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Wetlands of the Nile Basin Inventory

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Document Sheet

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The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

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Nile basin wetlands of transboundary significance: inventory, baseline study and framework management plan

Wetlands of the Nile Basin Inventory

Executive summary

The Nile Basin has been a source of life since the first settlements on its banks were established. For decades, researchers have been studying its unique features. Wetlands are important components within the basin and essential to keep the basin healthy and productive. Wetlands are also complex ecosystems combining terrestrial and aquatic features and generally featuring high biodiversity. The project has 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 research and stakeholder consultation. The project has yielded a baseline inventory and maps for the overall basin organised at sub-basin level, wetland groups within the sub-basins and a focus on wetlands of international importance. Special attention was given to the Sudd wetland.

The status and biodiversity of the selected major wetlands in the Nile basin has been assessed and described using available literature as well as reports, narrative information, data provided by the project working group members and data collected through direct approaches from local knowledge groups. This information was included in the report as well as stored in a database, linked to respective wetland maps. For selected wetlands within the wetland groups as listed above, the detailed information provided with the report and within the database provides valuable knowledge for wetland related questions. The information provides the foundation for future upgrading of the inventory with information collected by local or regional studies.

Results of the study were used to analyse wetland status and “trends” for the period 1985-2015. This was done using satellite information and trends described in other inventories and literature. For detailed information about maintenance and updating of the database, a methodology manual has been developed. The manual includes strategic, as well as technical information important for wetland management, maintenance and updating of previous work.

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, based on state of the art remote sensing data. Wetlands throughout the basin are under pressure caused by population growth and associated demands for food and energy. Climate change and subsequent uncertain rainfall patterns, flash floods and possible droughts add additional pressures on the whole Nile Basin and its wetlands. At the same time the wetlands are highly valued for the benefits they provide (e.g. food, water, climate regulation). To allow for a more sustainable use of all wetlands in the basin the main recommendation is to increase monitoring, especially for those wetlands that were identified as data poor and to continuously update the database when new information comes available. This will allow for better and evidence-based management plans and decisions at local and national level with coordination support of the Nile Basin Initiative, which is of high importance as new challenges and many uncertainties about the future of wetlands will arise in this era of climate change.

List of 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

Glossary

Africover	Africover was a UN project which collected and collated geographical information on Africa mostly using satellites. It gathered data on areas such as land usage, climate conditions and it also locates natural resources. One major usage of this system has been to provide flood warnings to governments and NGOs, who then pass the information onto farmers.
Alien species	A species occurring in an area outside of its historically known natural range as a result of intentional or accidental dispersal by human activities. Also known as introduced species.
Avifauna	All of the birds found in a given area.
Band	A single layer of an image created using a specific range of wavelengths. A colour digital image is composed of three bands that record red, green, and blue wavelengths of light.
Biodiversity	The totality of genes, species, and ecosystems in a region or the world. The variation of life forms within a given ecosystem.
Biome	A major portion of the living environment of a particular region (such as a fir forest or grassland), characterized by its distinctive vegetation and maintained by local climatic conditions.
Biota	All of the organisms, including animals, plants, fungi, and microorganisms, found in a given area.
Biotic	Pertaining to any aspect of life, especially to characteristics of entire populations or ecosystems.
Buffer zone	The region near the border of a protected area; a transition zone between areas managed for different objectives.
Centre of diversity	Geographic region with high levels of genetic or species diversity.
Channel	This is typically synonymous with "band" of a remote sensing sensor
Characteristic diversity	The pattern of distribution and abundance of populations, species, and habitats under conditions where humanity's influence on the ecosystem is no greater than that of any other biotic factor.
Class	In taxonomy, a category just beneath the phylum and above the order; a group of related, similar orders.
Classification	The process of identifying and labelling features in an image. Pixels are grouped into categories using manual or automated methods.
Common property Resource management	The management of a specific resource (such as a forest or pasture) by a well-defined group of resource users with the authority to regulate its use by members and outsiders.

Community	An integrated group of species inhabiting a given area; the organisms within a community influence one another's distribution, abundance, and evolution (A Human Community is a social group of any size whose members reside in a specific locality).
Conservation	The management of human use of the biosphere so that it may yield the greatest sustainable benefit to current generations while maintaining its potential to meet the needs and aspirations of future generations: Thus conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration, and enhancement of the natural environment.
Conservation of biodiversity	The management of human interactions with genes, species, and ecosystems so as to provide the maximum benefit to the present generation while maintaining their potential to meet the needs and aspirations of future generations; encompasses elements of saving, studying, and using biodiversity.
Database	A database is an integrated collection of logically related records or files consolidated into a common pool that provides data for one or multiple uses. In one view, databases can be classified according to types of content: bibliographic, full-text, numeric, and image.
DEM	A digital elevation model (DEM) is a digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM). A DEM can be represented as a raster (a grid of squares) or as a triangular irregular network. DEMs are commonly built using remote sensing techniques, but they may also be built from land surveying.
Demography	The rate of growth and the age structure of populations, and the processes that determine these properties.
Ecosystem	The organisms of a particular habitat, such as a pond or forest, together with the physical environment in which they live; a dynamic complex of plant, animal, fungal, and microorganism communities and their associated non-living environment interacting as an ecological unit. Ecosystems have no fixed boundaries; instead, their parameters are set according to the scientific, management, or policy question being examined. Depending upon the purpose of analysis, a single lake, a watershed, or an entire region could be an ecosystem. Within the Millennium Ecosystem Assessment (MA), ecosystems are described as the complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services).

Electromagnetic Spectrum	The range of wavelengths of electromagnetic radiation. Remote sensing applications typically use wavelengths that include the visible wavelengths (blue through red), the infrared, and microwave regions of the electromagnetic spectrum. The shorter wavelength ultraviolet, x-ray, and gamma rays are not typically used. The long wavelength radio waves are also not typically used.
Endemic	Restricted to a specified region or locality.
Evolution	Any gradual change. Organic evolution is any genetic change in organisms from generation to generation.
Fauna	All of the animals found in a given area.
Flora	All of the plants found in a given area.
Genetic diversity	Variation in the genetic composition of individuals within or among species; the heritable genetic variation within and among populations.
GIS	A geographic information system (GIS) or geographical information system captures, stores, analyses, manages, and presents data that is linked to location. Technically, GIS is geographic information systems which includes mapping software and its application with remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and tools that can be implemented with GIS software. Still, many refer to "geographic information system" as GIS even though it doesn't cover all tools connected to topology.
Habitat	The environment in which an organism lives. Habitat can also refer to the organisms and physical environment in a particular place.
Hotspot	A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction.
Indicator species	A species whose status provides information on the overall condition of the ecosystem and of other species in that ecosystem.
Infrared	The portion of the electromagnetic spectrum that lies between the visible and microwave wavelengths (0.7 nanometres – 100 micrometers).
Introduced species	A species occurring in an area outside of its historically known natural range as a result of intentional or accidental dispersal by human activities. Also known as alien species.
Life form	Characteristic structure of a plant or animal.
Native species	Plants, animals, fungi, and microorganisms that occur naturally in a given area or region.

Optical sensor	Sensor that is sensitive to visible and infrared wavelengths of light.
Pixel	An individual "picture element" from an image. When an image is magnified the individual pixels can be seen as a square or rectangular block in image.
Population	A group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group.
Protected area	A legally established land or water area under either public or private ownership that is regulated and managed to achieve specific conservation objectives.
Radar	Radar is an acronym for Radio Detection and Ranging (RADAR – although the letters are usually not capitalized). It is a remote sensing instrument that emits a microwave signal and measures the time for the signal to return to the detector as well as the intensity of the returned signal. Interpreting the returned signal can provide digital elevation models (DEMs), changes in water level and information about land cover.
Radiation	Energy transferred as particles or waves through space or other media. In remote sensing radiation often comes from the sun although it can also come from the sensor as is the case with LIDAR and RADAR sensors.
Ramsar	The Convention on Wetlands (Ramsar, Iran, 1971) is an intergovernmental treaty whose mission is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”.
Rehabilitation	The recovery of specific ecosystem services in a degraded ecosystem or habitat.
Resolution	The smallest detail visible in an image. Usually resolution refers to spatial resolution. The spatial resolution of an image is an indication of the size of a single pixel in ground dimensions. It is usually presented as a single value that represents the length of one side of a square. For example, a spatial resolution of 30 metres means that one pixel represents an area 30 metre by 30 metre on the ground. If the pixel is rectangular, it will be recorded as a height and width dimension (i.e., 56m × 79m).
Restoration	The return of an ecosystem or habitat to its original community structure, natural complement of species, and natural functions.
Sensor	A device that is capable of recording the intensity of electromagnetic radiation. In remote sensing these devices

	typically record this information in images, rather than from a single point.
Species	A group of organisms capable of interbreeding freely with each other but not with members of other species.
Species diversity	A function of the distribution and abundance of species. Approximately synonymous with species richness. In more technical literature, includes considerations of the evenness of species abundances. An ecosystem is said to be more diverse, according to the more technical definition, if species present have equal population sizes and less diverse if many species are rare and some are very common.
Species richness	The number of species within a region. A term commonly used as a measure of species diversity, but technically only one aspect of diversity.
Subspecies	A subdivision of a species; a population or series of populations occupying a discrete range of differing genetically from other subspecies of the same species.
Sustainable development	Development that meets the needs and aspirations of the current generation without compromising the ability to meet those of future generations.
Trophic level	Position in the food chain, determined by the number of energy-transfer steps to that level.
Visible spectrum	The portion of the electromagnetic spectrum between the ultraviolet and infrared wavelengths. This is the range of wavelengths (including the colours in the spectrum from blue through red) that can be detected by the human eye.
Wavelength	Distance between two crests of a wave. In remote sensing electromagnetic waves are typically measured in nanometres, millimetres, and centimetres.
Wetland	As defined by the Ramsar Convention, wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs.

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1 Introduction

1.1 The Nile Basin and its Wetlands

The Nile Basin (Figure 1) is an extensive river and watershed system with a length of approximately 6,800 km and a catchment area of 3,27 million km^2, stretching over central and north-eastern Africa. The Nile has two major tributaries, the Blue Nile and the White Nile. The Blue Nile is the source of most of the Nile's water. The White Nile receives water from the Equatorial Lakes region of central Africa, with the most distant source still undetermined but located in either Southern Rwanda or Northern Burundi. The waters then flow north through Tanzania, Lake Victoria and Uganda, with the DR Congo contributing waters at Lake Albert, continuing through South Sudan. The Blue Nile originates at Lake Tana in Ethiopia, flowing into Sudan from the southeast, merging with the White Nile at the Sudanese capital Khartoum. While the upper stretches of the White Nile are flowing through tropical areas and the Blue Nile originates from the Ethiopian highlands, the northern section of the Nile flows almost entirely through desert from Sudan into Egypt. The Nile ends in a large delta at the Mediterranean Sea. Eritrea contributes to the Nile flow through the Atbara.

The wetlands along the Nile are distributed unevenly. Most wetlands can be found near to the source of the Nile in east and central Africa. The equatorial lakes also host extensive wetlands, mainly along the lake shores, and wetlands continue to be present along the course of the Victoria Nile down to the Ugandan-Sudanese border at Nimule. Further downstream between Nimule and Juba, the Nile, here called the Bahr el Jebel, crosses a mountainous region, then spreading into the massive Sudd wetland area, approximately 60,000 km^2 in size. In the northern Sudd region, the Bahr el Ghazal joins the system with a small contribution as the waters drain into the extensive Bahr el Ghazal swamps. The Sobat which joins the system further downstream near Malakal drains the large Baro-Pibor area, 225,000 km^2 in size, contributing a significant flow to the downstream White Nile originating from the Baro-Akobo-Sobat wetlands, the two former being on the Ethiopian side, as well as from the Machar Marshes. The combined waters, now named White Nile, flow further downstream, fringed by smaller wetlands along the shores. At Lake Tana in Ethiopia the Blue Niles starts its journey. The lake hosts a variety of wetlands along its shore and boasts a significant biodiversity. Downstream of Lake Tana, further wetlands are found along the course of the Blue Nile as well as along its tributaries. The Blue and White Nile merge to form the River Nile at Khartoum. Further downstream throughout the north of Sudan and in Egypt wetlands are relatively small and only fringing the river shores. This situation is only interrupted by some larger wetland areas in shallow parts of the Merowe and Aswan reservoirs. Rising from the high mountains west of Lake Tana, the Atbara River shows a similar picture with wetlands constricted to the river shores while flowing through the incised landscape. Reaching the Mediterranean and forming the Nile Delta, a last significant wetland area is observed, most of which has been converted to agricultural land.

