavy sedimentation (Moussa, 2019). Each year the reservoir is flushed to remove silt and sand. As a result the fish population in the reservoir suffers from great losses each year (Ahmed et al., 2011).



ntroduction	151
Socio-economic context of wetlands in Main Nile sub-basin	152
Hydrological context of wetlands in Main Nile sub-basin	153
The Lower Nile Valley	154
Wadi El Rayan Protected Area	155
Lake Qarun	157
The Nile Delta	159
Lake Maryut	161
Lake Idku	163
Lake Burullus	
Lake Manzala	
References	169

INTRODUCTION

Overview

The Main Nile sub basin starts at Khartoum after the Blue-White-Nile confluence. The main Nile System is divided into the Sudanese part, upstream of Aswan Dam and the Egyptian part, downstream of Aswan. The main part of the sub basin is characterized as Sahara desert ecoregion, except for the floodplains of the Nile, which are defined as flooded savanna. As a result of high flow rates from the Blue Nile, peak flows in the Main Nile occur between August and September.

Climate

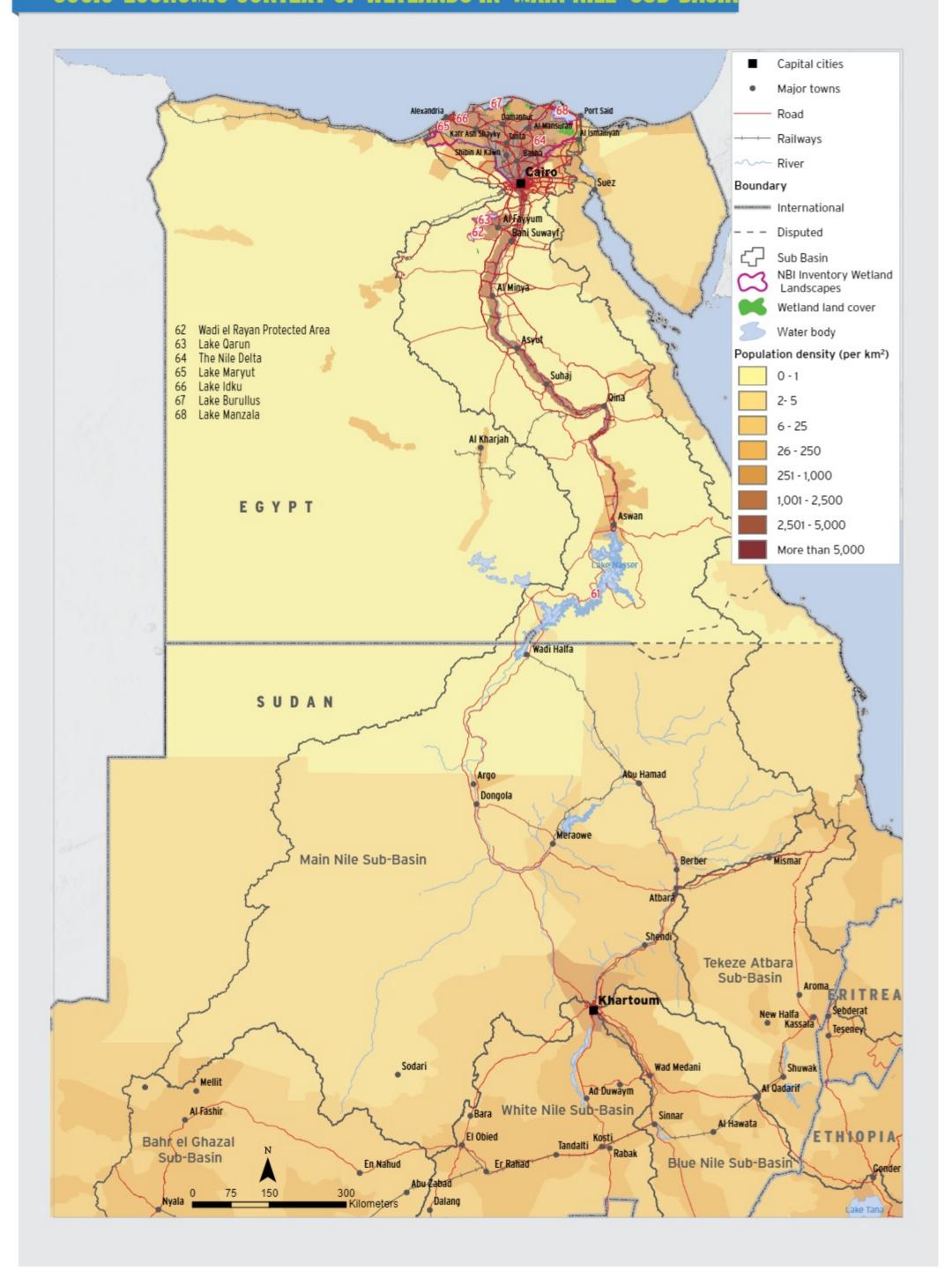
The Main Nile receives the least amount of rainfall of all the subbasin. Mean annual rainfall in the greater part of the basin can be as low as 50 mm/year. At the Mediterranian Sea, the Nile Delta rainfall can be as high as 200 mm/year. Average potential evapotranspiration is 2,200 mm/year (NBI, 2016).

Ecosystem services

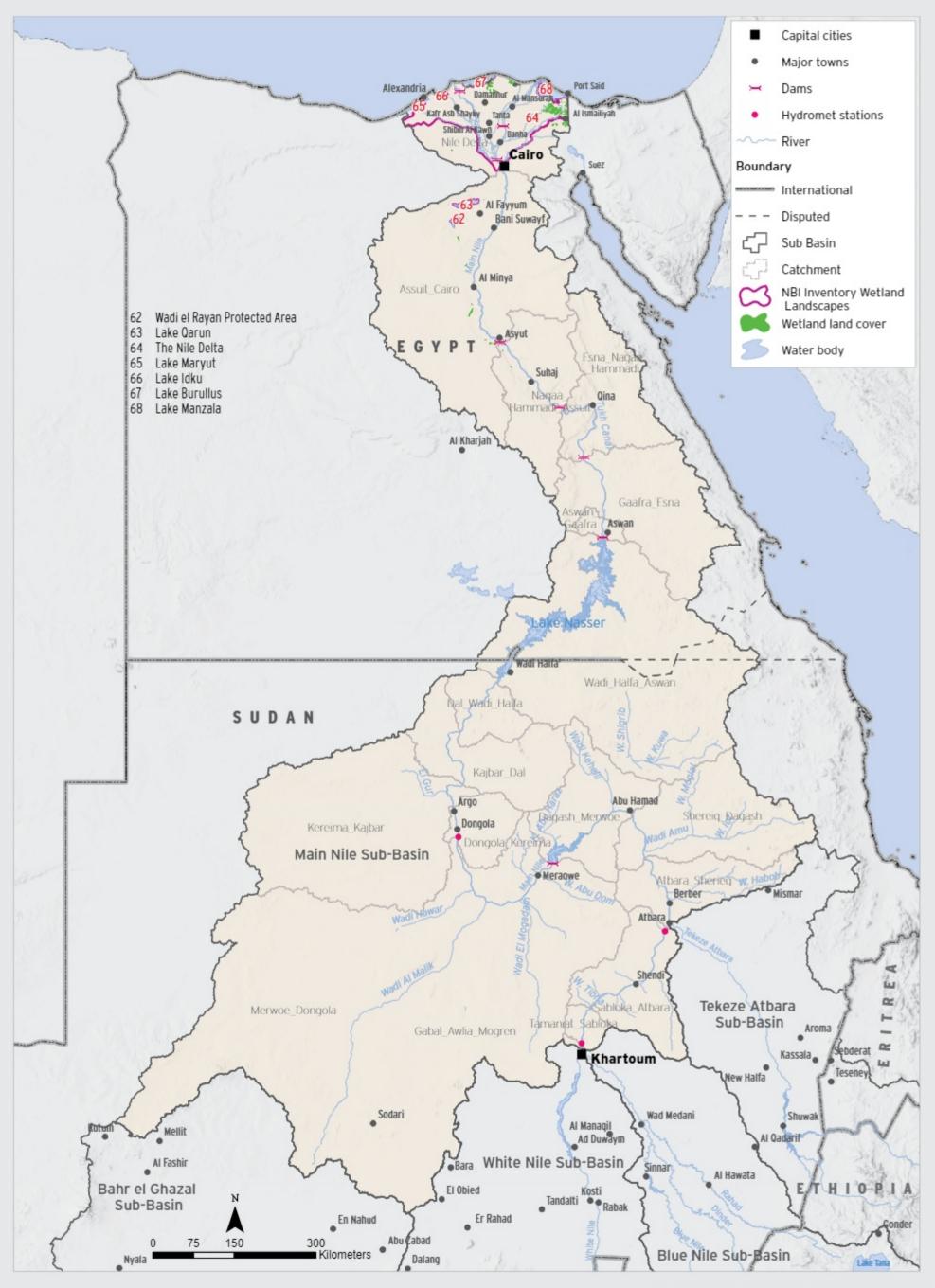
Historically, flood recession farming was common all along the Nile River Floodplains, but after the completion of the second Aswan Dam in 1970 the loss of seasonal flood pulse and wetland habitats allowed year-round agriculture (Rebelo & McCartney 2012). Since then this is the most important agricultural region of Egypt (Rebelo & McCartney 2012).



SOCIO-ECONOMIC CONTEXT OF WETLANDS IN MAIN NILE SUB-BASIN



HYDROLOGICAL CONTEXT OF WETLANDS IN MAIN NILE SUB-BASIN



THE LOWER NILE VALLEY

Overview

The Nile Valley below Aswan varies 20-30 km in width and is confined by steep sides, particularly on the east. Since the closure of the High Dam at Aswan the valley is no longer flooded each year. It is however, irrigated and traversed by a number of streams and canals on the western side. The longest of these is the Bahr Yûsef which flows in parallel with the Nile. The Bahr Yûsef receives water from the Nile at various points and terminates in vicinity of El Faiyûm, from where, ultimately, its waters drain to Lake Qaroun. A number of small lakes also occur along the western side of the valley. A succession of deep Wadis run down from the eastern hills to the right bank of

the river and comparatively little agriculture occurs on this side of the valley.

Climate

The Lower Nile Valley lies within the Sahara ecoregion and has a typical arid climate, which is hot and dry with sunshine throughout the year and scanty winter rains. In July/August the minimum temperature is 24°C and maximum temperatures go almost up to 40°C. In January/ December minimum temperature is 10 and the maximum temperature is 22°C (Zaghloul et al., 2012). The precipitation rate averages 10.1 mm annually, the highest rainfall occurs in December (40% of annual rainfall) and the lowest (0%) in August.

Potential evapotranspiration rate is extremely high in all months of the year, resulting in a mean annual aridity index of 0.004. Winds occur throughout the year, mostly from the north and northwest. Relative humidity averages 51%, ranging from 39% in May to 64% in December (Fouda & Fishar, 2012b).

Ecosystem services

The El-Rayan Lakes and Lake
Quarun are a very important
source of irrigation water for
agriculture in the El-Fayoum
Governorate of Egypt. In addition
the lakes are used for aquaculture,
and fishing. However, due to the
increase of the salinity level, the
original fish fauna disappeared
and the commercial catch also

dropped. Therefore Lake Qarun was stocked with fish species tolerant to high salinity, such as mullets and soles (Fouda & Fishar, 2012a, 2012b).

The lakes are also historically significant, as many fossils were found in the surrounding area. Some fossils date back to 40 million years, such as the EL-Fayoum Giant animal, which resembles a rhinoceros. Since 1992 water from Lake Qarun is pumped to evaporation ponds to extract sodium sulphate. Both Ramsar sites, Wadi el Rayan and Lake Qarun are popular tourist destination, for birdwatching, safaris and visiting historical sites (Fouda & Fishar, 2012a, 2012b).