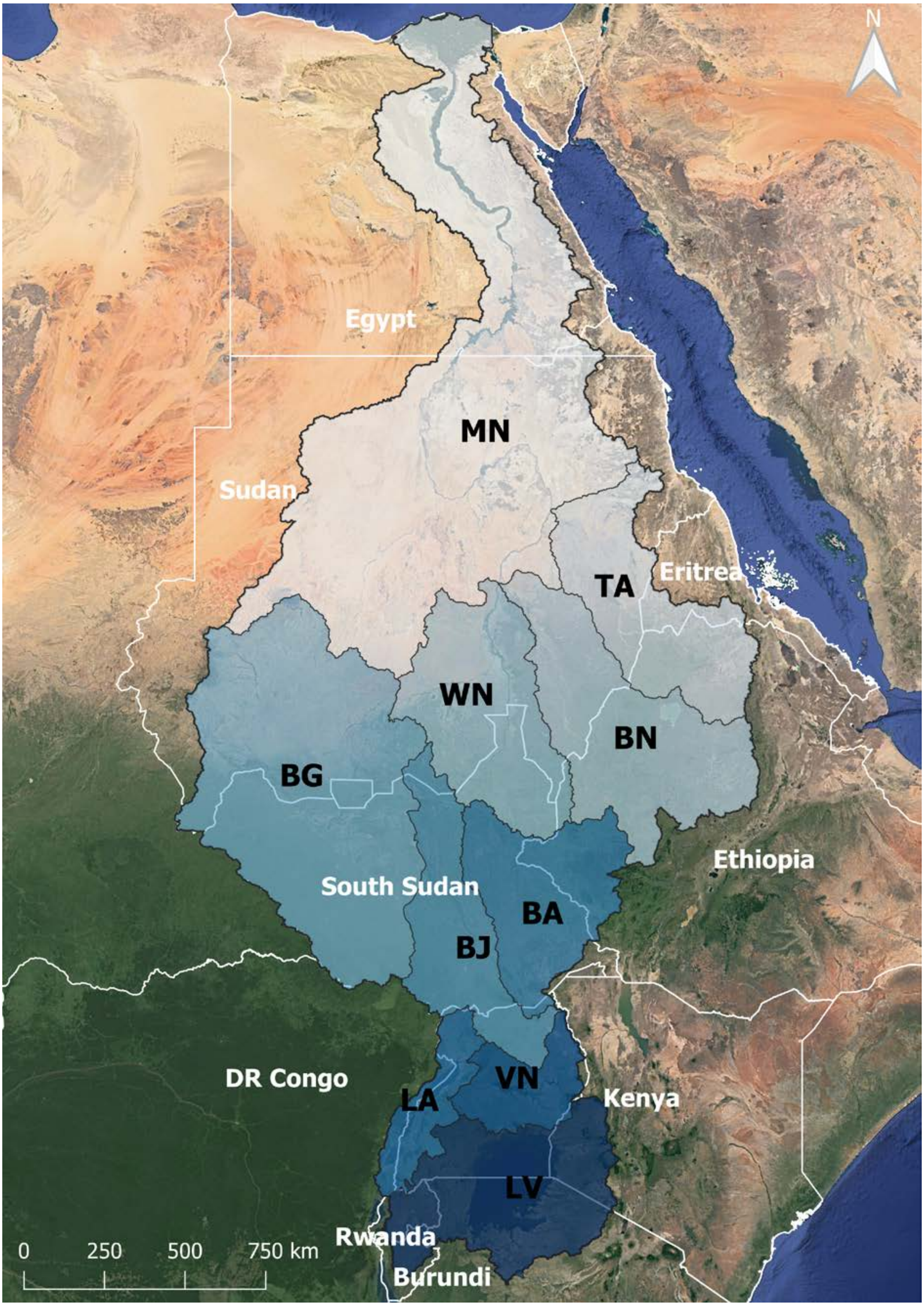

Figure 1 Map of the Nile Basin divided into its then sub basins; MN = Main Nile, TA = Tekeze Atbara, BN = Blue Nile, WN = White Nile, BG = Bahr el Ghazal, BA = Baro Akobo Sobat, BJ = Bahr el Jebel, LA = Lake Albert, VN = Victoria Nile, LV = Lake Victoria.

1.2 The value of wetland ecosystems

Wetlands deliver a wide range of critical and important services that are vital for human well-being such as: fish and fibre, water supply, water purification, carbon sequestration, flood prevention, climate change mitigation and adaptation, pollination, coastal protection, recreational opportunities and tourism. Maintaining the natural functioning of wetlands will enable them to continue to deliver these services. The described wetlands fulfil several of these functions and roles. They act as biodiversity strongholds, breeding areas, flood retention areas, microclimate drivers and productivity areas, providing strong economical asset due to their natural resources and production capacity. Their preservation and management will ensure optimized (economic) benefits based on their functions. The Nile Basin Initiative (NBI) acknowledges the important ecosystem functions of wetlands and therefore strives to understand the wetland resources of the Nile in order to optimize management and decision making in this regard. For a coordinated management of wetlands, knowledge about their resources as well as their behaviour is necessary, the NBI has launched this study to create a wetland inventory by mapping these and collating relevant resource information in publically accessible databases.

2 Methods

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 data was stored in a literature based database in Microsoft Excel and a GIS database and then analysed.

2.1 Data collection

2.1.1 Review of literature

The first aim of the inventory was to create a list of wetlands with transboundary significance in the Nile Basin. To do so, the list of wetlands from the previous Baseline Inventory and Mapping Report by NBI (2009) was compared with the Directory of African Wetlands (Hughes & Hughes, 1992). Next wetlands were excluded which are not in the Nile Basin or small undeliniated riverine wetlands. Similar wetlands were grouped into one larger wetland complex. It was also a priority to include all 20 Ramsar sites which lie within the Nile Basin. This compilation resulted in a list of 68 wetlands which are all discussed individually in the 2020 Inventory of Nile Basin wetlands with transboundary significance (Figure 2).

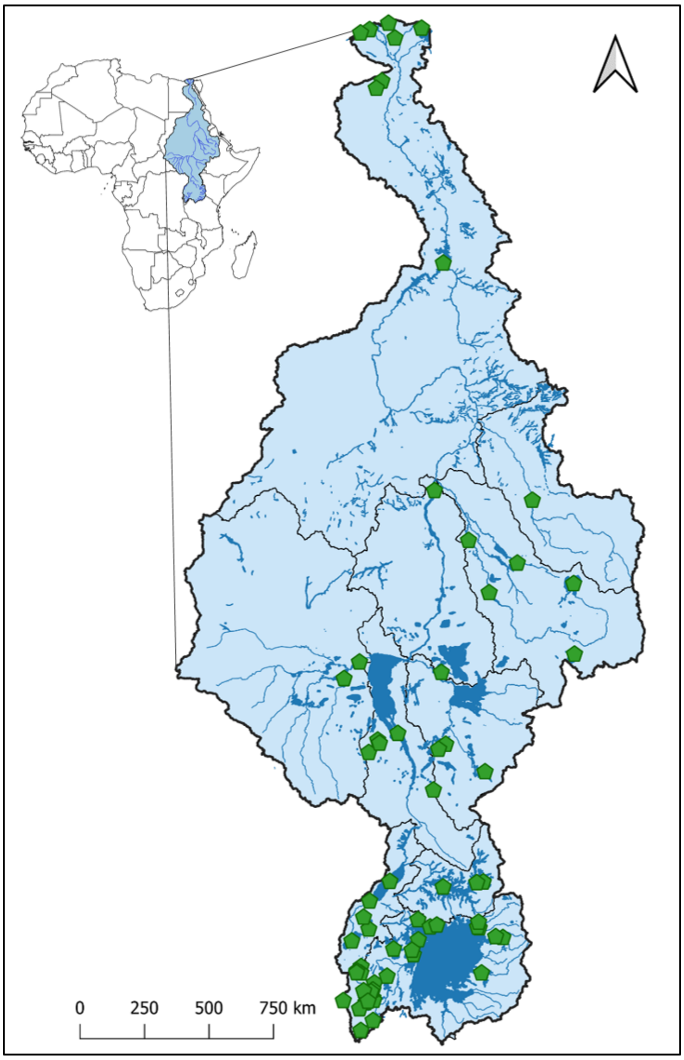

Figure 2 The Nile Basin with its 68 wetlands (green) of transboundary significance

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. A second structural layer are the twelve main wetland groups of transboundary significance, which were decided on during stakeholder consultation with NBI. Each individual wetland is connected to 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 description of each wetland aims to provide an overview of each individual wetland that focuses on the wetland's physical feature. The structure of the wetland descriptions follows the structure outlined in the Directory of African Wetlands (Hughes & Hughes, 1992). The inventory tries to incorporate most features of the Ramsar Information Sheet (RIS) (Ramsar, 2014) for each wetland. The RIS is very detailed and was treated as the standard for a wetland description as it covers all main aspects of a wetland, from biological features to management and ecosystem services. This inventory tries to incorporate the features of a RIS, but we combined several categories of a RIS into one, outlined in Table 1. The climate and ecosystem services are described at sub basin and wetland group level. Information on ecosystem services is mainly derived from WP 3. Biological features are discussed on wetland group level and draw from the information provided by WP4. If the biodiversity of an individual wetland differs from its respective wetland group or if there is a noteworthy ecological feature of a wetland, it was included in the individual wetland description. The management status of each wetland shows, which protected areas a wetland belongs to. The management or protection status of all wetlands was assessed, using the UNEP and IUCN World Database on Protected Areas (UNEP-WCMC & IUCN, 2020). In addition, each wetland is classified after the RIS classification system (Ramsar, 2014) using expert judgement based on the literature review.

Table 1 Structure of wetland descriptions in comparison with Ramsar core inventory fields

Ramsar core wetland inventory fields	**NB inventory fields**
Site name: Official name of site and catchment/other identifier(s)	Sub-basin name Wetland group Wetland (site) name Overview (narrative)
Area, boundary and dimensions: Site shape (cross-section and plan view), boundaries, area, area of water/wet area (seasonal max/min), length, width, depth (seasonal max/min where relevant)	Country or countries Coordinates Area Nearest Town(s)
Location: Projection system, map coordinates, map centroid, elevation	Maps Altitude
Geomorphic setting: Setting in the landscape/catchment/river basin - including altitude, upper/lower zone of catchment, distance to coast where relevant, etc.	Physical features Wetland Classification
Biogeographical region:	Physical features Wetland Classification
Climate:	Physical features

Ramsar core wetland inventory fields	NB inventory fields
Overview of prevailing climate type, zone and major features (precipitation, temperature, wind)	
Soil: Geology, soils and substrates; and soil biology	Physical features
Water regime: Water source (surface and groundwater), inflow/outflow, evaporation, flooding frequency, seasonality and duration; magnitude of flow and/or tidal regime, links with groundwater	Physical features
Water chemistry: Temperature; turbidity; pH; colour; salinity; dissolved gases; dissolved or suspended nutrients; dissolved organic carbon; conductivity	Physical features
Biota: Plant communities, vegetation zones and structure (including comments on particular rarity, etc.); Animal communities (including comments on particular rarity, etc.); Main species present (including comments on particular rare/endangered species, etc.); population size and proportion where known, seasonality of occurrence, and approximate position in distribution range (e.g., whether near centre or edge of range)	Biological features
Land use: Local, and in the river basin and/or coastal zone	Land use and land cover
Pressures and trends: Concerning any of the features listed above, and/or concerning ecosystem integrity	Drivers of Change Change trajectories 1985-2015
Land tenure and administrative authority: For the wetland, and for critical parts of the river basin and/or coastal zone	Management status
Conservation and management status of the wetland: Including legal instruments and social or cultural traditions that influence the management of the wetland; and including protected area categories according to the IUCN system and/or any national system	Management status
Ecosystem services: (for a list of relevant ecosystem services, see the Ramsar ecological character description sheet)	Management status

The literature review combined the foundation of information that is stored in the various regional and country wide wetland inventories with recent (scientific) studies. The literature search was mainly focused on recent information useful for the wetland descriptions, but also describing ongoing or recent changes and developments within or around the wetlands.

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. In addition a literature review was conducted using the search engines Scopus and Google Scholar. The name and alternative 'local' names of each wetland in combination with key terms such as 'wetland', 'swamp', 'floodplain', 'lake', 'river 'or 'dam' was searched for.

Judging from the literature search, the wetlands were classified into wetlands with a (i) good, (ii) fair, and (iii) poor level of information. For the wetland descriptions mainly information from key scientific publications with the most recent or the most complete information were chosen alongside the information provided by NBI reports.

2.1.3 Remote sensing

The wetlands within the Nile basin are mapped based on various Earth Observation (EO) satellites. Table 2 lists the satellite data that are used for this purpose. 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.

Table 2 List of satellite data that has been used for wetland mapping

Sensor name	Main characteristics	Revisit frequency	Spatial resolution	Number of spectral bands	Data availability
Sentinel-2	Newest generation satellite in the optical domain	5-daily	10m	10	≥2016
Sentinel-1	Newest generation satellite in the microwave domain	10-daily	15m	2	≥2014
Landsat	Longest lasting satellite family in the optical domain	16-daily	30m	8	≥1985
MODIS	Currently best global coverage satellite with daily revisit frequency	Daily	250m	NDVI	≥2002
AVHRR	Earliest global coverage satellite with daily revisit frequency	Daily	1km	NDVI	1982-2013

All input Sentinel-2 data – and all other EO data – were corrected for atmospheric effects (using the open Sen2Cor toolbox of ESA, v2.8) and cloud masked. Cloudy pixels were excluded from the calculations. For relatively coarse resolution land cover maps (scale 1:1.000.000) for the years 1985-2015, EO time series from MODIS and AVHRR satellites were used.