The Nile Delta

WADI EL RAYAN PROTECTED AREA

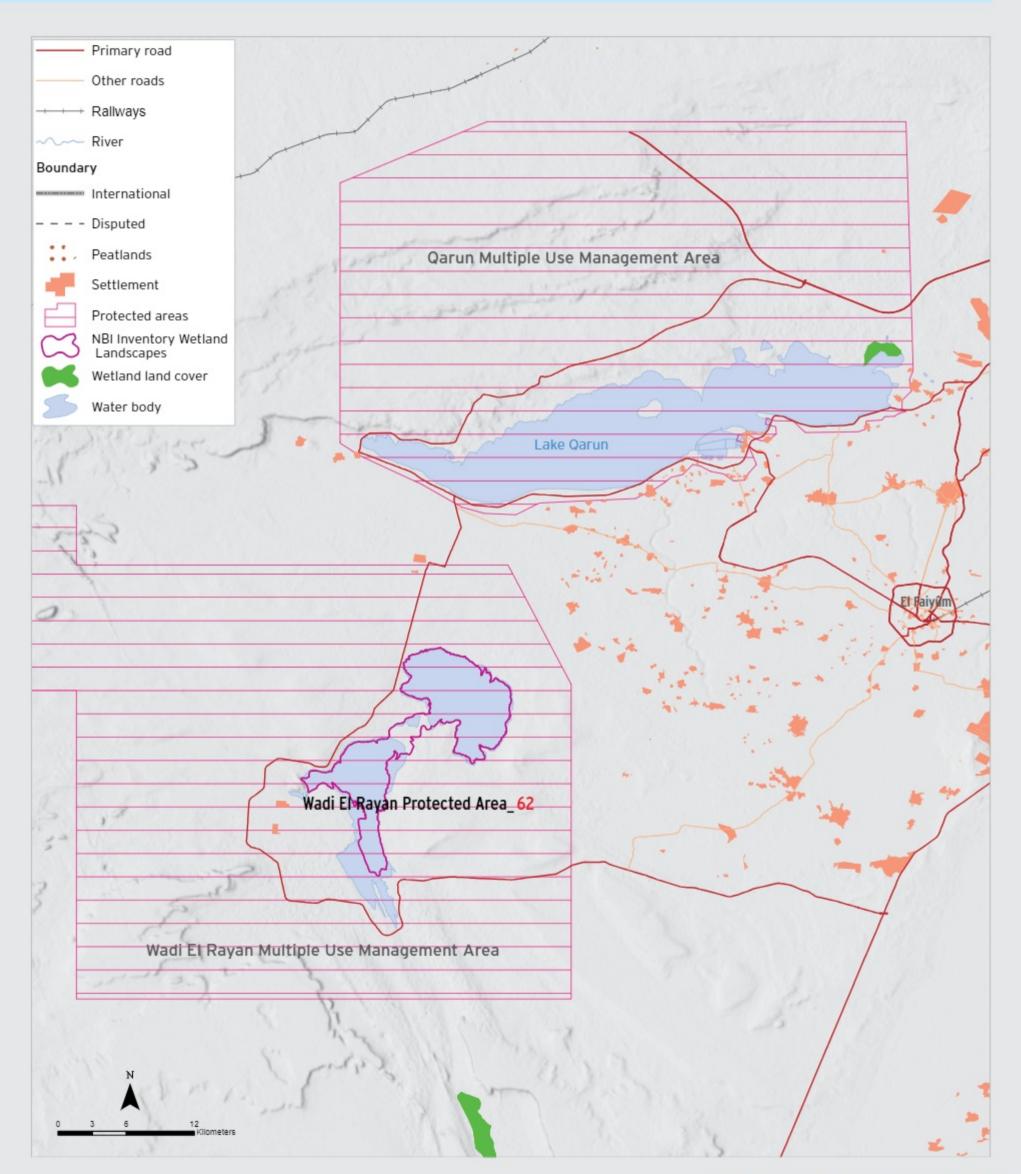
Name: Wadi El Rayan Protected Area

Country: Egypt

Coordinates: 29°12′35" N / 30°26′37" E Altitude: 113 m b.s.l.

Altitude: 113 m b.s.l. Area: 90 km² Nearest Towns: El Faiyum

International Importance: Ramsar site, Important Bird Area



The two Wadi El Rayan lakes are depression located to the southwest of Faiyum, about 130 km southwest of Cairo. The northern lake has a surface area of 50 km² and a maximum depth of 14 m whereas the southern lake is 56 km² large and is maximum 36 m deep (Hereher, 2015). In 2017 their combined area was estimated to be 75.75 km² (S. A. Mohamed & El-Raey, 2019). The two lakes (north and south) are connected through a 5 km long canal of cascading terraces. This shallow canal provides habitat for a continuous cover of emergent aquatic macrophytes. During winter it receives thousands of migratory birds form Europe each year

Physical Features

At the location of Wadi el Rayan, there used to be a dry depression in the desert. The maximum depth of the depression is 57 m below sea-level. As of 1973, excess agricultural drainage water from the Fayoum depression was diverted into the Wadi El Rayan valley through a tunnel as an alternative site to Lake Qarun. Two large lakes were formed as a result. The Upper Basin has oval shape of 10.5 km length and 8.5 km maximum width, with total surface area of 48.0 km2. The lower basin is pear shaped of 13.7 km length and 5.3 km maximum width, with total surface area of 45.9 km2 (Fouda & Fishar, 2012b).

The lakes are open water, with patches of aquatic plants. Most of those plants cover the Upper basin's shoreline, especially in the south border and also near the connected channel zone.
The lower basin is open water
with no patches of aquatic plants
especially in the south. Sandy
Oval Islands are located in the
south of the Lower Basin. The two
lakes receive an annual discharge
of 2 million m³/year and hold
approximately 2.13 and 2.9 bm³,
respectively (Hereher, 2015).

Goher et al. (2019) are classified the water quality of both lakes as marginal for aquatic life habitat. The agricultural waste water draining into the lake varies in physical and chemical characteristics and the lakes suffer to different degree from metal contamination. The salinity of the northern lake ranges from 1.5 to 2.0 g/l and from 19.3 to 22.8 g/l in the southern lake (Goher et al., 2019). Currently the rate of water inflow is lower than water use and evaporation, especially in the southern lake, which has no outflow, therefore its salt concentration has been increasing since its formation.

Management

The El Rayan valley is developing management resources protected area and a natural national heritage since 1989. It is under the jurisdiction of Nature Conservation Sector, Egyptian Environmental Affairs Agency. In addition the wetland is within an IBA, which has a medium threat score that was assesses in 1999. Since 2012 the Wadi El Rayan Protected Area is a Ramsar site. The valley lies in the El- Fayoum Governorate, close to the UNESCO world heritage site Wadi El-Hitan in which fossils of whales were found that are more than 40 million years old. Some land is owned by the government and the other lands and fish farms owned by private sectors. The existing land ownership and authority of the shorelines of Wadi El Ravan Lakes in the Fayoum governorate are shared among several government jurisdictions and governed by different laws. A management plan for the Wadi El Rayan Protected Area was designed in 2002. The main objectives of the plan aims to protection of the natural resources in accordance with the declaration decree of the protected area, improving control over water use in the lake system and coordination between the various public agencies active in the Protected Area (Fouda & Fishar, 2012b).

Drivers of Change

Human activities with high impact occurred since the 1980s with agricultural land reclamation, digging and exploration for crude oil, aquaculture and commercial fisheries and building of infrastructure for tourists (Goher et al., 2019). In the whole El-Fayoum Governorate, there was a remarkable increase in slum and urban area between 2000 and 2017 but an overall decrease in agricultural area (S. A. Mohamed & El-Raey, 2019). Area covered with sand dunes also increased. due to wind transport of sand (S. A. Mohamed & El-Raey, 2019). Since it was first flooded the water level in the valley has been subject to great variability. The lakes reached their maximum extension in 2000 with a total surface area of at 106 km². Then the combined area of both lakes decreased to 86 km² (Hereher, 2015). However, shrinking was mainly observed with the lower lake and can possibly be attributed to the development of agriculture in the area and the intensive use of water for irrigation in addition to fish-farming. Other reasons for shrinking are sedimentation of drifting sands and high evaporation rates in this hyperarid region (Hereher, 2015). These observations correspond to a remote sensing analysis by Mohamed and El-Raey (2019) who measured the surface area of the two lakes in 1996, 2000 and 2017. The water surface shrank from 103 to 99 to 75 km², respectively.

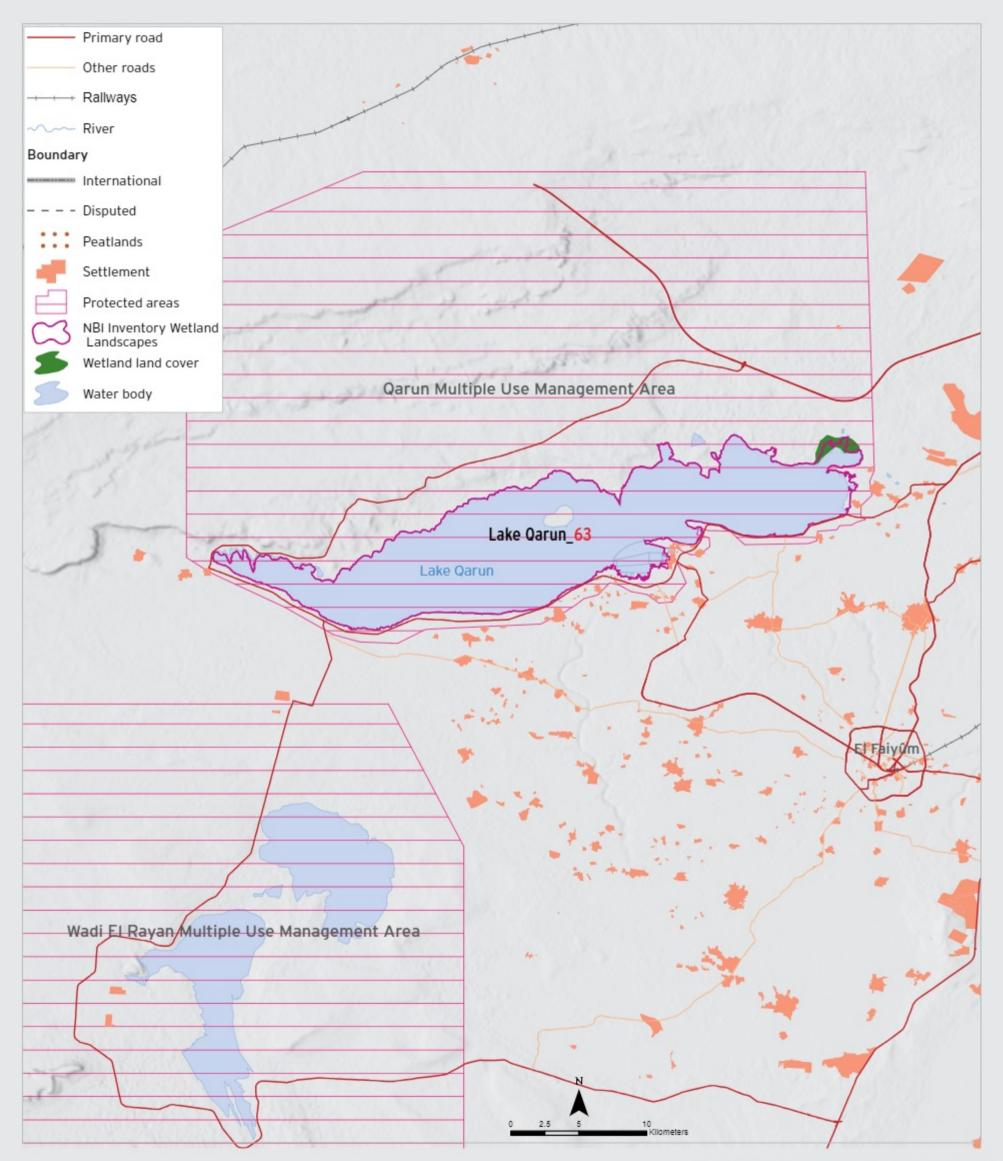
LAKE QARUN

Name: Lake Qarun Country: Egypt

Coordinates: 29°27'36" N / 30°38'27" E Altitude: 13 m b.s.l.

Altitude: 13 m b.s.l. Area: 242 km² Nearest Towns: El Faiyum

International Importance: Ramsar site, Important Bird Area



Lake Qarun is situated 80 km southwest of Cairo and occupies the deepest part of the Fayoum. Depression. The lake is one of the oldest lakes in Egypt and was known to ancient Egyptians as Lake Moeris. Today the lake has an irregular elongated shape with an approximate area of 240 km² and the main reservoir for all agricultural and other drainage water of the area. The lake is bordered by agricultural land to the south and desert to the north. There are several lagoons and bays along the southern and northern shores of the lake, some of which hold mud or salt flats of various sizes. El Qarun, the only sizeable island in the lake, covers almost 2 km2 (Hughes & Hughes, 1992). Each year it receives thousands of migratory birds from Europe plus it provides habitat for nesting birds. The lake is a nature reserve and also used for salt extraction and fishing.

Physical Features

At the location of Wadi el Rayan, Lake Qarun occupies the deepest part of the Fayoum Depression and is 45 m below sea level. Its area has decreased form 249 km2 in 1996 to 232 km² in 2017 (S. A. Mohamed & El-Raey, 2019). The average depth of the lake is 4 m and its maximum depth is 8 meters. The lake which has no outlet stores 800 million m3 (Fouda & Fishar, 2012a).

About 370 million m3 of agricultural drainage water reach the lake each year through two major drains: El-Bats and El-Wadi. The El-Bats Drain receives nearly 193.3 x 106 m³ per year of water that discharges into the eastern part of the lake. El-Wadi Drain receives wastewater from the middle region of the El-Fayoum depression and discharges 84.5 x 106 m³ at the mid-southern shore of the lake (Abdel Wahed et al., 2015). In addition to some water loss from groundwater seepage, annual water loss due to evaporation is 415 x 106 m3 (Abdel Wahed et al., 2015).

With the intensification of cultivation and irrigation, the salt load of the water reaching Qarun has increased significantly in the 20th century to between 2.9 and 38 g/l (El-Kady et al., 2019). In the last two decades, salinity stayed nearly constant showing only slight variations depending on the amount of wastewater discharged into the lake (Fouda & Fishar, 2012a).

Besides the high salt content the lake water is eutrophic and suffers from a serious pollution problem, due to uncontrolled solid and liquid domestic and industrial waste disposal practices, agrochemical contamination and lack of sustainable wastewater management. Especially close to the Al-Bats drain, heavy metal contamination is high (El-Kady et al., 2019).

With the intensification of cultivation and irrigation since the beginning of the 20th century, the salt load of the water reaching Qarun has increased significantly as the lake has no outflow. (Hugehs & Hughes, 1992).

Management

The Lake Qarun Area is a protected site in the El-Favoum Governorate since 1989 and a Nature Reserve with IUCN category 1a. It is under the jurisdiction of Nature Conservation Sector, Egyptian Environmental Affairs Agency, and Ministry of State of Environment. The site is also a UNESCO World Heritage Site since 2003. In addition the wetland is within an Important Bird Area and since 2012 the Lake Oarun Protected Area is a Ramsar site. Some land is owned by the government and the other lands and fish farms owned by private sectors. The existing land ownership and authority of the shorelines of Lake Qarun in the Fayoum governorate are shared among several government jurisdictions and governed by different laws and decrees.