To depict the temporal evolution of land cover over the approx. 30 years at very high resolution (scale 1:10.000), suitable Landsat/Sentinel imagery from 1985-2015 were identified and downloaded. More than 10.000 scenes had to be downloaded and processed to cover the entire region of interest and time period. Care was taken to select imagery as close as possible to the chosen anchor years. Due to cloud coverage and sensor mal-functions, this was not always feasible. In particular, for 1985 time stamp, data from 1984-1989 had to be used. For the time stamp 2015, we used the most recently available data (mainly 2018 and 2019).

Ground truth information was available for ca. 4.600 polygons scattered over the Nile basin. The ground truth is important for the supervised classification of the EO data. The reference data was provided by the project team through expert interpretation of very high resolution (GE) imagery. 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. For the coarse resolution LC we also used existing Africover LC (FAO, 2019) and information provided by ESA in the form of CCI land cover (European Space Agency (ESA), 2019).

2.2 Data analysis

2.2.1 Creating databases

An Excel file accompanies the wetlands inventory. It consists of five sheets. In the first Excel sheet (68 wetlands), all 68 wetlands featured in the inventory are listed with some additional information concerning protection status and physical features of each respective wetland. Sheet two is the metadata sheet for the wetlands list (Table 3).

Table 3 Metadata of the '68 wetlands database'

Short name	Explanation
Nr	Wetland number, each wetland in the inventory has a unique number
Sbasin	Sub basin names: WN=White Nile; MN=Main Nile; LV=Lake Victoria; VN=Victoria Nile; LA=Lake Albert; BN=Blue Nile; BA=Bara Akobo Sobat; BJ=Bahr el Jebel; BG=Bahr el Ghazal; TA=Tekeze Atbara
Wetland	Name or names of the wetland. Sometimes the same wetland is known under different (local) names
WLGroup	Wetland Group names: ND=Nile Delta; DW=Dinder wetlands; LTW=Lake Tana wetlands; BASW=Baro Akobo Sobat wetlands; Sudd; BeG=Bahr el Ghazal wetlands; LKW=Lake Kyoga wetlands; SW=Semliki wetlands; LVW=Lake Victoria wetlands; KW=Kagera wetlands; MW=Mara wetlands; SNYN=Sio Nzoia Yala Nyando wetlands
Country	Country or countries. Order of countries based on the area of the wetland in the respective countries, country with largest area first.
River/Lake	Lake and or river the wetland is connected to
Lat	Latitude
Long	Longitude
Altitude	Elevation based on Google Earth Pro, meters above sea level (m.a.s.l)
Area	Area of the wetland in km^2
Nearest Town	Nearest town
Transboundary	Is it transboundary yes (1) or no (0)?
Ramsar	Is it a Ramsar site yes (1) or no (0)?
Ramsar year	Year the wetland was declared a Ramsar site
IBA	Is it an Important Bird Area yes (1) or no (0)?
IBA threat score	Threat (pressure) on the IBA according to http://datazone.birdlife.org/ Low, medium, high, very high, Not Assessed (N.A.)
IBA monitoring	Year of most recent IBA monitoring assessment

Short name	Explanation
IBA criteria	Year of most recent IBA criteria assessment (quantitative ornithological criteria assessment)
IBA name	Name of the Important Bird Area the respective wetland is part of
Forest Reserve	Name(s) of the Forest Reserve the respective wetland is part of
National Park	Name(s) of the National Park the respective wetland is part of
World heritage Site	Name of the World heritage Site the respective wetland is part of
Wildlife Sanctuary	Name(s) of the Wildlife Sanctuary the respective wetland is part of
Wildlife Reserve	Name(s) of the Wildlife Reserve the respective wetland is part of
UNESC-MAB Biosphere Reserve	Name(s) of the UNESC-MAB Biosphere Reserve the respective wetland is part of
Protected Landscape	Name(s) of the Protected Landscape the respective wetland is part of
National Sanctuary	Name(s) of the National Sanctuary the respective wetland is part of
National Reserve	Name(s) of the National Reserve the respective wetland is part of
Multiple Use Management Area	Name(s) of the Multiple Use Management Area the respective wetland is part of
Community Wildlife Area	Name(s) of the Community Wildlife Area the respective wetland is part of
Game Reserve	Name(s) of the Game Reserve the respective wetland is part of

Sheet number three is the literature database, which highlights the information sources assessed and indicates which kind of information each reference provides. Sheet number four is the metadata (Table 4) for the literature database. The fifth sheet provides a table which indicates how much information is available for each wetland.

Table 4 Metadata from the literature database

Short name	Explanation
Full Reference	Full reference APA style
Citation	In-text citation
Year	Year of publication
Type of Document	Ramsar Information Sheet (RIS), Report, Scientific Publication (Paper), Book, Book Chapter
Sbasin	Sub basin names: WN=White Nile; MN=Main Nile; LV=Lake Victoria; VN=Victoria Nile; LA=Lake Albert; BN=Blue Nile; BA=Bara Akobo Sobat; BJ=Bahr el Jebel; BG=Bahr el Ghazal; TA=Tekeze Atbara
WLGroup	Wetland Group names: ND=Nile Delta; DW=Dinder wetlands; LTW=Lake Tana wetlands; BASW=Baro Akobo Sobat wetlands; Sudd; BeG=Bahr el Ghazal wetlands; LKW=Lake Kyoga wetlands; SW=Semliki wetlands; LVW=Lake Victoria wetlands; KW=Kagera wetlands; MW=Mara wetlands; SNYN=Sio Nzoia Yala Nyando wetlands
Wetland	Name the wetland
Country	Country or countries. Order of countries based on the area of the wetland in the respective countries, country with largest area first.
Map	Map of the Wetland/Study area available
Climate	Climate type and other relevant climate information (e.g. temperature and rainfall patterns) described in the reference
Remote sensing	Reference includes remote sensing analysis
Physical Features	Physical features of the wetland/group/basin described in the reference
GeomorphSoil	Geomorphic setting and soil described in the reference
Hydrology	Everything related water quantity and water flows described in the reference
Water Quality	Water chemistry described in the reference
Biodiversity	Biodiversity described in the reference
Vegetation	Vegetation described in the reference
Birds	Birds described in the reference

Fish	Fish and fisheries described in the reference
Class	Information useful for classification of the wetland
PolicyFram	Policy framework, management information, conservation status, land tenure and administrative authority described in the reference
EcosystemServices	Ecosystem services described in the reference
Land Use	Local land use described in the reference
Drivers	Pressures, direct and indirect drivers of change described in the reference

2.2.2 Using remote sensing data

Whereas previous attempts to map the wetlands of the Nile basin were solely based on the use of NDVI from Landsat (acquired during the dry season), we chose here a top-down approach (from coarse to fine resolution) that moreover leverages the full spectral information of the various sensors. A list of the main differences between the current and former approach is given in Table 5.

Table 5 Comparison of current approach with methodology used in 2009 for wetland mapping.

2009	This study	Advantages
Only Landsat satellite data @30m used as data source	Using optical Sentinel-2 @10m (+ Microwave Sentinel-1 & Landsat-8)	Higher level of spatial detail
Imagery was mainly from 1984-1988 … Occassionally period was extended	Using imagery from 2017 (± 1 year)	Mapping of actual situation
„One shot“ data from dry season	Using multi-temporal data from dry & wet season combined	Identification and mapping of permanent & non-permanent wetlands
NDVI thresholding method	Machine learning using all ten spectral bands + microwave backscattering + NDVI	Better identification of land cover and wetland types; more thematic details
	Using multi-temporal acquisitions and not single shots	Better distinction and mapping of permanent & non-permanent wetlands
	Inclusion of information on plant functional types derived from MODIS time series	Improved wetland characterisation
Reduced set of Ramsar classes (only 3 land cover classes)	Distinction of additional classes (Wetland Units) next to open water, wetland & irrigated land	More thematic detail, such as papyrus, reeds, grasslands, ….
„Trends“ for selected sites (40 year gap)	Trend analysis based on NDVI time series covering entire Nile basin	Identification of recent (degradation) trends covering the entire Nile basin
No coarser resolution time series with daily resolution used	Full scale monitoring & change detection using imagery with daily revisit frequency	Better capturing of seasonal and inter-annual variations in wetland & vegetation dynamics

Land Cover Classification & Maps

To describe the land cover in a meaningful way, and to characterize the wetlands in their actual setting (2015) as well as regarding their former state (1985), the following nine land cover classes were distinguished in a standardized way across the Nile Basin and for the three epochs:

- Water
- Papyrus
- Wetland grasses
- Reeds
- Grass/Shrubland/Bush
- Forest
- Agriculture
- Desert/Bare soil
- Settlement

The maps for the three epochs were produced with a resolution of 10m and delivered in two formats:

- Geo-tiffs
- Shape files

To ease data handling and GIS processing, the maps covering the entire Nile Basin were split-up into smaller parts:

- 10 sub-basins (tif-files)
- 87 grid cells of 1 x 1° (tif-files and shape files)

Description of Wetland Classification 2015

For the most recent epoch (approx. 2015), data from the two European Sentinel-2 satellites were available and used for wetland mapping. The two identical satellites (2A and 2B) cover the entire Earth every 5 days at 10 m spatial resolution. Each image tile covers approx. 110 x 110 km^2. In total 415 Sentinel-2 tiles had to be processed to cover the entire Nile Basin.

For the two seasons, seasonal composites for the following two time frames had been generated and used:

- Dry season: August 1st, 2018 to Dec 1st, 2018
- Rainy season: January 1st, 2019 to June 30th, 2019

For each of the two seasons, all available Sentinel-2 data were downloaded and pre-processed (geometric and atmospheric correction). Cloud masks were derived and from the resulting temporal stack, median images (and percentiles) were calculated. The atmospheric correction, cloud masking and seasonal compositing are illustrated in Figures 3 to 5, respectively.

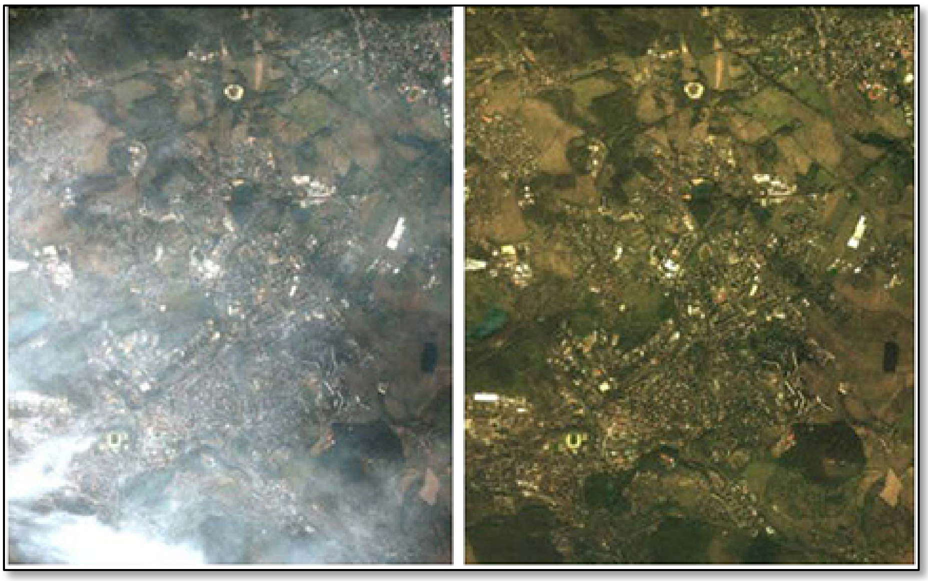

Figure 3 Illustration of the atmospheric correction using Sen2Cor algorithm. (Left) before atmospheric correction, (right) after successful atmospheric correction

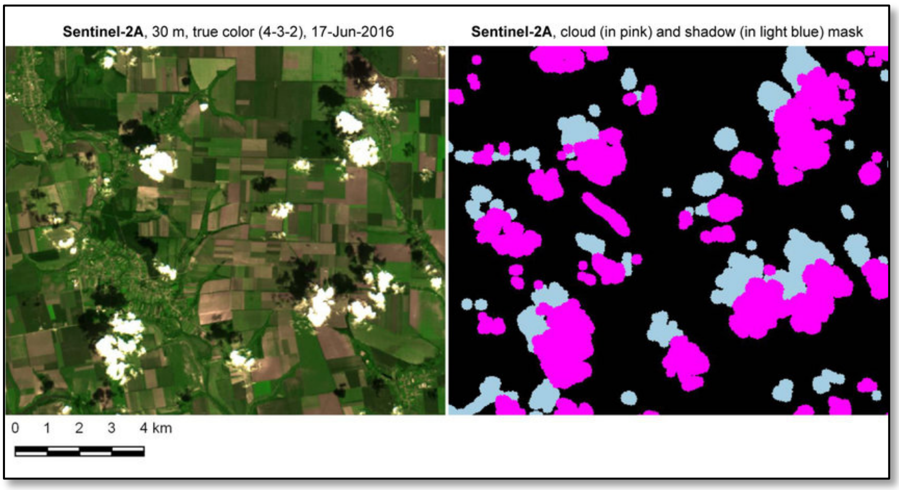

Figure 4 Illustration of the cloud detection using Sen2Cor algorithm. (Left) input image, (right) after successful identification of clouds and cloud shadows

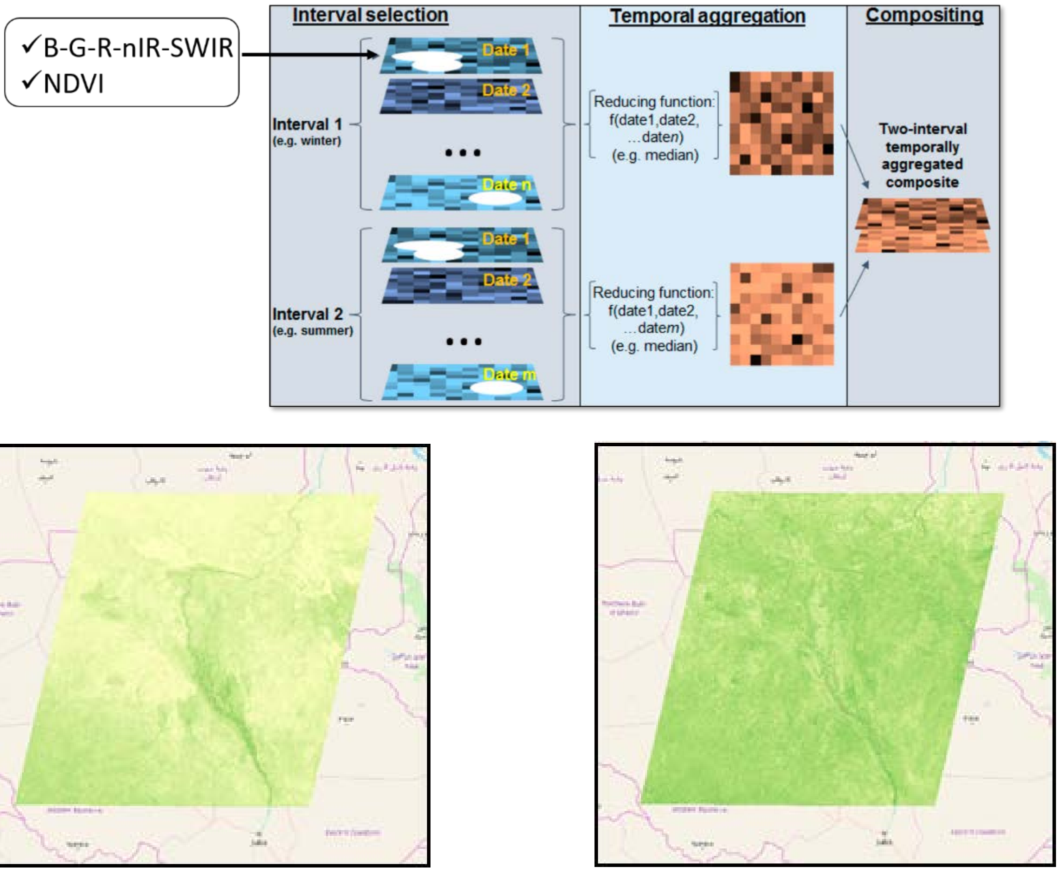

Figure 5 Illustration of the seasonal compositing approach. (Top) workflow, (bottom) Sudd wetland NDVI composites for dry (left) and wet season (right). Greener colour indicates higher biomass

Reference data were generated within the project via Google Earth (GE) image interpretation. The image interpretation was done by a skilled interpreter with long lasting experience in East Africa, and in particular the Sudd and Lake Victoria (G. Petersen). Some reference samples are illustrated in Figure 6.

The GE interpreter generated a vector layer with spatial points spread across the whole Nile Basin (majority in the Lake Victoria and Sudd regions), depicting the following land cover classes:

- Water (486 points)
- Papyrus (628 points)
- Wetland grasses (370 points)
- Reeds (293 points)
- Grass/Shrubland/Bush (375 points)
- Forest (305 points)
- Agriculture (562 points)
- Agriculture rain fed (610 points),
- Settlement (430 points)

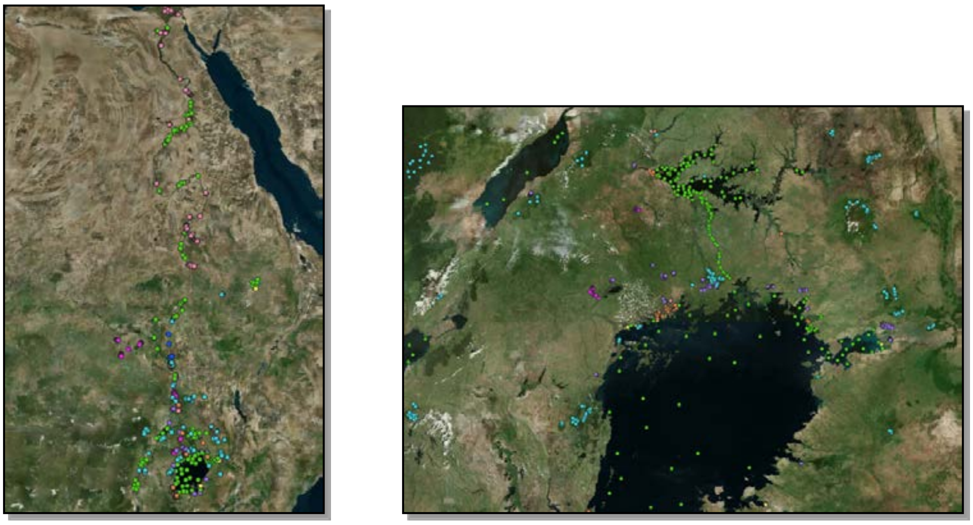

Figure 6 Example reference data within the Nile Basin. The different colours indicate the various reference classes. Reference samples were generated through visual interpretation of GE imagery

Based on the acquired EO data the class separability was investigated. As settlements were mostly small and difficult to distinguish, it was decided to depict the spatial location of settlements using Open Street maps. The classes (irrigated) agriculture and agriculture rain fed were merged as no separability was possible.

The main processing steps are outlined below. They consist of:

- Screening of possible EO data and land cover maps covering the study area (in regards to cloud situation, availability, …)
- Download and pre-processing of available EO data
- Geometric correction of EO images
- Atmospheric correction of EO images
- Generation of seasonal cloud-free composites
- Calculation of relevant vegetation index (NDVI) from the seasonal composites
- Segmentation of the Sentinel-2 scenes into small homogeneous objects
- Extraction of zonal statistics for each image object
- Preparation and cleaning of reference data, matching with created objects
- Coarse Nile Basin stratification
- RandomForest (RF) model calibration and fine-tuning per stratum
- Prediction of Sentinel-2 tiles and land cover mapping
- Map refinement, gap-filling and spatial harmonization
- Tiling of results (tifs) to a 1° x 1° grid cells
- Clipping of results (tifs) into ten sub-basins
- Conversion of 1 x 1° tiles to vector files
- Extraction of wetland-specific land cover statistics for all epochs, including change vectors
- Data upload to file server

Note that for each of the two seasons, cloud free composites have been created per Sentinel-2 tile (Figure 3). This was done for the bands 2 (blue), 3 (green), 4 (red), 6 (red edge) and 8 (nIR) by computing the median value across the stack of images for each pixel while taking into account just the cloud free observations. Cloudy pixels were previously identified using the Sen2Cor program provided by ESA (Figure 4).

For each Sentinel-2 tile, an image segmentation has been carried out by the MeanShift algorithm as implemented in Orfeo ToolBox 6.6.1 (Figure 7). As input data for the segmentation a stack was created using Sentinel-2 cloud free composites for the dry season – the wet season was not used, as cloudiness created sometimes artefacts. In the course of the segmentation a series of zonal statistics for each obtained object were calculated: mean, standard deviation, variance and several percentiles. These are the features used for the supervised RF classification (Figure 8).

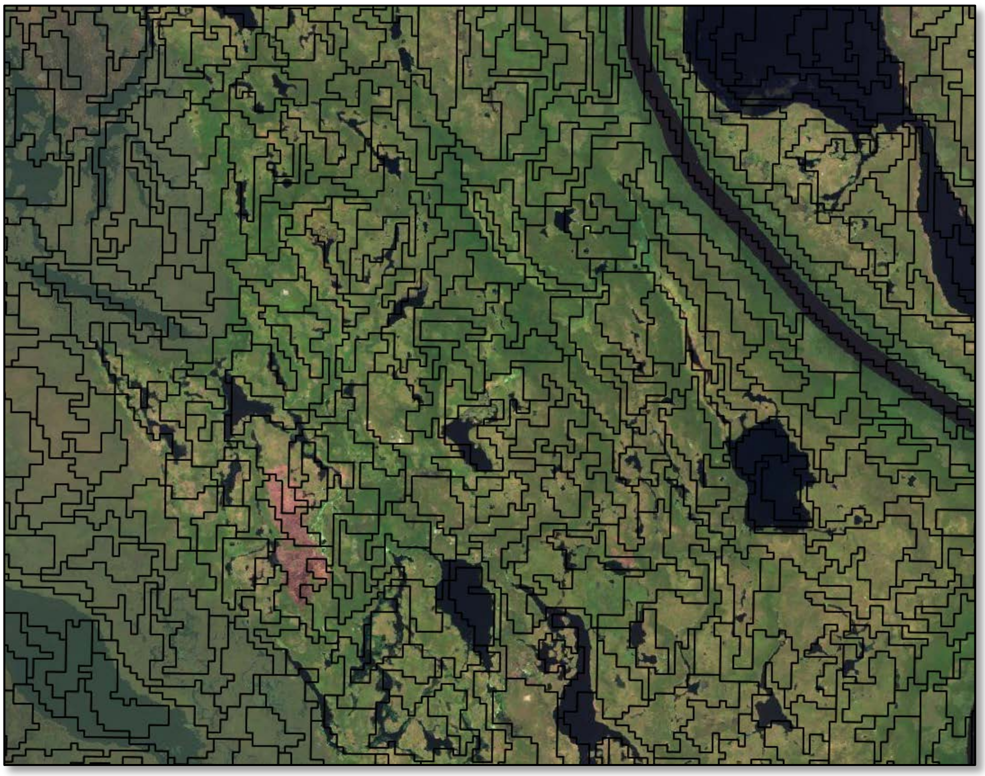

Figure 7 . Example segmentation result data. The black lines indicate the automatically derived object boundaries. The underlying image is an RGB composite

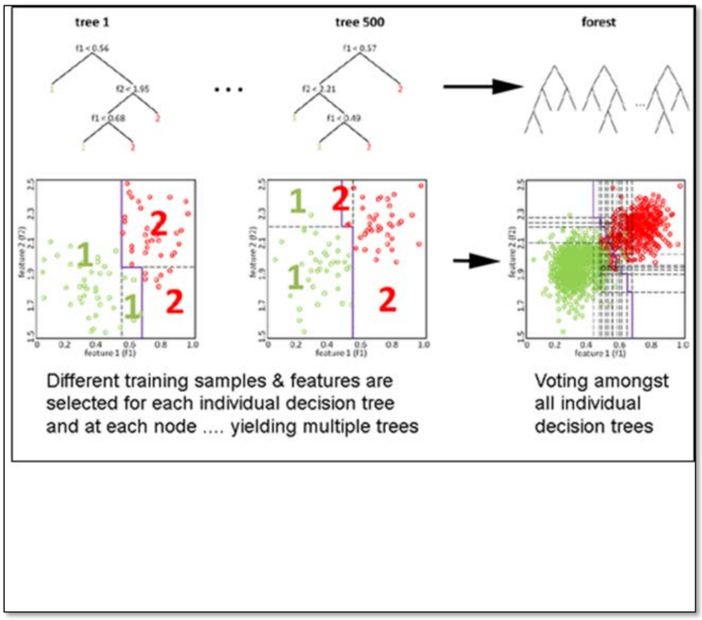

Figure 8 Illustration of the functioning of the ensemble RandomForest (RF) classifier. In the example, 500 individual decision trees are generated. The final vote selects the class winning most of the individual votes

To permit data handling, the Nile Basin was divided in suitable strata - for each stratum, a separate model was developed and processed

- Southern part - Lake Victoria region - 4S - 4N latitude
- Central part - South Sudan - 5N-10N latitude
- Northern part - 10N - 32N latitude

This was done because the climate and geographical conditions are very different across the research area, between the Northern part, with extremely dry desert climate and the southern area with sub-tropical to tropical climate.

Training of random forest (RF) classification models were done separately for each strata using the features derived from the two seasonal composites. To classify the entire research area, three models have been created according to the above defined geographical strata.

The predictions were done by applying the trained models to the entirety of objects for each S2-tiles. As a result of this step, we got raster layers with class labels per pixel. These were exported as shape files for grid cells of 1 x 1° (Figure 9). Classifications have been executed by using the scikit-learn module in python with default settings and 500 estimators.