Drivers of Change

Drivers of Change According to a remote sensing analysis by Mohamed and El-Raey (2019) there was a remarkable increase in slum and urban area in the EL-Fayoum Governorate between 2000 and 2017 but a decrease in agricultural area. One possible factor for surface area reduction of Lake Qarun is sand dune invasion. Due to strong winds from the north and northwest, large amounts of sand is moved on the Qarun Lake (S. A. Mohamed & El-Raey, 2019). This sand movement pushes the water southward causing some environmental problems, such as increasing groundwater table, salinization and waterlogged areas (Kotb et al., 2017).

THE NILE DELTA

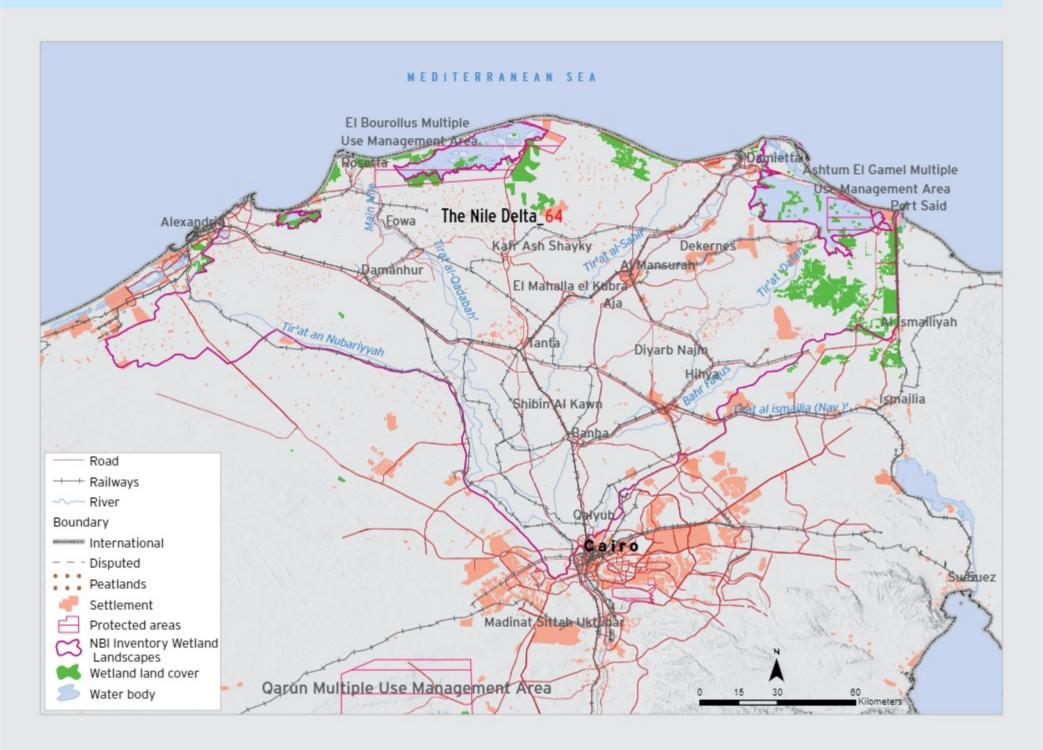
Name: The Nile Delta

Country: Egypt

Coordinates: 30°57'9" N / 31°5'53" E

Altitude: 0-30 m a.s.l Area: 21,480 km²

Nearest Towns: Alexandria, Port Said



Overview

The Nile Delta is an arc shaped delta resembling triangle formed by sedimentary processes that started in the Miocene. The delta was formed by seven distributaries of the Nile, which have since silted up and been replaced by the present Damietta (east) and Rosetta (west) branches. The Nile is considered to be an "arcuate" delta (arc-shaped), as it resembles a triangle or lotus flower when seen from above. The outer edges of the delta are eroding, and some coastal lagoons have seen increasing salinity levels as their connection to the Mediterranean Sea increases. Only fragments of the former wetlands of the

delta remain. The best remaining habitats are found in the Lakes El Mannah, El Qatta, Faraontya, Sinnéra, Sanel Hagar and the coastal lagoons of Manzala and Miheishar (Hughes & Hughes, 1992). To the north-west are three other coastal lakes or lagoons: Lake Burullus, Lake Idku and Lake Maryut.

From north to south the Nile Delta is approximately 160 km in length. From west to east it covers some 240 km of coastline. The southern apex of the delta is approximately 30 km north of Cairo and the north forms approximately 1,000 km of the Mediterranean coastline. Even though the delta represents only about 2.4% of the total area of Egypt, it provides

63% of arable lands, hosts 50% of Egypt's industrial production, 65% of agricultural production (Hamza, 2009.

Climate

The climate of the Nile delta is mainly influenced by the Mediterranean Sea, with hot and humid summers and wet and mild winters. Annual rainfall is concentrated during the winter months, with a mean annual rainfall of 50 mm/year (NBI, 2016). Temperatures range from 9°C in winter to 40°C in summer

Biological Features

There are 37 taxa in the Nile Delta that have an IUCN threat status of interest. In total there are 22 flagship species for example Sonchus macrocarpus and Zygophyllum aegyptium. The vegetation around the Delta consists of Phragmites australis, Typha capensis, and Juncus maritimus, with some small sedges. The Manzala lagoon has beds of Ceratophyllum demersum, Potamogeton crispus, and P. pectinatus around the southern shore. Other lake shore species are Najas pectinata, Eichhornia crassipes, Cyperus spp. and Juncus spp. The salt tolerant Halocnemum spp. and Nitraria retusa grow in marshes

along the Mediterranean coast.
Farther south along the river,
dense swamp vegetation grows
unchecked without the seasonal
fluctuations of the Nile, held
back by the Aswan Dam. The
islands along the river, especially
those found between Luxor and
Kom Ombo, have reed swamp
vegetation (Fraser & Keddy, 2005;
Hughes & Hughes, 1992; WWF,
2019).

The Nile Delta is part of one of the world's most important migration routes for birds. Every year, millions of birds pass between Europe and Africa during spring and autumn along the 'eastern African flyway', and the wetland areas of Egypt are important resting sites. Some water birds overwinter in the Delta, and Lake Manzala is the most important site with the world's largest concentrations of Larus minutus (little gull) and Chlidonias hybrida (whiskered tern) thus

making it an Important Bird Area. For a complete list of birds, see the Biodiversity Assessment.

Some of the remaining mammals that have been recorded from the Nile River bank include: Vulpes vulpes (red fox), Gerbillus andersoni (Anderson's gerbil), Psammomys obesus (fat sand rat); Rousettus aegyptiacus (Egyptian fruit bat), Rhinopoma macrophyllum (greater mousetailed bat), Arvicanthis niloticus (Nile or field rat), Felis chaus (Jungle cat), Crocidura floweri (Flower's shrew), Hemiechinus auritus (long eared hedgehog) and the Acomys cahirinus (Cairo spiny mouse) (Ahmed et al., 2011).

Three fish flagship species for the Delta are Heterobranchus longifilis (Vundu catfish), Anguilla anguilla (European eel), Lates niloticus (Nile perch).

Ecosystem services

The region near the Nile Delta is one of the most industrialized, populated and cultivated areas in Egypt, holding over 60% of the country's population (Rebelo & McCartney 2012). This area is also a source of oil and natural gas. Some of the existing wetlands in the delta are threatened by urban development, agricultural activities and illegal fish farms (Nile-Eco-VWU, 2016).

The main resources the local communities depend on are the fishery resources, followed by agriculture (Nile-Eco-VWU, 2016). Although aquaculture has been developed in the Nile Delta (Rebelo & McCartney 2012), fisheries exploitation in Lake Burullus is still unsustainable, illegal fish farms have been established, and the annual fish catch from this lake has decreased over the past 10 years (Nile-Eco-VWU, 2016).

Other provisioning services of Lake Burullus include provisioning of fresh water and grazing areas for buffaloes, cows, sheep, goats and camels along the lake's shores within the protected area. Hunting of birds, although illegal, is still a common activity. Salt extraction from the marshes and the use of several plants of economic importance (fuel, medicinal, food, building materials) are also products the local communities benefit from (Nile-Eco-VWU, 2016).

Other potential ecosystem services not directly mentioned in the literature could be the use of water as a means of transportation, regulating services like water purification, natural hazard regulation, erosion regulation, pollination and biological control. The ecosystem services identified for the Nile Delta wetlands are further presented in WP 3: Ecosystem Service Assessment



River Nile in Egypt. Life on the River Nile

LAKE MARYUT

Name: Lake Maryut, Lake Mariout or Mariut

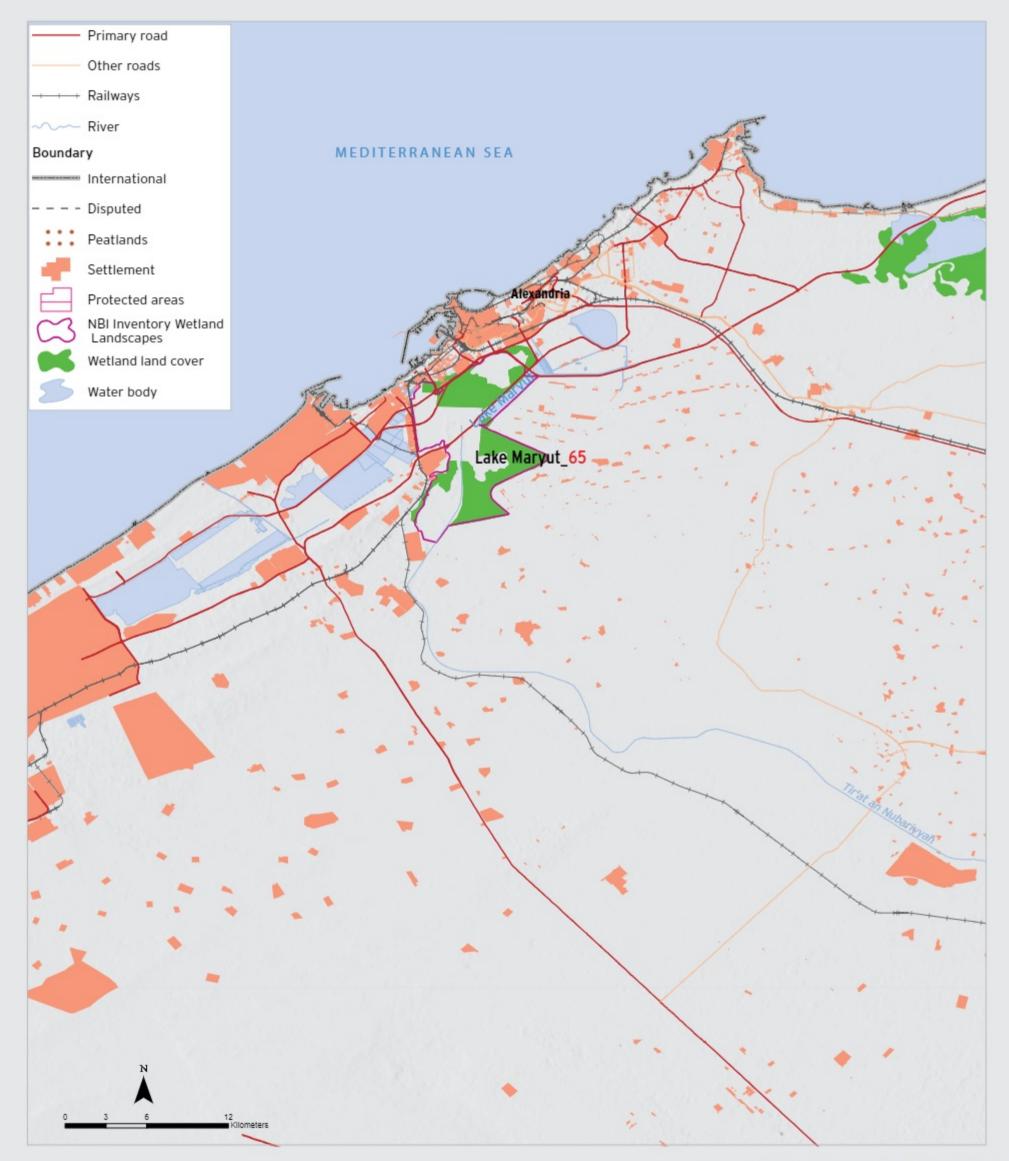
Country: Egypt

Coordinates: 31°7'51"N / 29°53'49" E Altitude: 4 m b.s.l. (water surface)

Area: 66 km²

Nearest Towns: Alexandria (2 km SW

International Importance: Important Bird Area



Lake Maryut is a brackish water wetland on the Mediterranean coast of Egypt. The lake is two km south of Alexandria, is 25 km long and 10 km wide with a total surface area of 191 km2 (Abou El Magd & Ali, 2019). Its average depth is one meter. A lithified ridge from the late Pleistocene separates the lake and the Mediterranean Sea. The present Lake Maryut represents a small portion of a larger lake that was known during the Roman era by the name Lake Mariutus or Mareotis. The lake lies practically within the boundaries of greater Alexandria and its sprawling suburbs. What remains of the lake proper is brackish, receiving agricultural drainage-water through several farms, as well as large quantities of municipal and industrial effluent from Alexandria. Much of the lake shore is fringed by extensive Typha and Phragmites marshes. The lake still supports fishery and aquaculture and water is diverted into drying pans to gain salt.