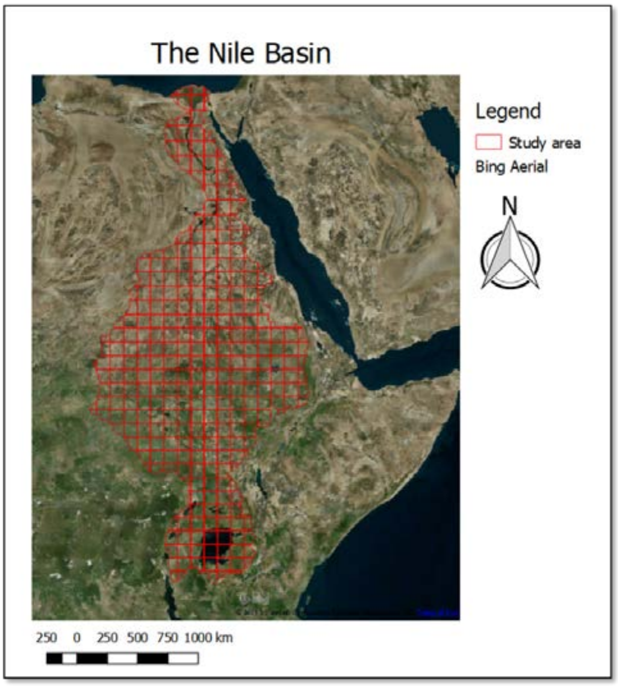

Figure 9 Tile of the Nile Basin into 1 x 1° grid cells for data export and sharing

An overview of the mapping results for 2015 is given in Figure 10.

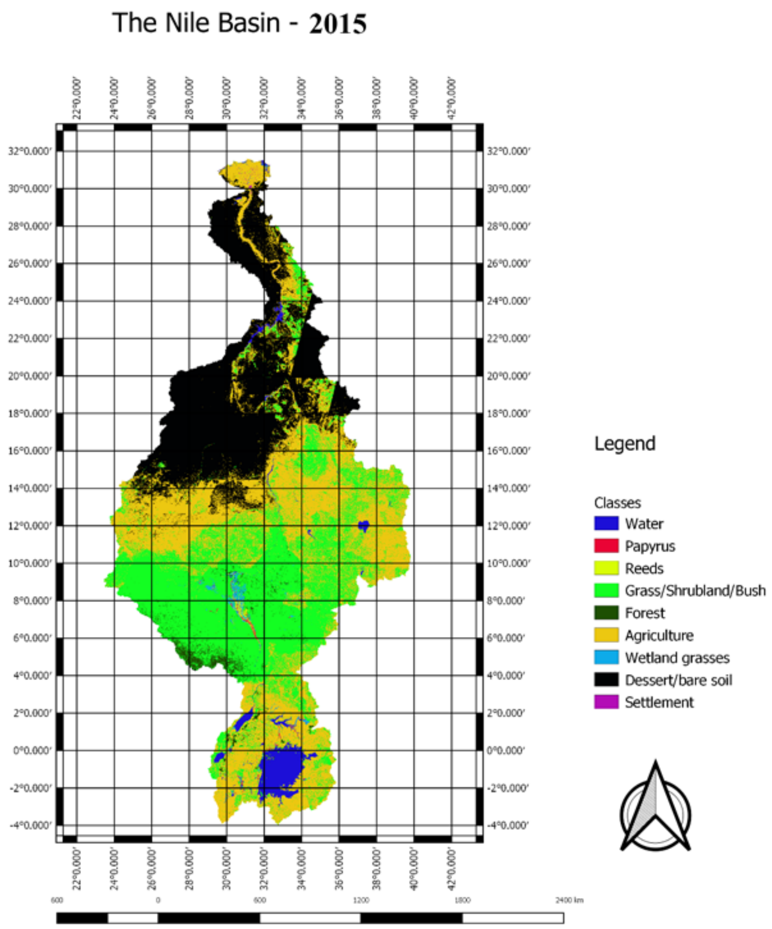

Figure 10 Nile Basin mapping results 2015

A more detailed view on the Sudd wetlands (2015) is provided in Figure 11. In Figure 12 some randomly selected zoom-ins are shown.

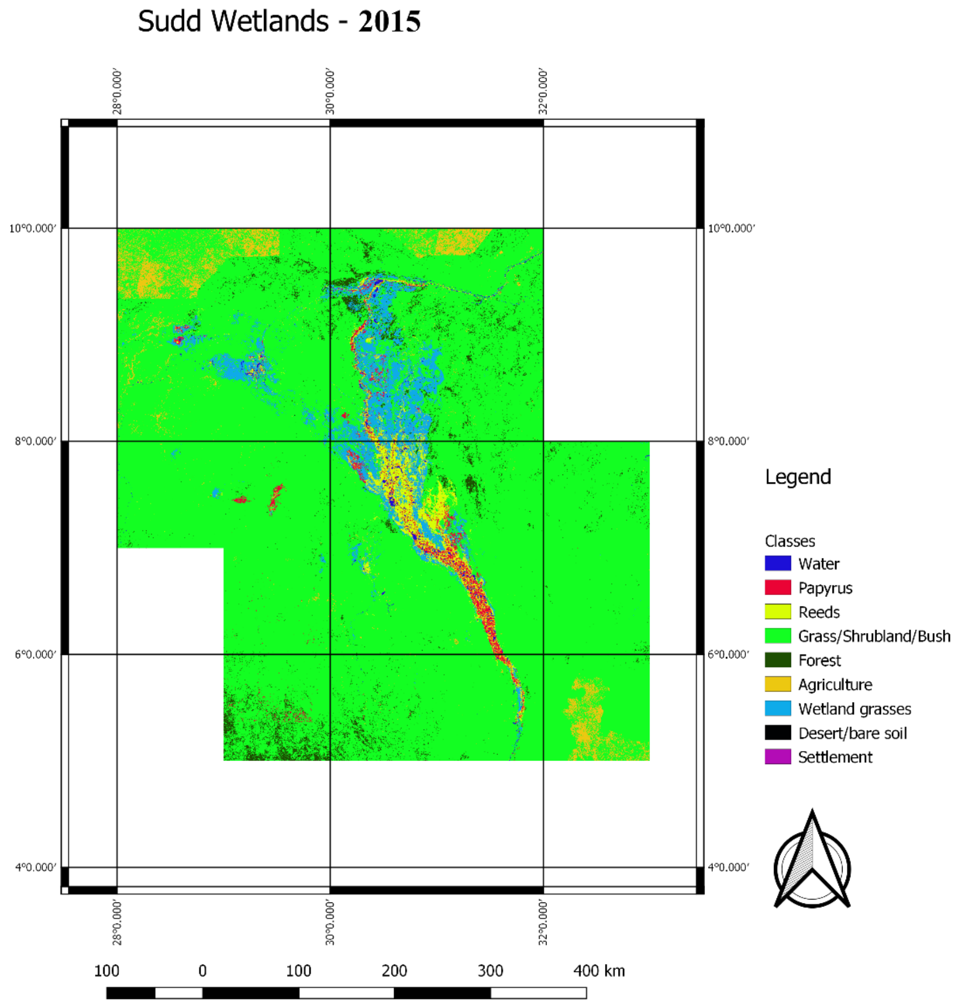

Figure 11 Sudd wetland mapping results 2015

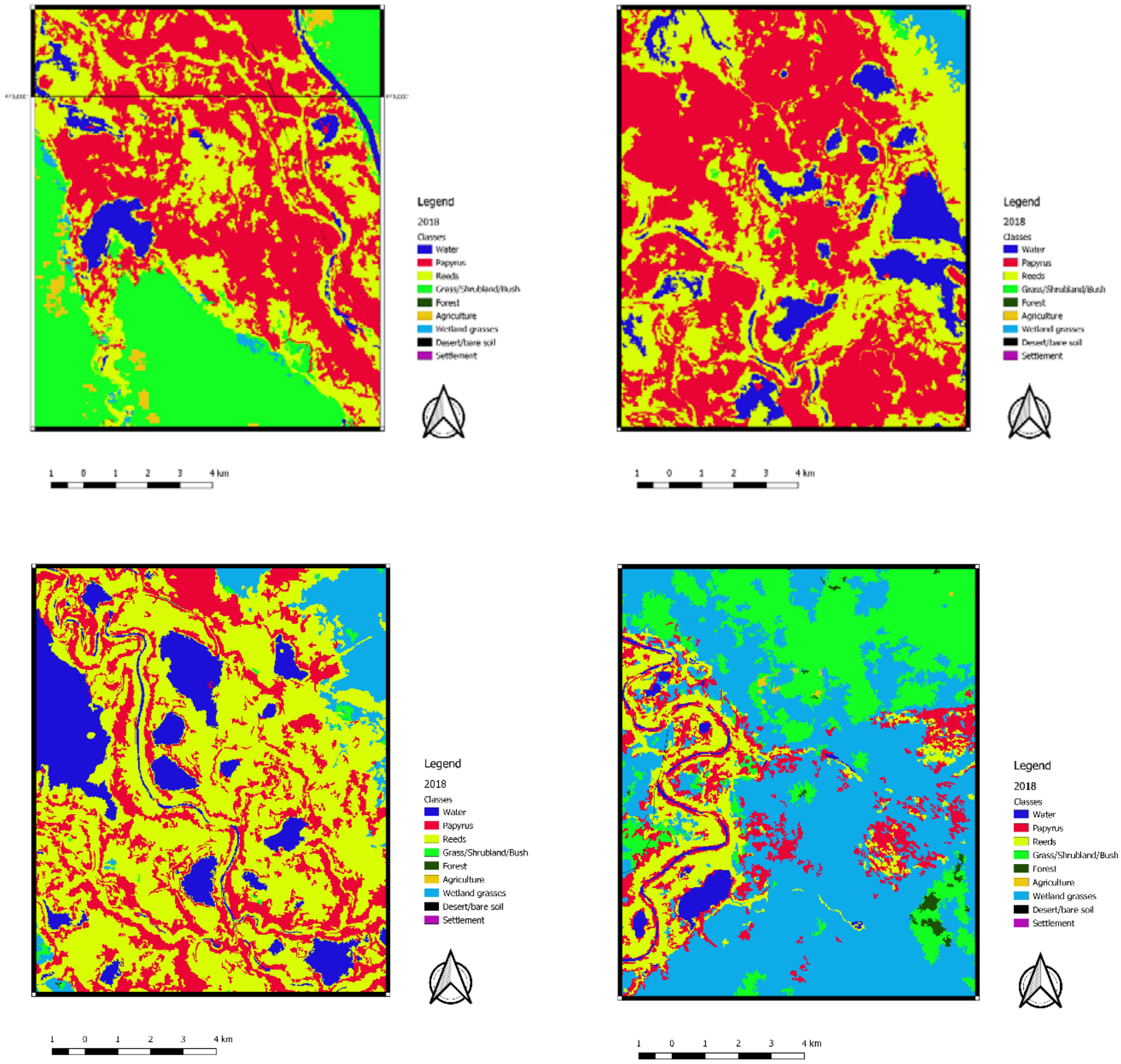

Figure 12 Sudd Wetlands mapping results 2015 with zoom-ins

Description of Wetland Classification 1985

For the first epoch (approx. 1985), EO data from Landsat-5 satellite was used. The general approach was similar to the above description for 2015 data processing, with a few particularities which are described below.

- Time series of Landsat-5 images in:
    - 30 m spatial resolution (instead of 10m for Sentinel-2)
    - 16 days temporal resolution (instead of 5 days for Sentinel-2)

It has to be noted that not all the Landsat images have been archived by USGS. We quite often noticed gaps in the time-series. Sometimes, Landsat tiles were completely missing.

With respect to the seasonal compositing, the same could only be produced for the dry season. For the rainy season, data was too sparse to create meaningful composites. Hence, for the rainy season, the produced seasonal composites were discarded and not used in the classification. The time frame for the seasonal compositing was identical to the one used for Sentinel-2.

The reference data was again created within the project using various Google products and Landsat RGB images for image interpretation. The classes were kept identical to those described for 2015. However, visual interpretation was seriously hindered by lower image quality compared to 2015.

A detailed list of processing steps follows:

- Screening of possible input data and land cover maps covering the study area (in regards to cloud situation, availability, …)
- Download and pre-processing of available input data
- Geometric correction of input images
- Atmospheric correction of input images
- Generation of cloud-free composites
    - For each of the seasons, cloud free composites have been created per Landsat-5 tile for the bands 1 (blue), 2 (green), 3 (red), 4 (nIR), 5 (SWIR), 7 (SWIR) and NDVI. The composites were created by computing the median value across the stack of images for each pixel while taking just the cloud free observations into account. As described above, only the results for the dry season were usable. The wet season composites were therefore discarded.
- Segmentation
    - For each Landsat tile, an image segmentation has been carried out by the MeanShift algorithm as implemented in Orfeo ToolBox 6.6.1. As input data for the segmentation a stack was created using Landsat 5 cloud free composites for the dry season. Wet layer was not usable
    - In the course of the segmentation a series of zonal statistics for each obtained object has been calculated: mean, standard deviation, variance and percentiles.
    - Training of random forest (RF) classification models separately for each stratum. The random forest model and prediction has been carried out in two steps:
        - First, modelling and prediction have been done for 4 more general land cover classes:
            - Grass & Wetland
            - Woodland/Forest
            - Agriculture
            - Water
        - Second, another classification has been done just for the class Grass & Wetland from the first step. This classification looked for papyrus, reeds and wetland grasses within the grass and wetland areas.
- Classifications have been executed by using the scikit-learn module in python with default settings and 500 estimators.
- Model fine-tuning, improvements in reference data, and model validation
- Prediction of Landsat tiles using the random forest model

- Map refinement, gap-filling and spatial harmonization
- Tiling of results to a 1° x 1° grid cells
- Separation of 1 x 1° grid cells in ten sub-basins
- Conversion of results to vector files
- Extraction of wetland-specific land cover statistics
- Resampling of predictions to a 1° x 1° grid
    - The grid is the same as the one used for Sentinel-2 images
    - Predictions are resampled to 10 m to match the Sentinel-2 predictions

For the epoch 1985, Figure 13 shows the mapping results for the entire Nile Basin, and Figure 14 for the Sudd Wetlands.

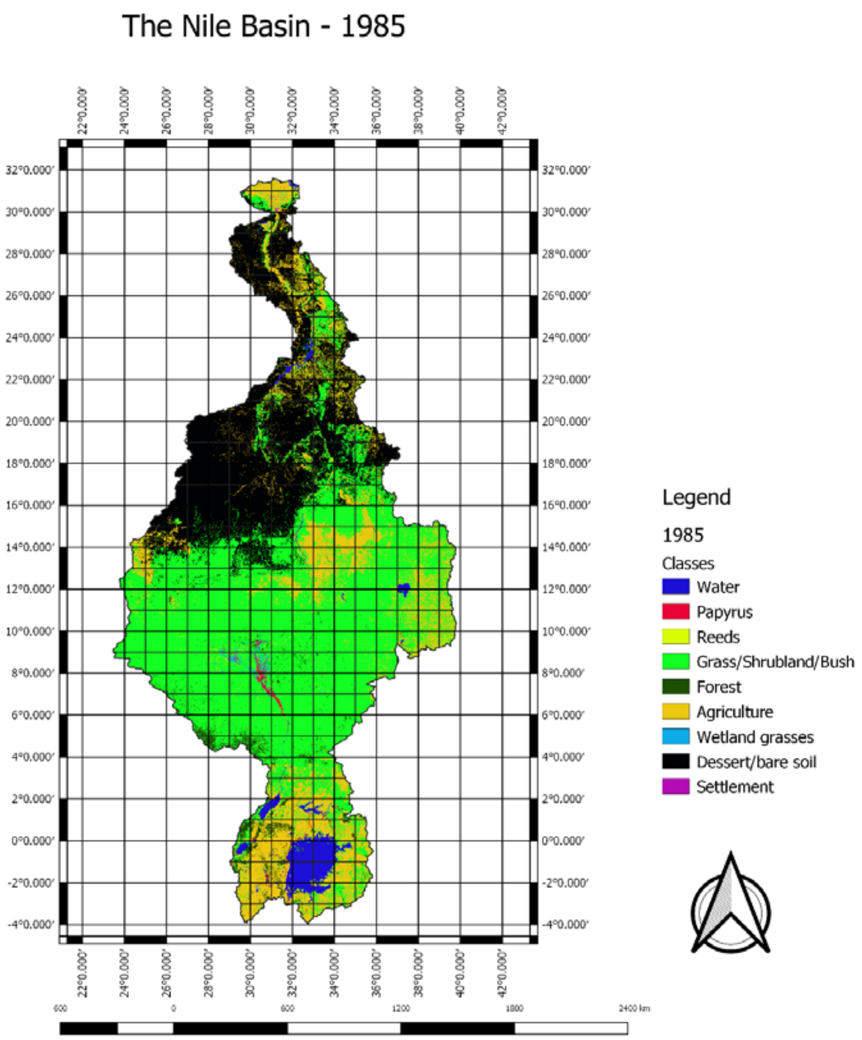

Figure 13 Nile Basin mapping results 1985

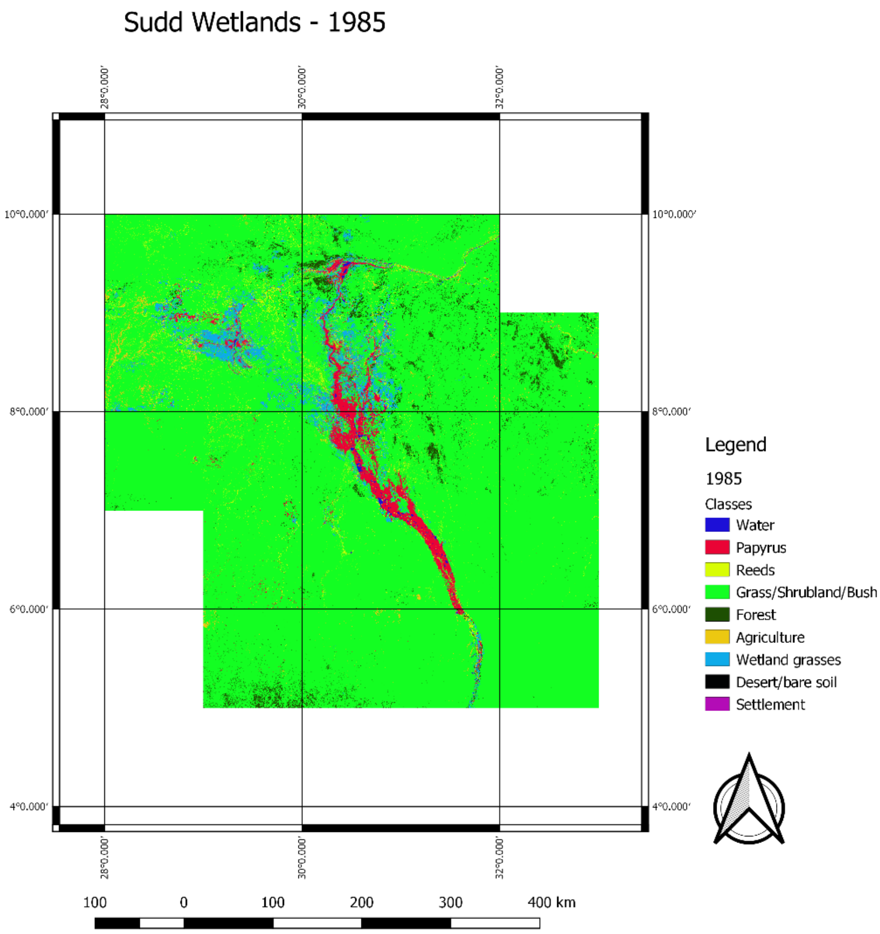

Figure 14 Sudd wetland mapping results 1985

The maps generated for the two epochs (1985 and 2015) permit to analyse changes in the wetland land cover. An example is provided in Figure 15, showing Lake Victoria for 1985 and 2015. In this figure we also provide zoom-ins highlighting the high level of spatial detail that was achieved.

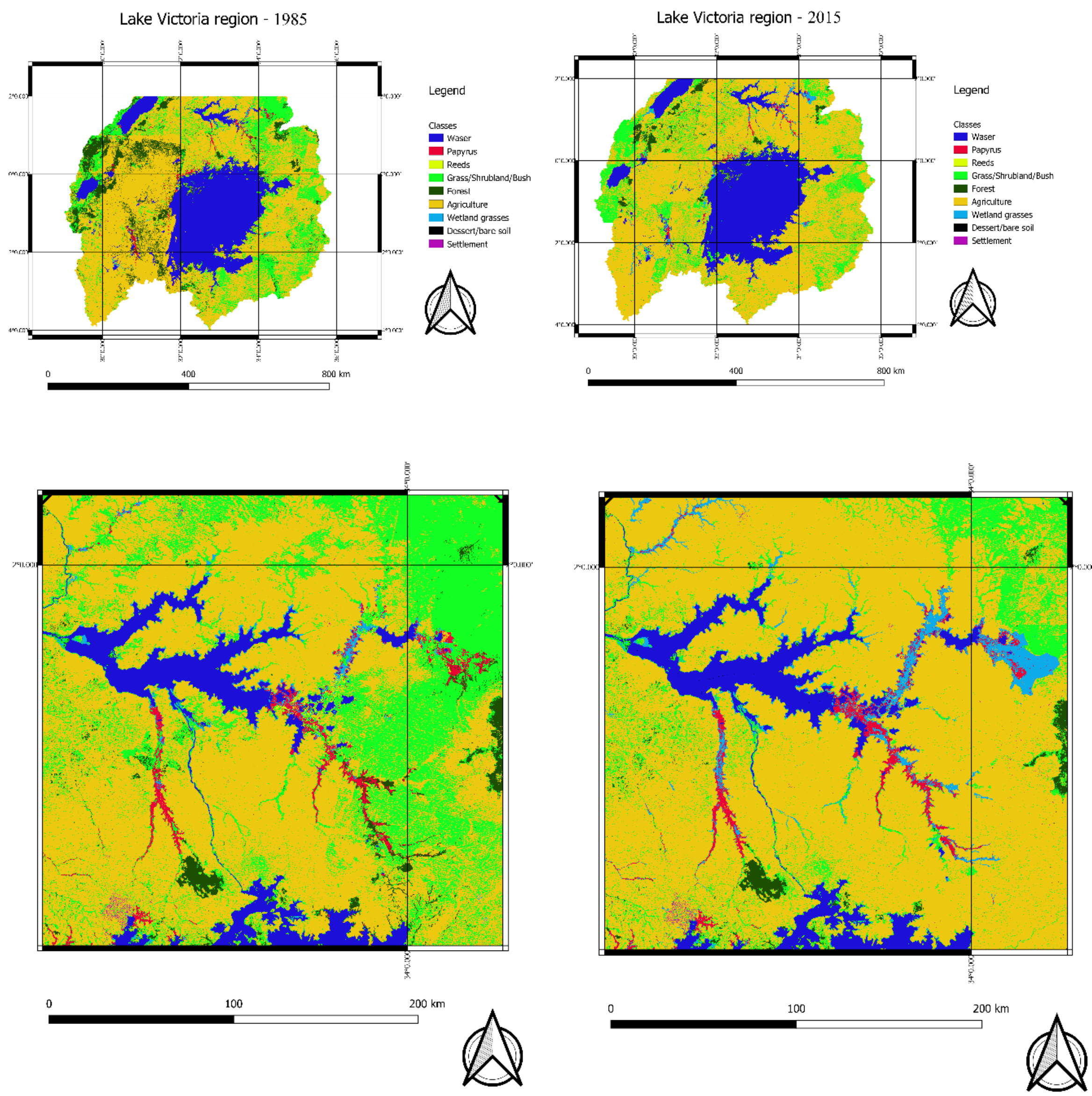

Figure 15 Mapping results for Lake Victoria and epochs 1985 (left) and 2015 (right). (top) overview Lake Victoria. (bottom) zoom-ins

3 Results

3.1 Wetland Inventory

The following section is the main part of the inventory of all 68 Nile Basin wetlands of transboundary significance (Table 6). All wetlands are described as illustrated in the methodology section. In total there are 20 Ramsar sites in the Nile Basin, 12 wetlands that cross borders and 42 wetlands are part of an Important Bird Area.