Physical Features

Lake Maryut is the westernmost of the northern delta wetlands (Maryut, Idku, Burullus, and Manzala) however, its history and origin differ to the other lakes. The lake used to be fed by a delta branch of the Nile before the 12th century until too much silt accumulated and the connection between the lake and the Nile broke off. Therefore, the lake was dry for about seven centuries until the early 19th century the lake was artificially flooded with seawater twice. Later, in 1820 when the El-Mahmudiya canal was built agricultural runoff and irrigation water were diverted into the lake (Hassan & Badran, 2016). This created the present shallow brackish salty swamp which, today is artificially segmented by a number of canals, highways and railroads. The lake is now separated into four basins: the Main Basin, the Fisheries Basin, the North-western Basin with drying pans for salt refining and the South-western Basin.

Lake Maryut receives water from several different sources. The Qalaa Drain discharges almost 680,000 m³/day of primary treated wastewater and agricultural discharge into the main basin (Khairy, 2013). Other sources of water are from a wastewater treatment plant in the west, mixed industrial, agricultural, and domestic wastes from the Nubaria Canal and the Umum drain. Water from the basin in the northwest is used as cooling water to Amreya Petroleum Refinery Company and receives their treated industrial wastewater effluents.

Several studies have shown that Lake Maryut is one of the most polluted aquatic ecosystems in Alexandria, with high concentrations of nutrients, metals, pesticides, PCBs and PAHs (El-Hattab, 2015; Hassan & Badran, 2016; Khairy, 2013). According to BirdLife International Lake Maryut is the most polluted wetland in Egypt.

Especially in the main basin phenolic compounds from

industrial and wastewater treatment plant discharges are of high concern (Khairy, 2013). In addition, the lake is eutrophic with infestation of water hyacinth (El-Hattab, 2015). The Southwestern Basin, rans parallel to the coastline, is separated from the main basin. This part of the lake is fed by groundwater seepage, rainfall and agricultural runoff. Therefore its sediment contamination with metals is lower than in the other parts of the lake, which receive industrial wastewater (Hassan & Badran, 2016).

Drivers of Change

Pollution of the lake has been aggravated by the development of Alexandria. Alexandria alone hosts about 40 % of the Egyptian industrial activities, of which most are dependent on Lake Maryut as a dumpsite or for cooling water (El-Hattab, 2015). In addition some of the marshy areas around the lake have been reclaimed for urban development (Hassan & Badran, 2016).

LAKE IDKU

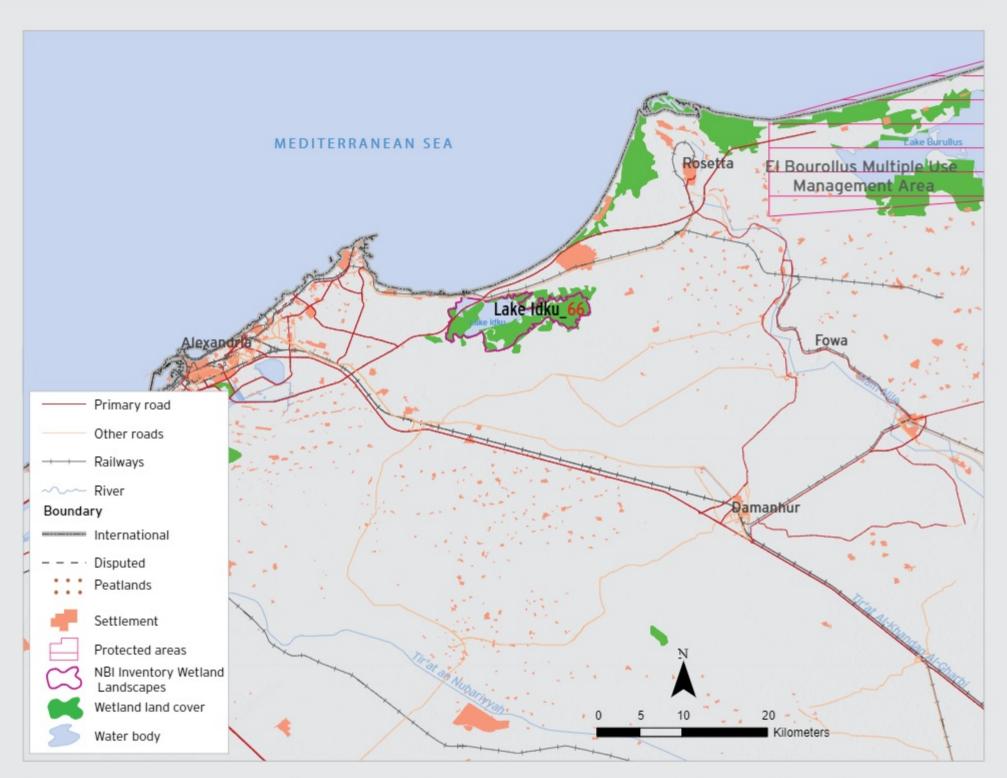
Name: Lake Idku, Lake Edku

Country: Egypt

Coordinates: 31°14'43"N / 30°12'40"E

Altitude: sea level Area: 55 km² Nearest Towns: Alexandria

International Importance: Important Bird Area



Overview

Lake Idku is a shallow coastal wetland located west of the Rosetta Nile branch, 30 km east of Alexandria. Three main drains discharge into the lake, while Bughaz El Maadia provides a connection with the sea. The water in the lake is mainly fresh, but increases in salinity towards the Bughaz and during the summer. Most of the lake margins are covered with dense growths of Typha and Phragmites, which cover about 50% of the lake's area. Saltmarshes, salinas and high dunes, as well as some orchards, are found on the

sandbar separating the lake from the Mediterranean. Lake Idku is an Important Bird area and is of moderate importance for both wintering and breeding water birds.

Physical Features

The lake's surface area is about 126 km² and it is between 0.5 and 2 m deep. The lake is elongated, between 5 and 11 m wide. The Bughaz El Maadia provides a connection with the sea. Approximately 3.3 x 10⁶ m³ of water per day flow out of Lake Idku into Abu Qir Bay through the Bughaz El Maadia canal (Radwan et al., 2019).

Three main drains Bersik, Idku, and El-Bousily discharge their water into the eastern side of the lake. Drainage water is discharged into the lake through a group of pumping stations. The amount of water discharged into the lake is about 83 - 280 x 10³ m³ per day (Ali & Khairy, 2016).

Lake Idku is intensely used for fisheries and fish farming. On average 8,500 tons of fish are produced in the lake. In total 8.8% of the total national agricultural income in 2014 come from goods provided from Lake Idku (Ali & Khairy, 2016).

Drivers of Change

The lake is eutrophic with a tendency to hypertrophy and also suffers from heavy metal pollution. The three main inflows into the lake carry agricultural and urban wastewater in addition to drainage water from more than 300 fish farms (Radwan et al., 2019).The water is almost stagnant and hosts a diverse community of phytoplankton with over 100 species found. The main issue is the quality of the water that is discharged into the lake. However, 75 % of fisherman, working in the lake, suffer from schistosomiasis (Ali & Khairy, 2016).

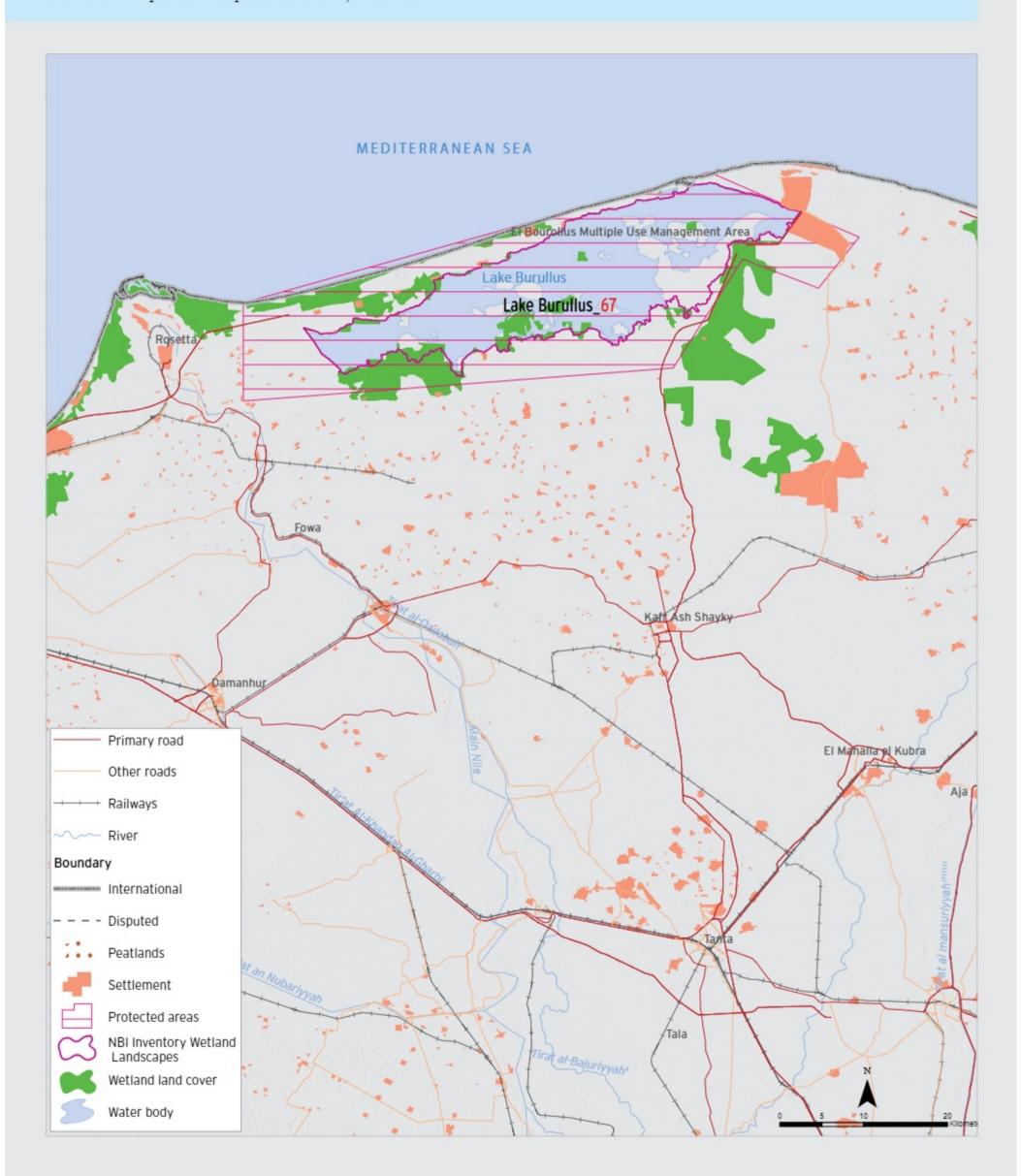
LAKE BURULLUS

Name: Lake Burullus Country: Egypt

Coordinates: 31°28'10"N / 30°52'22"E Altitude: 17 m b.s.l.

Altitude: 17 m b.s.l. Area: 450 km² Nearest Towns: Rashid

International Importance: Important Bird Area, Ramsar Site



Lake Burullus is a large, shallow, fresh-to-brackish coastal lagoon located between the two Nile branches forming the delta. The lake is separated from the sea by a broad, dune-covered sandbar, which varies in width from a few hundred meters in the east to 5 km in the west. There are some 50 islands scattered throughout the lake with a total area of 0.7 Km² (BirdLife International, 2019). Burullus is by far the least disturbed and damaged of the delta wetlands, but still it suffers from several humanly induced pressures.

Physical Features

Lake Burullus is elongate in shape and extends for 47 km from east to west with an average width of 14 km and a depth between 0.4 and 2 m (Ghoraba et al., 2019). In 2012 the lake had a surface area of 461 km² which reduced to 285 km² in 2012 (Abou El Magd & Ali, 2019). At the north eastern

part of the lake at Bughaz El Burullus the lake connects to the Mediterranean Sea. From the west the lake receives water through the Brimbal Canal, which branches directly from the Rosetta branch of the Nile. Through the east, the lake receives seawater though the El-Boughaz opening. Therefore there is a salinity gradient from east to west. Through nine main drains Lake Burullus receives a mix of agricultural and urban wastewater plus discharge from fish farms. The lake receives up to 4 billion m³ of agricultural drainage annually which represents about 97% of water inflow into the lake (Egyptian Environment Affairs Agency, 1998). The water is highly eutrophic which leads to excessive growth of macrophytes. Salinity in lake has dramatically decreased from 14 g/l in 1966 to 3 g/l in 2015 due to increased wastewater discharges from agriculture into the lake. This changed the biota of the lake from a more brackish species composition to a freshwater

species (Ghoraba et al., 2019).
The north shores of the lake are
dominated by saltmarshes and
mudflats, while the southern
shore is bordered by an extensive
fringe of reed-swamps of mainly
Typha and Phragmites (Egyptian
Environment Affairs Agency,
1998).

Management Status

In 1998 the lake and its surrounding wetlands were declared a protected area and was designated a Ramsar wetland of international importance in 1988. In addition the site is an Important Bird Area with the current threat score 'high', which was assessed in 1999.