Table 6: List of wetlands described in the Nile Basin inventory. Sbasin = sub basin, WL = Wetland

Nr	Sbasin	Name	WL Group	Country	River/Lake
1	LV	Nyando	SNYN WL	Kenya	Nyando River
2	LV	Yala Swamp	SNYN WL	Kenya	Yala River
3	LV	Nzoia River	SNYN WL	Kenya	Nzoia River
4	LV	Sio Siteko	SNYN WL	Kenya, Uganda	Sio/ Siteko
5	LV	Mara Wetland	Mara WL	Tanzania, Kenya	Lake Victoria
6	LV	Ruvubu National Park	Kagera WL	Burundi	Ruvubu River
7	LV	Ruvyironza River	Kagera WL	Burundi	Lake Victoria
8	LV	Paysage Aquatique Protégé du Nord	Kagera WL	Burundi	Akanyaru
9	LV	Lake Cohoha South	Kagera WL	Burundi, Rwanda	Akanyaru
10	LV	Lake Rwihinda	Kagera WL	Burundi	Nyabarongo/ Kagera River
11	LV	Lake Kanzigiri	Kagera WL	Burundi	Lake Rweru
12	LV	Lake Rweru	Kagera WL	Burundi, Rwanda	Akanyaru River
13	LV	Akanyaru Swamps	Kagera WL	Burundi	Akanyaru
14	LV	Akanyaru River Swamps	Kagera WL	Burundi, Rwanda	Akanyaru
15	LV	Lake Cohoha North	Kagera WL	Rwanda	Akanyaru
16	LV	Rugezi Marsh	Kagera WL	Rwanda	Rwangabavu
17	LV	Lake Burera	Kagera WL	Rwanda	Lake Ruhondo
18	LV	Lake Ruhondo	Kagera WL	Rwanda	Mukungwa
19	LV	Kamiranzovu Swamp	Kagera WL	Rwanda	Lukarara /Kamiranzovu
20	LV	Lake Muhazi	Kagera WL	Rwanda	Nyabarongo
21	LV	Nyabarongo Wetlands	Kagera WL	Rwanda, Burundi, Tanzania	Nyabarongo
22	LV	Lake Mugesera	Kagera WL	Rwanda	Nyabarongo
23	LV	Kagera Swamps	Kagera WL	Rwanda, Tanzania	Kagera River
24	LV	Lake Mburo Nakivali System	Kagera WL	Uganda	Ruizi River, Kibali River
25	LV	Sango Bay-Musambwa Islands -Kagera Wetland System	Kagera WL	Uganda, Tanzania	Katonga, Bukola, Lake Victoria
26	LV	Lake Wamala	LV Shoreline WL	Uganda	Akanyaru
27	LV	Nabajjuzi Wetland	LV Shoreline WL	Uganda	Nabajjuzi

Nr	Sbasin	Name	WL Group	Country	River/Lake
28	LV	Lake Nabugabo	LV Shoreline WL	Uganda	Lake Victoria
29	LV	Mabamba Bay	LV Shoreline WL	Uganda	Lake Victoria
30	LV	Lutembe Bay	LV Shoreline WL	Uganda	Lake Victoria
31	LV	Winam Gulf	LV Shoreline WL	Kenya	Lake Victoria
32	VN	Lake Bisina	LV Shoreline WL	Uganda	Lake Kyoga
33	VN	Lake Opeta	LV Shoreline WL	Uganda	Lake Kyoga
34	VN	Kyoga Kwania Swamp Complex	Lake Kyoga	Uganda	Lake Kyoga, Victoria Nile
35	LA	Rwenzori Mountains Ramsar Site	Semliki WL	Uganda, DRC	George, Edward, Albert, Semliki
36	LA	Lake George	Semliki WL	Uganda	Lake Edward
37	LA	Lake Edward	Semliki WL	Uganda, DRC	Semliki
38	LA	Semliki Valley Wetlands	Semliki WL	Uganda	Semliki
39	LA	Murchison Falls Lake Albert Delta	Semliki WL	Uganda, DRC	Semliki River, VN, AN
40	LA	Lake Bunyonyi	Semliki WL	Uganda	Ishasha, Semliki
41	BJ	The Sudd	The Sudd	South Sudan	Bahr el Jebel
42	BJ	Lake Yirol	Lakes in BJ	South Sudan	Yei River
43	BJ	Lake Anyi	Lakes in BJ	South Sudan	Yei River
44	BJ	Lake Nyiropo	Lakes in BJ	South Sudan	Lau River
45	BG	Bahr el Ghazal Floodplain	Bahr el Ghazal	South Sudan	B. el Ghazal
46	BG	Lake Ambadi	Bahr el Ghazal	South Sudan	B. el Ghazal
47	BA	Badigeru Swamp	Baro Akobo Sobat	South Sudan	Kinyeti River
48	BA	Kenamuke/ Kobowen Swamp	Baro Akobo Sobat	South Sudan	Kangen River, Sobat River
49	BA	Lotilla River Swamps	Baro Akobo Sobat	South Sudan	Lotilla River
50	BA	Veveno/Adiet/Lilebook Swamps	Baro Akobo Sobat	South Sudan	Lotilla River
51	BA	Baro-Akobo-Sobat Wetlands	Baro Akobo Sobat	Ethiopia	Alwero
52	BA	Machar Marshes	Baro Akobo Sobat	South Sudan	Sobat River
53	WN	White Nile Floodplain		South Sudan, Sudan	White Nile
54	WN	Gebel Auliya		Sudan	White Nile
55	BN	Dinder Floodplain	Dinder	Sudan	Dinder River
56	BN	Lake Tana	Lake Tana	Ethiopia	Lake Tana
57	BN	Fincha-Chomen		Ethiopia	Blue Nile
58	BN	El Roseires		Sudan	Blue Nile
59	BN	Sennar		Sudan	Blue Nile

Nr	Sbasin	Name	WL Group	Country	River/Lake
60	TA	Khashm el Girba		Sudan	Atbara River
61	MN	Lake Nubia/Nasser	Lower Nile Valley	Sudan, Egypt	Nile
62	MN	Wadi El Rayan Protected Area	Lower Nile Valley	Egypt	Nile
63	MN	Lake Qarun	Lower Nile Valley	Egypt	Nile
64	MN	The Nile Delta	Nile Delta WL	Egypt	Nile Delta
65	MN	Lake Maryut	Nile Delta WL	Egypt	Nile Delta
66	MN	Lake Idku	Nile Delta WL	Egypt	Nile Delta
67	MN	Lake Burullus	Nile Delta WL	Egypt	Nile Delta
68	MN	Lake Manzala	Nile Delta WL	Egypt	Nile Delta

3.1.1 Lake Victoria

Overview

The Lake Victoria basin has a total area of 194,000 km^2 and forms the drainage basin of the world's second largest freshwater lake. The surface area of Lake Victoria is 68,800 km^2. A total of 44 % (85,000 km^2) of the basin's drainage area are 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. As the largest tributary to Lake Victoria, the rukarara spring, which is the starting point of Kagera River is considered to be the source of the Nile. The outlet of Lake Victoria is located near 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 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 3 m. Generally it follows a downward trend since 1964 with the lowest water levels in October 2005. Low water levels between 2004 and 2007 can be attributed to a combination of low rainfall and increased water outflow caused by excess water release at the Nalubaale dam for electricity production. Since then lake water levels have increased again (Vanderkelen et al., 2018). A drop in the lake water level exacerbates lake transportation problems, may expose drinking water supply intakes, affects fishing and reduces potential energy production in form of hydropower. During low water level situations littoral fish breeding grounds in wetlands around the shoreline of Lake Victoria are decoupled 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 can be found 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 km^2, 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 Lake Victoria Environmental Management Project (LVEMP) for example is an East African Community (EAC) project coordinated by the Lake Victoria Basin Commission (LVBC). Other transboundary umbrella programs 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 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 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). The ecosystem services identified for the Lake Victoria sub-basin are further presented in WP 3: Ecosystem Service Assessment.

Land Cover

Table 7 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	68149	68184	0.1
Papyrus	1657	1183	-28.6
Wetland grasses	591	2011	240.2
Reeds	123	67	-45.3
Total area*	264040	264040	0.00

* Total area based on all 9 land cover classes

LV. Sio Nzoia Yala Nyando Wetlands

Overview

The rivers Sio, Nzoia, Yala and Nyando originate in the highlands of Kenya and contribute approximately 23 % of surface water inflow to Lake Victoria (LVBC and GRID-Arenda, 2017). In each of the river basis 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 therefore the flooding patterns of these four main rivers and their tributaries are similar (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, as they (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 (Schuijt, 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 believes 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). The ecosystem services identified for the SNYN wetlands are further presented in WP 3: Ecosystem Service Assessment.

1. 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 km^2
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 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 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 eastern 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 Ombeyi 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 form 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 form 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 m^3/s to 30 m^3/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 $*10^6$ m^3 are retained, during the dry season 6.3 $*10^6$ m^3 (Mule et al., 2015).

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 Nyando wetland. There are two surface water exchange scenarios Nyando wetland depending on the season: (i) the floodwaters link the river-wetland 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).

Classification

Inland Wetland

L Permanent inland delta
M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
P Seasonal/intermittent freshwater lakes
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.
U Non-forested peatlands

Human-made wetlands

3 Irrigated land

Management Status

The Wetland is located in Kisumu County and belongs to Kenya's Rift Valley and Nyanza Provinces. The total wetland covers three administrative districts, Nyando, Nyakach and Kisumu East. The Nyando river channel forms the administrative boundary between the districts Nyakach, Nyando and Kisumu East. The Nyando wetland covers eight administrative locations (Kawino South, Bwanda, Kakola, Kochogo, North Nyakach, Nyalunya, Pap Onditi and Kombura locations in Kisumu County of Nyanza region in western Kenya).

Land Use and Land Cover

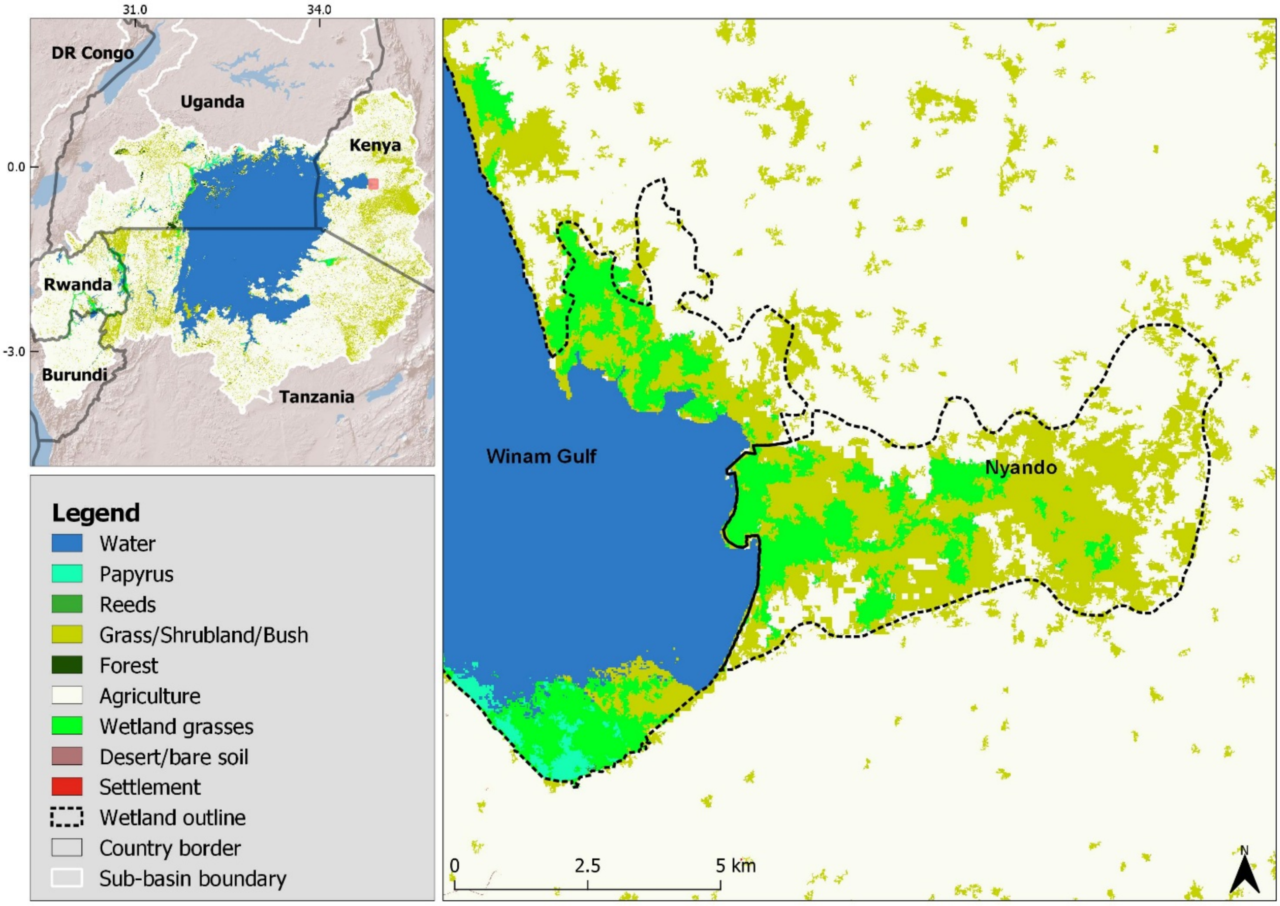

Figure 16 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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 hydropower generation. Okotto-Okotto et al. (2018) showed, that the wetland extend 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 adjacent floodplain is decoupled from the river most of the time. In addition wildlife movement and land use activities such as the construction of irrigation cannels 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 LV drops, the shoreline shifts away from its original boundaries making littoral zones and wetland areas available for agriculture. Seasonal changes 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.

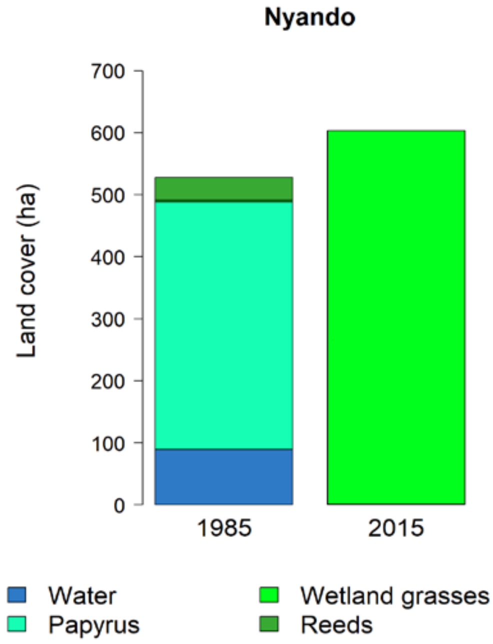

Figure 17 Land cover in 1985 and 2015

Table 8 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	90	1	-99
Papyrus	398	0	-100
Wetland grasses	3	602	19967
Reeds	37	0	-100
Total area*	3360	3361	0

* Total area based on all 9 land cover classes

2. 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 Kanayaboli 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 km^2. It has a catchment area of 175 km^2 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 km^2 and about 5 m deep at its centre. It is part of southern outlet of 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 km^2. 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 cuspidate* 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 near-threatened 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-and-white 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 Kayaboli 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 Kanyaboli and Namboyo (Angienda et al., 2011).