Drivers of Change

The lake surface area has decreased from an estimated 553 km² in 1952 to about 285 km² in 2012. One main reason for this is the drastic increase in fish farming from 30 km² of fish farms in 1987 to 272 km² in 2010 (Abou

El Magd & Ali, 2019). Ghoraba et al. (2019) have assessed the risk of collapse of Lake Burullus using the IUCN Red List of Ecosystems assessment. They found that increased discharge of nutrient rich wastewater into Lake Burullus has altered water quality, has led to eutrophication. Composition and abundance of fish and invertebrates has changed. Close to the outlets floating plants such as water hyacinth are abundant and obstruct waterways. A new international highway along the northern shore of the lake has disturbed the avifauna in the north Nile Delta and species residing in Burullus. There is hunting of waterfowl going on around the lake and fish is caught using illegal fishing gear with small mesh size. Fish farms are also expand in the lake, which cause additional nutrient input into the water. Ghoraba et al. (2019) classified the ecosystem as Critically Endangered under the IUCN framework.

LAKE MANZALA

Lake Manzala Name: Country: Egypt

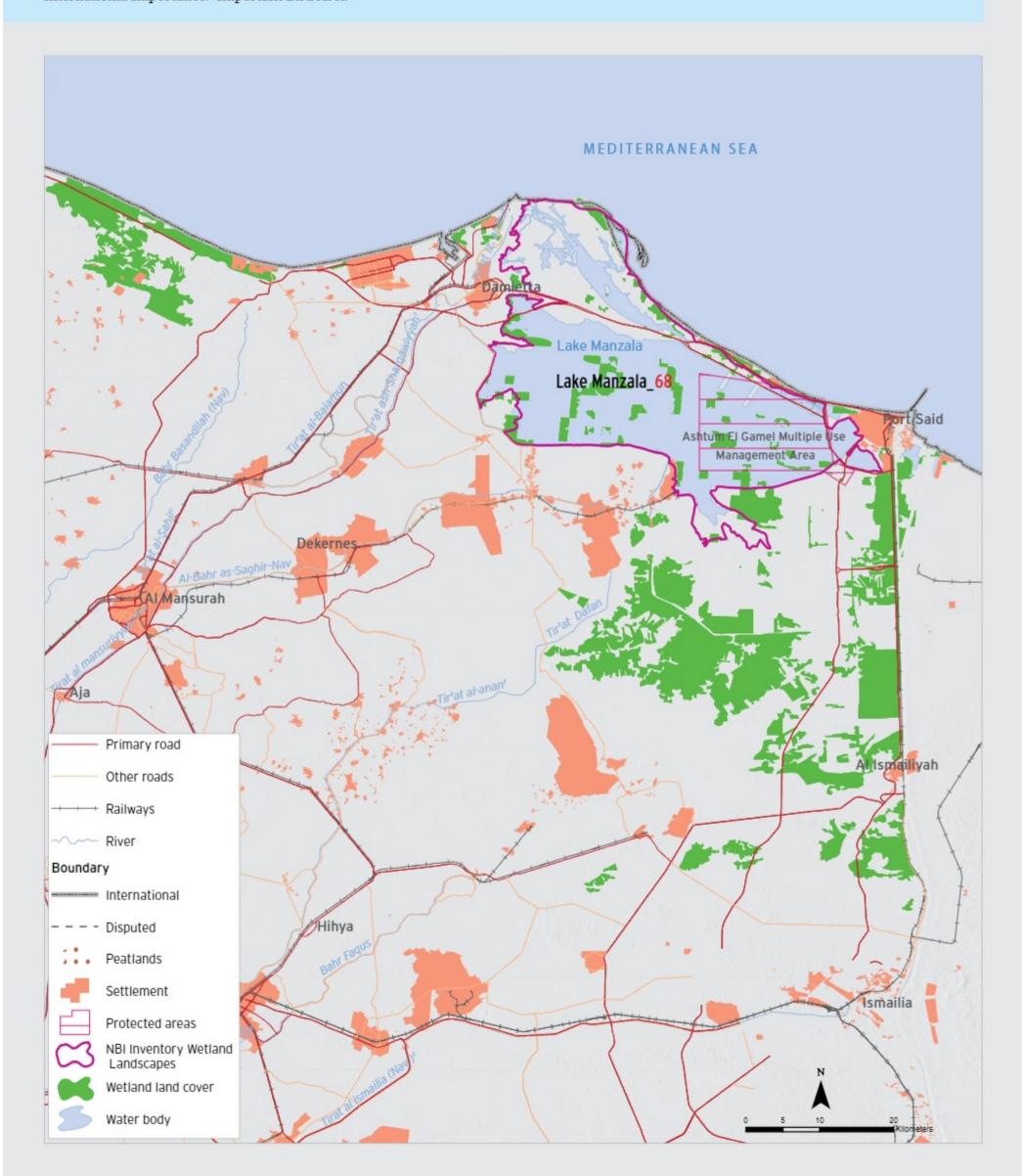
Coordinates:

 $31^{\circ}17^{'}38"N \ / \ 32^{\circ}1^{'}37"$ E sea level (saltmarsh partly below sea level) Altitude:

 $847 \, km^2$ Area:

Nearest Towns: Bur Said, Dumyat

International Importance: Important Bird Area



Lake Manzala is the largest lake across the Egyptian north coast and is located in the north eastern corner of the Nile Delta. The area of the lake has under gone dramatic changes. It decreased form an estimated 1,400 km² in 1952 to 501 km2 in 2013 (Hossen & Negm, 2016). There was a dramatic decrease in open water mass and increase in natural vegetation. Increasing industrial and agricultural wastewater input have degraded the hydrological and water quality status of the lake. The three main habitats of the lake are reed-swamps, saltmarshes and sandy areas (BirdLife International, 2019).

Physical Features

Lake Manzala is about 47 km long and 30 km wide. It has an average depth of 1 m and lies between the Damietta Branch of the Nile and the Suez Canal. In the west, the lake receives freshwater from the Damietta Branch through the Enanya Canal. Through the drains Fareskour, Elserw, Hadous, and Bahr Elbaqar and others Lake Manzala receives agricultural, industrial and domestic wastes. The lake used to be a marine estuary environment but due to increased inflow of wastewaters it is now a eutrophic freshwater system. Heavy metal pollution of lake sediments is high, possibly health threatening (Elshemy, 2019).

The lake is connected to the Mediterranean Sea through the El-Gamil and the New El-Gamil outlets and to the Suez Canal in the east through the small and narrow El-Qabuty Canal. Close to the outlets, the lake is influenced by the tides whereas in the water quality in the south, where most of the drains are classified as very bad, is very poor with maximum average concentrations of BOD (72.5 mg/l), COD (230 mg/l), TN (9.4 mg/l), and TP (1.07 mg/l) being in the harmful range

(Elshemy, 2019). A model on the impact of climate change by Elshemy (2019) predicts spatial changes in water temperature in the lake and an increase of salinity due to sea level rise. There is a new water quality management project, under construction, to improve the operation of the main two outlets of Lake Manzala.

Management Status

Lake Manzala is governed by five different governorates (Port Saied, Sharkia, Dkhahlia, Damietta, and Ismaelia). The Ashtoom El-Gamil and Tenis Island Protected Area in Port Said Governorate is a large protected area in the Nile Delta and the Mediterranean Coast. This protected area includes 35 km² of Lake Manzala. Lake Manzala is an Important Bird Area since 2001

Drivers of Change

The surface water area has decreased by about 57 % between

1984 and 2015 (Hossen & Negm, 2016). During the same period, vegetation has increased with the same rate possibly due to high nutrient input from the wastewater drains (Hossen & Negm, 2016). El-Hamaimi et al. (2018) summarized the main pressures in Lake Manzala as follows: The increase in the nutrients loading into the lake especially from the input drains that accelerate the eutrophication process occurring within the lake. There is an increase in heavy metal concentrations through the lake including Cu, Cd, Pb, Hg, Zn and Mn in water, sediments and fish. The lake is contaminated with high amount of TVB (total viable bacteria) and FCB (faecal coliform bacteria), therefore fish are contaminated on surface and internally tissues with a very high amount of TVB and FCB which can be dangerous for human health. In addition the lake has a lack of outlets and gets more and more fragmented due to intensification of fish farming.



A flock of white stork (Ciconia ciconia) in the mashes of Lake Manzala. The Nile Delta lies along one of the world's most important bird migration routes.

REFERENCES

- Abdel Wahed, M. S. M., Mohamed, E. A., El-Sayed, M. I., M'nif, A., & Sillanpää, M. (2015). Hydrogeochemical Processes Controlling the Water Chemistry of a Closed Saline Lake Located in Sahara Desert: Lake Qarun, Egypt. Aquatic Geochemistry, 21(1), 31–57.
- Abila, R. (2002). Utilisation and economic valuation of the Yala Swamp Wetland, Kenya. In M. Gawler (Ed.), Strategies for wise use of wetlands:

 Best practices in participatory management. Gland, Switzerland: IUCN The World Conservation Union.
- Abou El Magd, I., & Ali, E. (2019). Earth Observations for Egyptian Coastal Lakes Monitoring and Management. In *Handbook of Environmental Chemistry* (Vol. 5, pp. 201–219). Cham, Switzerland: Springer.
- Adonia, B. (2013). The cost of poor land use practices in Lake Nakivale Wetland in Isingiro District, Uganda. African Journal of Environmental Science and Technology, 7(6), 448-456.
- Agimass, F., & Mekonnen, F. (2011). Low-income fishermen's willingness-to-pay for fisheries and watershed management: An application of choice experiment to Lake Tana, Ethiopia. *Ecological Economics*, 71, 162–170.
- Agwanda, B. R. (2009). Ch 10: Mammals. In Henry Busulwa and Rose Sirali Antipa. Eds (2009) Baseline Report on State of Biodiversity in the Nile Kenya. A Production of the Wetlands and Biodiversity Conservation Component of the Nile Transboundary Environmental Action Project. Entebbe, Uganda: Nile Basin Initiative Secretariat.
- Ahmed, E. O., Ali, M. E., & Aziz, A. A. (2011). Length-Weight Relationships and Condition Factors of Six Fish Species in Atbara River and Khashm El- Girba Reservoir, Sudan. *International Journal of Agriculture Sciences*, 3(1), 65–70.
- Akwetaireho, S. (2009). Economic Valuation of Mabamba Bay Wetland System of International Importance, Wakiso District, Uganda. Klagenfurt, Austria: Alps-Adriatic University of Klagenfurt.
- Akwetaireho, S., Akugizibwe, T., & Plumptre, A. (2011). Socio-economic values of corridor forests in the Albertine Rift forests of the Murchison-Semliki landscape. Kampala, Uganda: Wildlife Conservation Society.
- Albright, T. P., Moorhouse, T. G., & McNabb, T. J. (2004). The Rise and Fall of Water Hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001. Journal of Aquatic Plant Management, 42, 73–84.
- Ali, E. M., & Khairy, H. M. (2016). Environmental assessment of drainage water impacts on water quality and eutrophication level of Lake Idku, Egypt. Environmental Pollution, 216, 437–449.
- Allam, M. M., Bekhit, H., Elzawahry, A. M., & Allam, M. N. (2018). Jonglei Canal Project Under Potential Developments in the Upper Nile States.

 Journal of Water Management Modeling, 26.
- Aloo, P. A. (2003). Biological diversity of the Yala Swamp lakes, with special emphasis on fish species composition, in relation to changes in the Lake Victoria Basin (Kenya): Threats and conservation measures. Biodiversity and Conservation, 12, 905–920.
- Alrajoula, M. T., Al Zayed, I. S., Elagib, N. A., & Hamdi, M. R. (2016). Hydrological, socio-economic and reservoir alterations of Er Roseires Dam in Sudan. Science of the Total Environment, 566–567, 938–948.
- Aneseyee, A. B. (2016). Vegetation Composition and Deforestation Impact in Gambella National Park, Ethiopia. Journal of Energy and Natural Resources, 5(3), 30–36.
- Angienda, P. O., Lee, H. J., Elmer, K. R., Abila, R., Waindi, E. N., & Meyer, A. (2011). Genetic structure and gene flow in an endangered native tilapia fish (Oreochromis esculentus) compared to invasive Nile tilapia (Oreochromis niloticus) in Yala swamp, East Africa. Conservation Genetics, 12, 243–255.
- Araia, M. (2005). Revealing the forest hidden value: the case study of Eritrea (MSc Thesis). University of Stellenbosch, Stellenbosch, South Africa.
- Atnafu, B. (2014). Valuing Conservation of Walia Ibex: An Application of Choice Experiment Valuation Method. Journal of Economics and Sustainable Development, 5(4), 171–180.
- Aymeric, R., Myint, M., & Westerberg, V. (2014). An economic valuation of sustainable land management through agroforestry in eastern Sudan. Nairobi, Kenya: IUCN.
- Balirwa, J. S. (1995). The Lake Victoria environment: Its fisheries and wetlands a review. Wetlands Ecology and Management, 3(4), 209-224.
- Barasa, J. E., Abila, R., Grobler, J. P., Agaba, M., Chemoiwa, E. J., & Kaunda-Arara, B. (2016). High genetic diversity and population differentiation in Clarias gariepinus of Yala Swamp: evidence from mitochondrial DNA sequences. *Journal of Fish Biology*, 89(6), 2557–2570.
- Bezabih, B., & Mosissa, T. (2017). Review on distribution, importance, threats and consequences of wetland degradation in Ethopia. International Journal of Water Resources and Environmental Engineering, 9(3), 64–71.
- BirdLife International. (2019). Important Bird Areas factsheet. Retrieved August 15, 2019, from www.birdlife.org
- Blackmore, D., & Whittington, D. (2008). Opportunities for Cooperative Water Resources Development on the Eastern Nile: Risks and Rewards
 An Independent Report of the Scoping Study Team to the Eastern Nile Council of Ministers A (Report). Addis Ababa, Ethiopia: Eastern Nile
 Council of Ministers.
- Börner, J., Mburu, J., Guthiga, P., & Wambua, S. (2009). Assessing opportunity costs of conservation: Ingredients for protected area management in the Kakamega Forest, Western Kenya. Forest Policy and Economics, 11(7), 259–467.
- Bush, G. (2009). The Economic Value of Albertine Rift Forests; Applications in Policy and Programming (PhD Thesis). University of Stirling, Stirling, UK.

- Bush, G., Hanley, N., Moro, M., & Rondeau, D. (2012). Measuring the Local Opportunity Costs of Conservation: A Provision Point Mechanism for Willingness-to-Accep. Stirling Economics Discussion Paper, Stirling, UK: University of Stirling.
- Busulwa, H. S. (2012). Baro Akobo Sobat Wetlands Knowledge Base (Report). Nile Basin Initiative.
- Busulwa, H., & Sirali Antipa, R. (2009). Baseline Report on State of Biodiversity in the Nile Kenya (Report). Entebbe, Uganda: Nile Basin Initiative, Nile Transboundary Environmental Action Project.
- Buyinza, M., Bukenya, M., & Nabalegwa, M. (2007). Economic Valuation of Bujagali Falls Recreational Park, Uganda. Journal of Park and Recreation Administration, 25(2), 12–28.
- Byaruhanga, A., & Kigoolo, S. (2005a). Lake Bisina Wetland System: Site no. 1633 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat
- Byaruhanga, A., & Kigoolo, S. (2005b). Lake Mburo-Nakivali Wetland System: Site no. 1634 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005c). Lake Nakuwa Wetland System: Site no. 1635 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005d). Lake Opeta Wetland System: Site No. 1636 (Ramsar Information Sheet). Gland, Switzerland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005e). Lutembe Bay Wetland System: Site no. 1637 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005f). Mabamba Bay Wetland: Site no. 1638 (Ramsar Information Sheet). Convention of Ramsar. Gland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005g). Murchison Falls Albert Delta Wetland System: Site no. 1640 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Byaruhanga, A., & Kigoolo, S. (2005h). Nabajjuzi Wetland System: Site no. 1639 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariate
- Byaruhanga, A., & Kigoolo, S. (2005i). Sango Bay-Musambwa Isabelnd Wetland System: Site no. 1641 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Citeau, J.-M., & Crerar, S. (2017). Baro-Akobo-Sobat Multipurpose Water Resources Development Project Study: Baseline, Development Potentials, Key Issues and Objectives Report (Report). Addis Ababa, Ethiopia: ENTRO.
- Degaga, A. H. (2018). Water Hyacinth (Eichhornia crassipes) Biology and its Impacts on Ecosystem, Biodiversity, Economy and Human Wellbeing. Journal of Life Science and Biomedicine, 8(6), 94–100.
- Degife, A. W., & Mauser, W. (2017). Socio-economic and Environmental Impacts of Large-Scale Agricultural Investment in Gambella Region, Ethiopia. Journal of US-China Public Administration, 14(4), 183–197.
- Dessie, M., Verhoest, N. E. C., Pauwels, V. R. N., Adgo, E., Deckers, J., Poesen, J., & Nyssen, J. (2015). Water balance of a lake with floodplain buffering: Lake Tana, Blue Nile Basin, Ethiopia. *Journal of Hydrology*, 522, 174–186.
- Di Vittorio, C. A., & Georgakakos, A. P. (2018). Land cover classification and wetland inundation mapping using MODIS. Remote Sensing of Environment, 204(September 2017), 1–17.
- Egyptian Environment Affairs Agency. (1998). Lake Burullus: Site no. 408 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- El-Hamaimi, A., Mirdan, A., Elshemy, M., & Hassan, A. (2018). Impact Assessment of Radial Channels Project on Water Quality Status in Lake Manzala, Eastern Nile Delta, Egypt. Port-Said Engineering Research Journal, 22(2), 8–18.
- El-Hattab, M. M. (2015). Change detection and restoration alternatives for the Egyptian Lake Maryut. The Egyptian Journal of Remote Sensing and Space Sciences, 18, 9–16.
- El-Kady, A. A., Wade, T. L., Sweet, S. T., & Klein, A. G. (2019). Spatial distribution and ecological risk assessment of trace metals in surface sediments of Lake Qaroun, Egypt. Environmental Monitoring and Assessment, 191(7).
- El-Shabrawy, G. M., & Dumont, H. J. (2003). Spatial and seasonal variation of the zooplankton in the coastal zone and main khors of Lake Nasser (Egypt). *Hydrobiologia*, 491, 119–132.
- Elshemy, M. (2019). Environmental and Climatic Implications of Lake Manzala, Egypt: Modeling and Assessment. In *Handbook of Environmental Chemistry* (Vol. 72, pp. 3–46). Cham, Switzerland: Springer.
- ENTRO (Eastern Nile Technical Regional Office). (2008a). One System Inventory. Vol II Annex 1: Baro-Akobo-Sobat and White Nile Sub-Basin (Report). Addis Ababa, Ethiopia: Author.
- ENTRO (Eastern Nile Technical Regional Office). (2008b). One System Inventory. Vol II Annex 2: Abay-Blue Nile Sub-Basin (Report). Addis Ababa, Ethiopia: Author.
- ENTRO (Eastern Nile Technical Regional Office). (2008c). One System Inventory. Vol II Annex 3: Tekeze Atbara Setit Sub-Basin (Report). Addis Ababa, Ethiopia: Author.
- European Space Agency (ESA). (2019). CCI Land Cover S2 Prototype Land Cover 20M Map of Africa 2016. Retrieved June 29, 2019, from http://2016africalandcover20m.esrin.esa.int/
- FAO. (2019). Geospatial information for sustainable food systems.
- Fischer, E. (2011). Biodiversity Inventory for Key Wetlands in Rwanda Final Report (Report). Kigali, Rwanda: Rwanda Environment Management Authority.
- Fouda, M., & Fishar, M. R. A. (2012a). Lake Qarun Protected Area: Site no. 2040 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Fouda, M., & Fishar, M. R. A. (2012b). Wadi El Rayan Protected Area: Site no. 2041 (Ramsar Information Sheet). Gland: Ramsar Convention Secre-

tariat.

- Fraser, L.., & Keddy, P.. (2005). The World's Largest Wetlands: Ecology and Conservation. Cambridge University Press.
- Ghoraba, S. M. M., Halmy, M. W. A., Salem, B. B., & Badr, N. B. E. (2019). Assessing risk of collapse of Lake Burullus Ramsar site in Egypt using IUCN Red List of Ecosystems. *Ecological Indicators*, 104, 172–183.
- Gichuki, J., Omondi, R., Boera, P., Okorut, T., Matano, A. S., Jembe, T., & Ofulla, A. (2012). Water Hyacinth Eichhornia crassipes (Mart.) Solms-Laubach Dynamics and Succession in the Nyanza Gulf of Lake Victoria (East Africa): Implications for Water Quality and Biodiversity Conservation. The Scientific World Journal, Article ID.
- Goher, M. E., Mahdy, E.-S. M., Abdo, M. H., El Dars, F. M., Korium, M. A., & Elsherif, A. A. S. (2019). Water quality status and pollution indices of Wadi El-Rayan lakes, El-Fayoum, Egypt. Sustainable Water Resources Management, 5(2), 387–400.
- Gowdy, J., & Lang, H. (2016). The Economic, Cultural and Ecosystem Values of the Sudd Wetland in South Sudan: An Evolutionary Approach to Environment and Development. Nairobi, Kenya: The Evolution Institute and United Nations Environment Programme (UNEP).
- Green, J. (1984). Zooplankton associations in the swamps of southern Sudan. Hydrobiologia, 113(1), 93-98.
- Green, J. (2009a). Nilotic Lakes of the Western Rift. In H. J. Dumont (Ed.), *The Nile: Origin, Environments, Limnology and Human Use* (pp. 263–286). Dordrech, The Netherlands: Springer Science+Business Media B.V.
- Green, J. (2009b). The Kyoga Catchment. In H. J. Dumont (Ed.), The Nile: Origin, Environments, Limnology and Human Use (pp. 205–214). Dordrecht, The Netherlands: Springer Science+Business Media B.V.
- Green, J., & El-Moghraby, A. I. (2009). Swamps of the Upper White Nile. In H. J. Dumont (Ed.), The Nile: Origin, Environments, Limnology and Human Use (pp. 193–204). Dordrecht, The Netherlands: Springer Science+Business Media B.V.
- Hamdan, A. M., & Zaki, M. (2016). Long-Term Estimation of Water Losses Through Evaporation from Water Surfaces of Nasser Lake Reservoir, Egypt. International Journal of Civil & Environmental Engineering IJCEE-IJENS, 16(05).
- Hamza, W. (2009). The Nile Delta. In H. J. Dumont (Ed.), The Nile: Origin, Environments, Limnology and Human Use (p. 818). Dordrecht, The Netherlands: Springer.
- Hassaballah, K., Mohamed, Y. A., & Uhlenbrook, S. (2018). The Mayas Wetlands of the Dinder and Rahad: Tributaries of the Blue Nile Basin (Sudan). In M. Finlayson, R. Milton, N. C. Davidson, UNESCO-IHE, & R. Crawford Prentice (Eds.), The Wetland Book II: Distribution, Description, and Conservation (pp. 1288–1298). Dordrecht, The Netherlands: Springer Science+Business Media B.V.
- Hassan, M. I., & Badran, H. M. (2016). Pioneering investigation of the characteristics and elemental concentrations in the environment of the declining Wadi Maryut Lake. Environmental Monitoring and Assessment, 188, 181.
- Hategekimana, S., & Twarabamenye, E. (2005). The impact of wetlands degradation on water resources management in Rwanda: the case of Rugezi Marsh (Report). Unpublished.
- Hereher, M. E. (2015). Assessing the dynamics of El-Rayan lakes, Egypt, using remote sensing techniques. Arabian Journal of Geosciences, 8(4), 1931–1938.
- Hien, D. P. (2011). Testing the applicability of Functional Assessment Procedures in tropical wetlands through assessing nutrient retention in Mara wetland, Tanzania (MSc Thesis). UN-IHE, Delft, The Netherlands.
- Hirwa, H., & Maniragaba, A. (2017). Effects of Water Variation on Hydropower Plant Functionality: A case of Ntaruka Hydropower. East African Journal of Science and Technology, 7(1), 39–52.
- Hossen, H., & Negm, A. (2016). Change detection of Manzala Lake using remote sensing and geographic information system. Egypt Int J Eng Sci Technol, 19(2), 353–358.
- Houbraken, M., Habimana, V., Senaeve, D., López-Dávila, E., & Spanoghe, P. (2017). Multi-residue determination and ecological risk assessment of pesticides in the lakes of Rwanda. Science of the Total Environment, 576, 888–894.
- Hughes, R. H., & Hughes, J. S. (1992). A Directory of African Wetlands. Gland, Switzerland and Cambridge: IUCN.
- Ibnaof, M., Salih, A., Mohamed, K., Mohamed, A., Tom, B., Shomo, F., ... Mohamed, J. (2013). The economic valuation of ecosystems and biodiversity, finance and its mainstreaming into national development policy and planning. A Case study of the agro-biodiversity of the Gum Arabic belt North Kordofan State, Sudan. Khartoum, Sudan: Ministry of Environment, Forestry and Physical Development.
- Isumbisho, M., Petit, P., Gashagaza, J. B., & Moreau, J. (2011). The feeding habit of the Cyprinidae Rastrineobola argentea in its new habitat, lakes Bulera and Ruhondo, two Rwandan lakes (Eastern Africa). Knowledge and Management of Aquatic Ecosystems, 403(04).
- Kakuru, W., Turyahabwe, N., & Mugisha, J. (2013). Total Economic Value of Wetlands Products and Services in Uganda. The Scientific World Journal.
- Karanja, F., Emerton, L., Mafumbo, J., & Kakuru, W. (2001). Assessment of the economic value of Pallisa District Wetlands, Uganda. Nairobi, Kenya: IUCN Eastern Africa Regional Office.
- Khairy, M. A. (2013). Assessment of priority phenolic compounds in sediments from an extremely polluted coastal wetland. *Environmental Monitoring and Assessment*, 185, 441–455.
- Khisa, P. S., Uhlenbrook, S., van Dam, A. A., Wenninger, J., van Griensven, A., & Abira, M. (2013). Ecohydrological characterization of the Nyando wetland, Lake Victoria, Kenya: A State of System (SoS) analysis. African Journal of Environmental Science and Technoloy, 7(6), 417–434.
- Kipkoech, A., Mogaka, H., Cheboiywo, & Kimaro, D. (2011). The Total Economic Value of Maasai Mau, Trans Mara and Eastern Mau Forest Blocks, of the Mau Forest, Kenya. Kisumu, Kenya: Lake Victoria Basin Commission Secretariat.
- Kotb, M. M., Ali, R. R., & El Semary, M. A. (2017). Use of Remote Sensing and GIS for Land Degradation Assessment of Qarun Lake Coastal Area, El-Fayoum, Egypt. In Water and Land Security in Drylands. Cham, Switzerland: Springer.
- Kulindwa, K. (2006). Valuation of Environmental Assets in the Lake Victoria basin. In E. O. Odada, D. O. Olago, & W. Ochola (Eds.), Environment for Development: An Ecosystems Assessment of Lake Victoria Basin. Nairobi, Kenya: UNEP/PASS.
- Labzae, M. (2016). Investment in the National Park? Encounters between Land Investment and Wildlife Conservation in Gambella Regional State.
 In D. Ambrosetti, J. Boisserie, D. Ayenachew, & T. Guindeuil (Eds.), Climatic and Environmental Challenges: Learning from the Horn of Africa. Addis Ababa, Ethiopia: Centre français des études éthiopiennes.

- Laisser, S. L. (2011). Biometric parameters and growth of Cyperus papyrus in seasonally and permanently flooded zones of the Mara Wetland, Tanzania (MSc Thesis). UN-IHE, Delft, The Netherlands.
- Lake Victoria Basin Commission and GRID-Arendal. (2017). Lake Victoria Basin: Atlas of Our Changing Environment. Kisumu and Arendal: Author.
- Langat, D., & Chebwoiwo, J. (2002). To conserve or not to conserve: a case study of forest valuation in Kenya. Journal of Tropical Forest Science, 22(1), 5–12.
- LTS Africa Ltd, & Tetra Tech ARD. (2016). Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development: Economic valuation of biodiversity and ecosystem services in the Mara Wetlands, United Republic of Tanzania. Nairobi, Kenya: USAID/Kenya and East Africa
- Lunt, M. F., Palmer, P. I., Feng, L., Taylor, C. M., Boesch, H., & Parker, R. J. (2019). An increase in methane emissions from tropical Africa between 2010 and 2016 inferred from satellite data. Atmospheric Chemistry and Physics Discussions, 19, 14721–14740.
- LVBC (Lake Victoria Basin Comission). (2016). Mara River Basin. transboundary Integrated Natural Resources Management Plan (Report). Kisumu, Kenya: Author.
- LVBC (Lake Victoria Basin Commission). (2011a). Identification and mapping of ecologically sensitive areas (ESAS) in Lake Victoria. Kisumu and Nairobi, Kenya: African Centre for Technology Studies Press, African Centre for Technology Studies, Lake Victoria Basin Commission.
- LVBC (Lake Victoria Basin Commission). (2011b). Water hyacinth on the River mouth to Lake Victoria 2011 (Report). The East African Community.
- Maclean, I., Tinch, R., Hassall, M., & Boar, R. (2010). Towards optimal use of tropical wetlands: an economic valuation of goods derived from papyrus swamps in Southwest Uganda (CSERGE Working Paper No. ECM 03-10). Norwich, UK.
- Mafabi, P. (2003). Lake Nabugabo Wetland System: Site no. 1373 (Ramsar Information Sheet). Gland: Ramsar Convention Secriatariat.
- Mango, L. M., Melesse, A. M., McClain, M. E., Gann, D., & Setegn, S. G. (2011). Land use and climate change impacts on the hydrology of the upper Mara River Basin, Kenya: Results of a modeling study to support better resource management. Hydrology and Earth System Sciences, 15(7), 2245–2258.
- Mati, B. M., Mutie, S., Gadain, H., Home, P., & Mtalo, F. (2008). Impacts of land-use/cover changes on the hydrology of the transboundary Mara River, Kenya/Tanzania. Lakes and Reservoirs: Research and Management, 13(2), 169–177.
- McKee, J. (2007). Ethiopia Country Environmental Profile EC Delegation Addis Abeba August 2007.
- Mekuria, W., Veldkamp, E., Tilahun, M., & Olschewski, R. (2011). Economic valuation of land restoration: the case of exclosures established on communal grazing lands in Tigray, Ethiopia. Land Degradation & Development, 22, 334–344.
- MEMR. (2012). Kenya Wetland Atlas. Nairobi, Kenya: Ministry of Environment and Mineral Resources.
- Menbere, I. P., & Menbere, T. P. (2018). Wetland ecosystems in Ethiopia and their implications in ecotourism and biodiversity conservation. *Journal of Ecology and The Natural Environment*, 10(6), 80–96.
- Mengistou, S., Woldu, Z., Emiru, S., Eshete, D., Saber, S. A., Wambura, J., ... Edited. (2009). The Biodiversity, Wetlands and Water Quality of the Lake Tana Sub Basin (LTSB) (Report). (H. Busulwa & C. Lippai, Eds.). Unknown: Nile Basin Initiative.
- Millman, R. (1973). Problems of the Natural Environment on the Kano Plains of Western. Cahiers d'études Africaines, 13(50), 181-192.
- Ministry of Environment Protection. (1990). Lake George Wetland: Site no. 394 (Ramsar Information Sheet). Gland, Switzerland: Ramsar Convention Secretariat.
- Misigo, A. W. S., & Suzuki, S. (2018). Spatial-Temporal Sediment Hydrodynamics and Nutrient Loads in Nyanza Gulf, Characterizing Variation in Water Quality. World Journal of Engineering and Technology, 06(02), 98–115.
- Mohamed, S. A., & El-Raey, M. E. (2019). Land cover classification and change detection analysis of Qaroun and Wadi El-Rayyan lakes using multi-temporal remotely sensed imagery. *Environmental Monitoring and Assessment*, 191(4).
- Mohamed, Y. A. (2018). Machar Marshes: Nile Basin (South Sudan). In M. Finlayson, R. Milton, N. C. Davidson, UNESCO-IHE, & R. Crawford Prentice (Eds.), The Wetland Book II: Distribution, Description, and Conservation (pp. 1279–1286). Dordrech, The Netherlands: Springer Science+Business Media B.V.
- Mohamed, Y. A., Bastiaanssen, W. G. M., & Savenije, H. H. G. (2004). Spatial variability of evaporation and moisture storage in the swamps of the upper Nile studied by remote sensing techniques. *Journal of Hydrology*, 289(1–4), 145–164.
- Mohamed, Y. A., & Savenije, H. H. G. (2014). Impact of climate variability on the hydrology of the Sudd wetland: Signals derived from long term (1900-2000) water balance computations. Wetlands Ecology and Management, 22, 191–198.
- Moussa, A. M. A. (2019). Assessment of Sediment Deposition in Aswan High Dam Reservoir During 50 Years (1964–2014). Handbook of Environmental Chemistry (Vol. 79). Cham, Switzerland: Springer.
- Moyini, Y., & Masiga, M. (2011). The Economic Valuation of the Proposed Degazettement of Mabira Central Forest Reserve. Kampala, Uganda: NatureUganda.
- Muala, E., Mohamed, Y. A., Duan, Z., & van der Zaag, P. (2014). Estimation of reservoir discharges from Lake Nasser and Roseires Reservoir in the Nile Basin using satellite altimetry and imagery data. Remote Sensing, 6(8), 7522–7545.
- Mule, S., Nguta, C., Geoffrey, K., Ongera, G., Wangila, P., Kiplimo, J., & Chirchir, D. (2015). Physical Parameters of Tropical Wetlands in Lake Victoria Basin: A Case Study of Kigwal/Kimondi, Nyando and Nzoia Wetlands. Journal of Environmental & Analytical Toxicology, 5(2).
- Munishi, P. K. T., Shear, T. H., Wentworth, T., & Temu, R. A. P. C. (2007). Compositional gradients of plant communities in Submontane Rainforests of Eastern Tanzania. *Journal of Tropical Forest Science*, 19(1), 35–45.
- Muruza, M., Mayo, W. M., & Norbert, J. (2013). Wetland Plant dominance, density and biomass in Mara river Basin Wetland Upstream of Lake Victoria on Tanzania. International Journal of Scientific & Technology Research, 2(12).
- Musinguzi, L., Efitre, J., Odongkara, K., Ogutu-Ohwayo, R., Muyodi, F., Natugonza, V., ... Naigaga, S. (2016). Fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hotspots: a case of Lake Wamala, Uganda. Environment, Development and Sustainability, 18(4), 1255–1273.

- Mutie, S. M., Mati, B., Gadain, H., & Home, P. (2005). Land cover change effects on flow regime of mara river. In *Proceedings of ISCRAM 2005 2nd International Conference on Information Systems for Crisis Response and Management* (pp. 237–246).
- NBI (Nile Basin Initiative). (2009). The Wetlands of the Nile Basin: Baseline Inventory and Mapping (Report). Khartoum, Sudan: Author, Transboundary Environmental Action Project.
- NBI (Nile Basin Initiative). (2016a). Nile Basin Climate. In The Nile Basin Water Resources Atlas (pp. 95-132). Entebbe, Uganda: Author.
- NBI (Nile Basin Initiative). (2016b). Nile Basin Water Resources Atlas. Kampala, Uganda: Author.
- Ndayisaba, F., Nahayo, L., Guo, H., Bao, A., Kayiranga, A., Karamage, F., & Nyesheja, E. M. (2017). Mapping and monitoring the Akagera wetland in Rwanda. Sustainability, 9(172), 1–13.
- Ndithia, H. (2009). Birds. In H. Busulwa & A. Rose Sirali (Eds.), Baseline Report on State of Biodiversity in the Nile Kenya. A Production of the Wetlands and Biodiversity Conservation Component of the Nile Transboundary Environmental Action Project. Entebbe, Uganda: Nile Basin Initiative.
- NEMA (National Environmental Management Authority). (2017). National State of the Environment Report 2016/17 (Report). Kampala, Uganda:
- Ngaboyamahina, T. (2015). Rugezi-Burera-Ruhondo, Rwanda: Site no. 1589 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Nhapi, I., Walib, U. G., Usanzinezab, D., Kashaigilic, J. J., Banaddad, N., & Kimwagae, R. (2012). Distribution of Heavy Metals in Lake Muhazi, Rwanda. The Open Environmental Engineering Journal, 5(1), 96–102.
- Nile-Eco-VWU. (2016). Guidelines for wetlands ecosystems valuation in the Nile Basin. Nile Ecosystems Valuation for Wise-Use (Nile-Eco-VWU).

 Cairo, Egypt: CGIAR Research Program on Water Land and Ecosystems and Nile Basin Capacity Building Network.
- Nkezabahizi, L., & Manirambona, A. (2009). Burundi's Important Bird Areas: Status and Trends (Report). Bujumbura, Burundi: Association Burundaise pour la protection des Oiseaux.
- Nyungwe Forest National Park. (2019). Kamiranzovu Swamp. Retrieved December 12, 2019, from https://www.nyungweforestnationalpark.org/kamiranzovu-swamp/
- Nzigidahera, B. (2007). Study of the Flora in the Cohoha Sub-Basin (Report). Bujumbura, Burundi: Nile Basin Initiative, Nile Transboundary Environmental Action Project.
- Obando, J. A., Makalle, A., & Bamutaze, Y. (2007). A Framework for Integrated Management of Transboundary Basins: The case of Sio sub-catchment in East Africa. Catchment and Lake Research LARS, 138–143.
- Oduor, F. O., Raburu, P. O., & Mwakubo, S. (2015). To conserve or convert wetlands: Evidence from Nyando wetlands, Kenya. Journal of Development and Agricultural Economics, 7(2), 48–54.
- Oindo, B. O. (2009). Plants. In H. Busulwa & R. S. Antipa (Eds.), Baseline Report on State of Biodiversity in the Nile Kenya. A Production of the Wetlands and Biodiversity Conservation Component of the Nile Transboundary Environmental Action Project. Entebbe, Uganda: Nile Basin Initiative Secretariat.
- Ojwang, W. O., & Ojuok, J. E. (2009). The Nile Basin Kenya. In H. Busulwa & R. S. Antipa (Eds.), Baseline Report on State of Biodiversity in the Nile Kenya. A Production of the Wetlands and Biodiversity Conservation Component of the Nile Transboundary Environmental Action Project. Entebbe, Uganda: Nile Basin Initiative, Nile Transboundary Environmental Action Project.
- Okely, P., Imberger, J., & Antenucci, J. P. (2010). Processes affecting horizontal mixing and dispersion in Winam Gulf, Lake Victoria. Limnology and Oceanography, 55(5), 1865–1880.
- Okotto-Okotto, J., Raburu, P. O., Obiero, K. O., Obwoyere, G. O., Mironga, J. M., Okotto, L. G., & Raburu, E. A. (2018). Spatio-Temporal Impacts of Lake Victoria Water Level Recession on the Fringing Nyando Wetland, Kenya. Wetlands in the Developing World, 38, 1107–1119.
- Okwi, P. (2010). Valuing Tropical Grasslands: The Case of Overstocking in Northeastern Uganda. In Social science research report series No. 24.

 Addis Ababa, Ethiopia: Organization for Social Science Research in Eastern and Southern Africa (OSSERA).
- Omer, A. Y. A., Ali, Y. S. A., Roelvink, J. A., Dastgheib, A., Paron, P., & Crosato, A. (2015). Modelling of sedimentation processes inside Roseires Reservoir (Sudan). Earth Surface Dynamics, 3, 223–238.
- Ondiek, R., Kitaka, N., & Odour, S. (2016). Assessment of provisioning and cultural ecosystem services in natural wetlands and rice fields in Kano floodplain, Kenya. *Ecosystem Services*, 21, 166–173.
- Ongore, C. O., Aura, C. M., Ogari, Z., Njiru, J. M., & Nyamweya, C. S. (2018). Spatial-temporal dynamics of water hyacinth, Eichhornia crassipes (Mart.) and other macrophytes and their impact on fisheries in Lake Victoria, Kenya. *Journal of Great Lakes Research*, 44(6), 1273–1280.
- Osman, M. M. A. (2009). Aquatic Plants of the Sudan. In H. J. Dumont (Ed.), The Nile: Origin, Environments, Limnology and Human Use (pp. 479–494). Dordrecht, The Netherlands: Springer Science+Business Media B.V.
- Petersen, G., Bast, H., & Fohrer, N. (2008). Estimation of ungauged Bahr el Jebel flows based on upstream water levels and large scale spatial rainfall data. Advances in Geosciences, 18, 9–13.
- Petersen, G., Sutclifffe, J. V, & Fohrer, N. (2008). Morphological analysis of the Sudd region using land survey and remote sensing data. Earth Surface Processes and Landforms, 33, 1709–1720.
- Raburu, P. O., Okeyo-Owuor, J. B., & Kwena, F. (2012). Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya. Nairobi, Kenya: KDC VIRED UNDP.
- Radwan, A. A. M., Abdelmoneim, M. A., Basiony, A. I., & El-Alfy, M. A. (2019). Water pollution monitoring in Idku lake (Egypt) using phytoplankton and NSF-WQI. Egyptian Journal of Aquatic Biology and Fisheries, 23(4), 465–481.
- Ramsar. (2014). Information Sheet on Ramsar Wetlands (RIS) 2009-2014 version. Retrieved July 3, 2019, from http://www.ramsar.org/pdf/ris/key_ris_e.pdf
- Rebelo, L. M., & El Moghraby, A. I. (2018). The Sudd (South Sudan). In M. Finlayson, R. Milton, N. C. Davidson, UNESCO-IHE, & C. Pre (Eds.),

 The Wetland Book II: Distribution, Description, and Conservation (pp. 1300–1306). Dordrecht, The Netherlands: Springer Science + Business

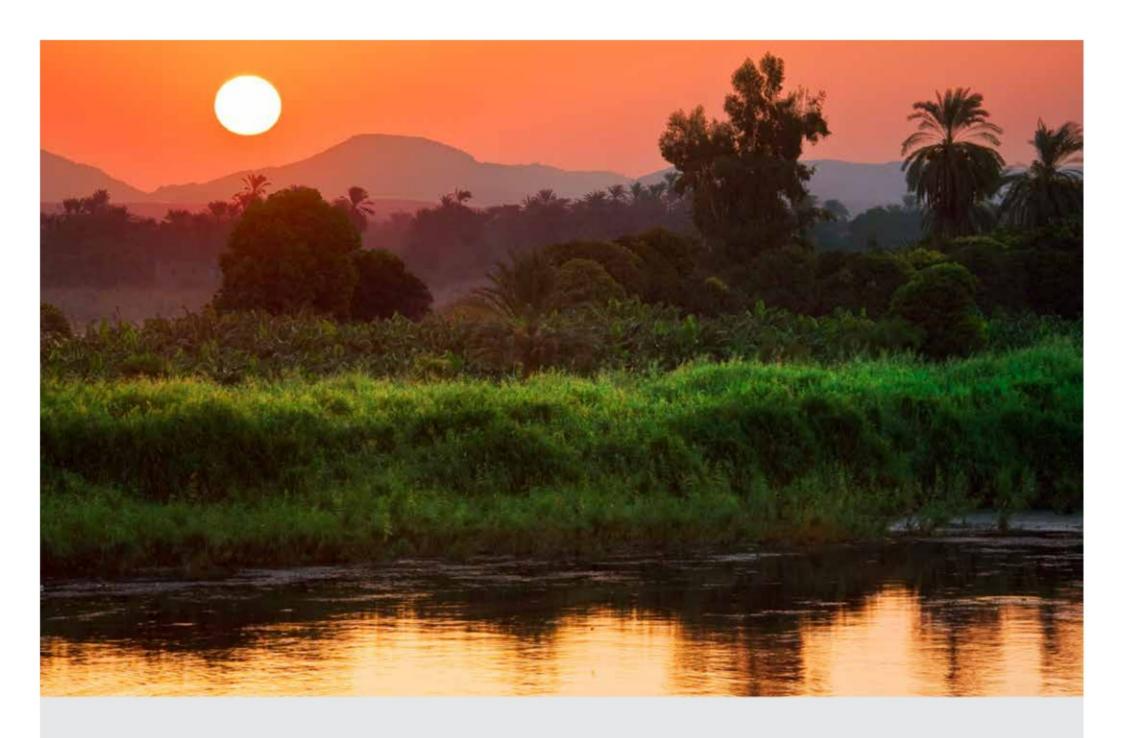
 Media B.V.
- Rebelo, L. M., & McCartney, M. (2012). Wetlands of the Nile Basin: distribution, functions and contribution to livelihoods. In S. B. Awulachew, V.

- Smakhtin, D. Molden, & D. Peden (Eds.), The Nile River Basin: water, agriculture, governance and livelihoods (pp. 212–228). Abingdon, UK: Routledge Earthscan.
- Rebelo, L. M., Senay, G. B., & McCartney, M. P. (2012). Flood pulsing in the Sudd wetland: Analysis of seasonal variations in inundation and evaporation in South Sudan. Earth Interactions, 16, 1–19.
- REMA (Rwanda Environment Management Authority). (2009). Rwanda State of the Environment and Outlook (Report). Kigali, Rwanda: Author.
- REMA (Rwanda Environment Management Authority). (2015). Rwanda State of the Environment and Outlook Report (Report). Kigali, Rwanda: Government of Rwanda.
- Riak, K. . (2006). Sudd Area as a Ramsar Site: Biophysical Features. In Proceedings of the Juba Workshop on the Post-Conflict national Plan for Environmental Management in Sudan, November 2006.
- Rongoei, P. J. K., Kipkemboi, J., Kariuki, S. T., & van Dam, A. A. (2014). Effects of water depth and livelihood activities on plant species composition and diversity in Nyando floodplain wetland, Kenya. Wetlands Ecology and Management, 22, 177–189.
- Rongoei, P. J. K., & Outa, N. O. (2016). Cyperus papyrus L. Growth Rate and Mortality in Relation to Water Quantity, Quality and Soil Characteristics in Nyando Floodplain Wetland, Kenya. Open Journal of Ecology, 6, 714–735.
- Rufuguta, E. (2013a). Parc National de la Ruvubu: Site no. 2148 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Rufuguta, E. (2013b). Paysage Aquatique Protégé du Nord: Site no. 2149 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- Russi, D., Ten Brink, P., Farmer, A., Badura, T., Coates, D., Förster, J., & Davidson, N. (2013). The Economics of Ecosystems and Biodiversity for Water and Wetlands. IEPP, London and Brussles; Ramsar Secretariat, Gland.
- Rwanda Energy Group Limited. (2018). Peat to Power in Rwanda. Retrieved June 5, 2019, from http://www.reg.rw/what-we-do/generation/peat/
- Sakataka, W., & Namisiko, P. (2014). Livelihood Activities that Impact on Sustainable Wetland use in Upper Nzoia River Basin, Kenya. Journal of Economics and Sustainable Development, 5(20), 70–83.
- Schuijt, K. (2002). Land and Water Use of Wetlands in Africa: Economic Values of African Wetlands. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Shamseddin, M. A. H., Hata, T., Tada, A., Bashir, M. A., & Tanakamaru, T. (2006). Estimation of flooded area in the Bahr El-Jebel basin using remote sensing techniques. *Hydrology and Earth System Sciences Discussions*, 3, 1851–1877.
- Sila, A., Pokhariyal, G., & Shepherd, K. (2017). Evaluating regression-kriging for mid-infrared spectroscopy prediction of soil properties in western Kenya. Geoderma Regional, 10, 39–47.
- Simiyu, B. M., Oduor, S. O., Rohrlack, T., Sitoki, L., & Kurmayer, R. (2018). Microcystin content in phytoplankton and in small fish from eutrophic nyanza gulf, lake Victoria, Kenya. *Toxins*, 10(7), 1–19.
- Simonit, S., & Perrings, C. (2011). Sustainability and the value of the 'regulating' services: Wetlands and water quality in Lake Victoria. *Ecological Economics*, 70, 1189–1199.
- Sosnowski, A., Ghoneim, E., Burke, J. J., Hines, E., & Halls, J. (2016). Remote regions, remote data: A spatial investigation of precipitation, dynamic land covers, and conflict in the Sudd wetland of South Sudan. Applied Geography, 69, 51–64.
- Sutcliffe, J. V. (2009). The Hydrology of the Nile Basin. In H. J. Dumont (Ed.), *The Nile: Origin, Environments, Limnology and Human Use* (pp. 335–364). Dordrecht, The Netherlands: Springer Science+Business Media B.V.
- Sutcliffe, J. V, & Brown, E. (2018). Water losses from the Sudd. Hydrological Sciences Journal, 63(4), 527-541.
- Sutcliffe, J. V, & Parks, Y. P. (1999). The Hydrology of the Nile. IAHS Special Publication. Wallingford, UK: IAHS Press Institute.
- Thenya, T., & Ngecu, W. M. (2017). Dynamics of resource utilisation in a tropical wetland, Yala swamp, Lake Victoria basin-Statistical analysis of land use change. *International Journal of Science Arts and Commerce*, 2(3), 12–38.
- Tshering, K. (2011). Spatial Variation of Denitrification in Mara Wetland, Tanzania (MSc Thesis). UN-IHE, Delft, The Netherlands.
- Twesigye, C. K. (2011). The Impact of Land Use Activities on Vegetation Cover and Water Quality in the Lake Victoria Watershed. The Open Environmental Engineering Journal, 4(1), 66–77.
- Uganda Wildlife Authority. (2008). Rwenzori Mountains: Site no. 1861 (Ramsar Information Sheet). Gland: Ramsar Convention Secretariat.
- UNEP-WCMC, & IUCN. (2020). The World Database on Protected Areas (WDPA). Cambridge, UK: Author.
- USAID. (2015). Uganda Environmental Threats and Opportunities Assessment (ETOA) Final ETOA Report.
- Van Dam, A., Kipkemboi, J., Rahman, M., & Gettel, G. (2013). Linking Hydrology, Ecosystem Function, and Livelihood Outcomes in African Papyrus Wetlands Using a Bayesian Network Model. Wetlands, 33.
- Van der Knaap, M. (1994). Status of fish stocks and fisheries of thirteen medium-sized African reservoirs. Rome, Italy: FAO.
- Vanderkelen, I., Lipzig, N. P. M. Van, & Thiery, W. (2018). Modelling the water balance of Lake Victoria (East Africa) Part 1: Observational analysis. Hydrology and Earth System Sciences, 22, 5509–5525.
- Vijverberg, J., Sibbing, J. F. A., & Dejen, E. (2009). Lake Tana: Source of the Blue Nile. In H. J. Dumont (Ed.), *The Nile: Origin, Environments, Lim-nology and Human Use* (pp. 163–192). Dordrecht, The Netherlands: Springer Science + Business Media B.V.
- Wang, G. dong, Wang, M., Yuan, Y. xiang, Lu, X. guo, & Jiang, M. (2014). Effects of sediment load on the seed bank and vegetation of Calamagnostis angustifolia wetland community in the National Natural Wetland Reserve of Lake Xingkai, China. Ecological Engineering, 63, 27–33.
- Wasige, J. E., Groen, T. A., Smaling, E., & Jetten, V. (2012). Monitoring basin-scale land cover changes in Kagera Basin of Lake Victoria using: Ancillary data and remote sensing. International Journal of Applied Earth Observation and Geoinformation, 21(1), 32–42.
- Wilusz, D. C., Zaitchik, B. F., Anderson, M. C., Hain, C. R., Yilmaz, M. T., & Mladenova, I. E. (2017). Monthly flooded area classification using low resolution SAR imagery in the Sudd wetland from 2007 to 2011. Remote Sensing of Environment, 194, 205–218.
- Witte, F., de Graaf, M., Mkumbo, O. C., El-Moghraby, A. I., & Sibbing, F. (2009). Fisheries in the Nile. In H. J. Dumont (Ed.), *The Nile: Origin, Environments, Limnology and Human Use* (pp. 723–747). Dordrecht, The Netehrlands: Springer Science+Business Media B.V.

Wood, A., Sutcliffe, J. V, & Dixon, A. (2018). Baro-Akobo River Basin Wetlands: Livelihoods and Sustainable Regional Land Management (Ethiopia). In M. Finlayson, R. Milton, N. C. Davidson, UNESCO-IHE, & R. Crawford Prentice (Eds.), *The Wetland Book: II: Distribution, Description, and Conservation* (pp. 1262–1267). Dordrecht, The Netherlands: Springer Science+Business Media B.V.

WWF. (2019). Nile Delta flooded savanna. Retrieved September 5, 2019, from https://www.worldwildlife.org/ecoregions/pa0904

Zaghloul, S., Pacini, N., Schwaiger, K., & de Villeneuve, P. H. (2012). Towards a Lake Nasser management plan: results of a pilot test on integrated water resources management. International Water Technology Journal, I(3), 249–258.



ONE RIVER ONE PEOPLE ONE VISION



NBI Member States



Burundi





Egypt



Ethiopia



Kenya



Rwanda





South Sudan



The Sudan





NILE BASIN INITIATIVE SECRETARIAT

P.O. Box 192 Entebbe – Uganda

rel: +256 417 705 000 +256 417 705 117 +256 414 321 424

+256 414 321 329
Email: nbisec@nilebasin.org
Website www.nilesec.nilebasin.org

EASTERN NILE TECHNICAL REGIONAL OFFICE

Dessie Road
P.O. Box 27173-1000
Addis Ababa – Ethiopia
Tel: +251 116 461 130/32
Fax: +251 116 459 407
Email: entro@nilebasin.org

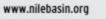
Website: www.entro.nilebasin.org

NILE EQUATORIAL LAKES SUBSIDIARY ACTION PROGRAM

Program Coordination Unit
Kigali City Tower
KCT, KN 2 St, Kigali
P.O. Box 6759, Kigali Rwanda
Tel: +250 788 307 334
Fax: +250 252 580 100
Email: nelcu@nilebasin.org
Website: www.nelsap.nilebasin.or









Nile Basin Initiative