Classification

<u>Inland Wetland</u>

L Permanent inland delta

M Permanent rivers/streams/creeks

N Seasonal/intermittent/irregular rivers/streams/creeks

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.

<u>Human-made Wetlands</u>

3 Irrigated land

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 km^2 of the swamp was leased to Dominion Farms (K) Ltd.

Table 9 Protected area related to the wetland

Name	Type	Designation Year
Lake Kanyaboli	National Reserve	2010

Land Use and Land Cover

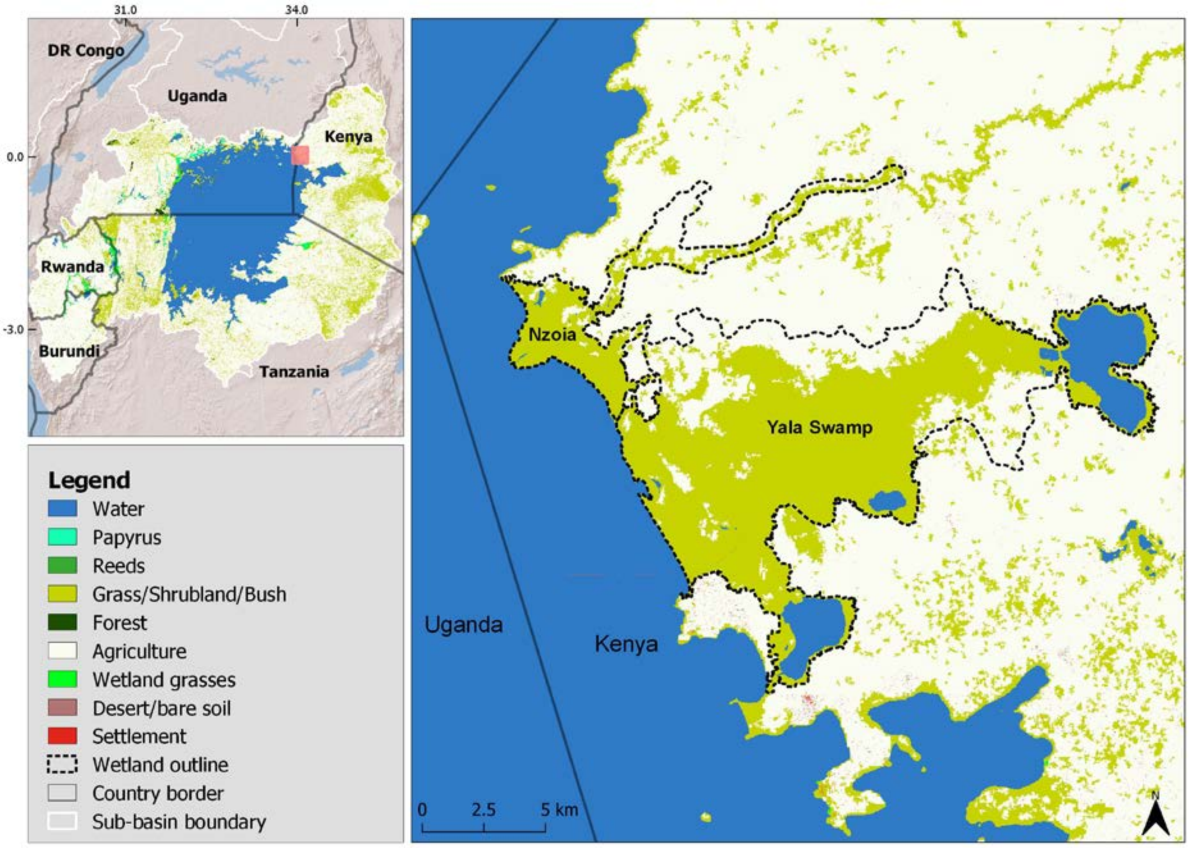

Figure 18 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

<u>Change Trajectories 1985-2015</u>

The Yala swamp was largely intact and used to cover a total of 17,500 ha until the 1960s (Thenya & Ngecu, 2017). In the late 1960s 2300 ha of wetland have been reclaimed for agriculture by the Ministry of Agriculture (MOA). By 1973 the destruction of the swamp had become more noticeable, particularly in the north and south-west (next to Lake Kanyaboli). This destruction included some extensive burn scars, particularly in the southeast of the Swamp (NBI, 2009).

In the African Wetland atlas published in 1992 it is estimated that at least 14 000 ha of the Yala Swamp could be made 'productive'. Thenya and Ngecu (2017) conducted a land-use change analysis for the period between 1973 and 2001 which showed that the farming area increased from 1,564 ha in 1973 to 5,939 ha in 2001, correspondingly the sedges-papyrus vegetation community decreased from 7,180 to 5,000 ha. Sedges-latifolia and tee sesbania bushes also decrease over the same period but the bushes-phoenix community that often appears as coloniser both in the disturbed areas or the less flooded eco-types, show an increase. Similarly, the open water area also decreased due to siltation and vegetation encroachment. These land cover changes have occurred mainly along the edge of the swamp and mainly along River Nzoia. The major changes have been occurring in the north-western region of the swamp in the administrative locations Bunyala North, Bunyala East, Bunyala West, Khajula, and Bunyala south. Some 10,000 ha were leased out for reclamation to a private company in 2002.

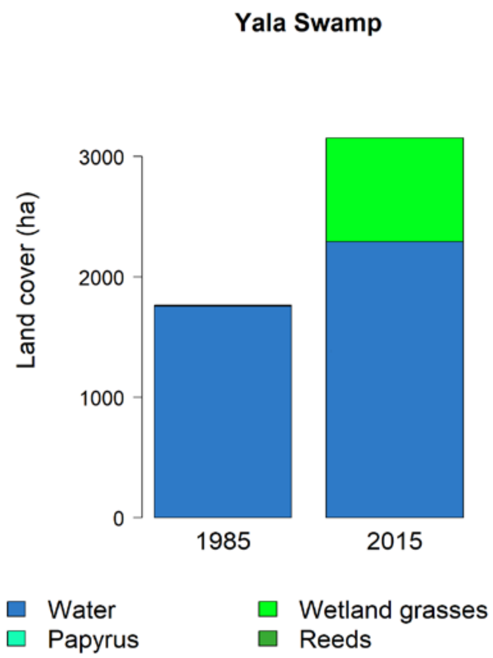

Figure 19 Land cover in 1985 and 2015

Table 10 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1756	2293	30.6
Papyrus	0	0	0.0
Wetland grasses	9	859	9444.4
Reeds	0	0	0.0
Total area*	71279	71279	0.0

* Total area based on all 9 land cover classes

3. Nzoia River

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

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 km^2 (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).

Classification

Inland Wetland

- L Permanent inland delta
- M Permanent rivers/streams/creeks
- N Seasonal/intermittent/irregular rivers/streams/creeks
- O Permanent freshwater lakes
- Tp Permanent freshwater marshes/pools
- Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.

Human-made wetlands

- 3 Irrigated land

Land Use and Land Cover

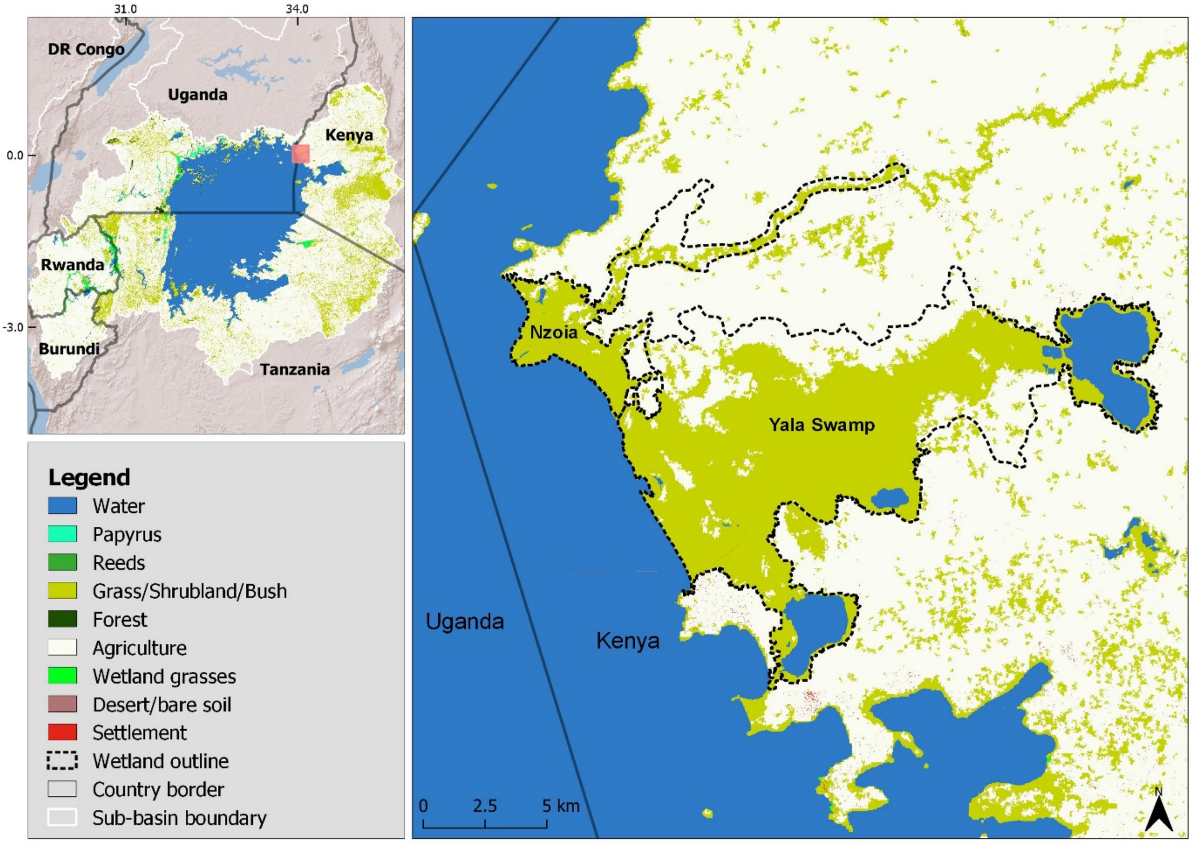

Figure 20 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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 sugarcane farming has increased from 84 km^2 in 1986 to 189.5 km^2 in 2005. There was a reduction in riverine vegetation from 3.6 km^2 in 1995 to 1.4 km^2 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).

Change Trajectories 1985-2015

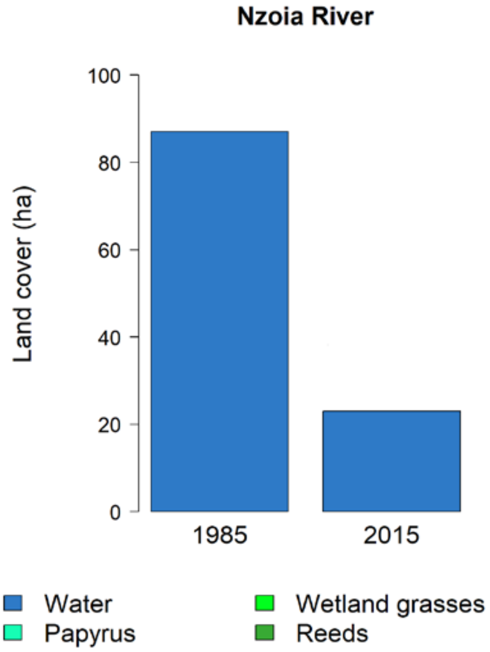

Figure 21 Land cover in 1985 and 2015

Table 11 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	87	23	-74
Papyrus	0	0	0
Wetland grasses	0	0	0
Reeds	0	0	0
Total area*	2627	2627	0

* Total area based on all 9 land cover classes

4. 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.
Area: 30 km²
Nearest Towns: Busia, Kisumu
International Importance: Important Bird Area, Transboundary Wetland

Overview

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 at Mt. Elgon, flows along the Kenya-Uganda border and after 85 km discharges into Lake Victoria. The Malaba River flows westwards into Lake Kyoga. The Sio basin area is 1,334 km^2 with its highest elevation at the summit of Mt. Elgon (4,320 m) and lowest 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 predominate vegetation found in the Sio wetland is *Cyperus papyrus* 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* (white-winged 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).

Classification

Inland Wetland

L Permanent inland delta
M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.

Human-made wetlands

3 Irrigated land

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 Management Authority (WRMA). The Sio-Malaba-Malakisi River Basin is shared by the Bududa, Bugiri, Busia, Butaleja, Manafwa, Namutumba, Pallisa, and Tororo districts in Uganda, and Bungoma, Busia, Mt. Elgon, and Teso districts 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.

Land Use and Land Cover

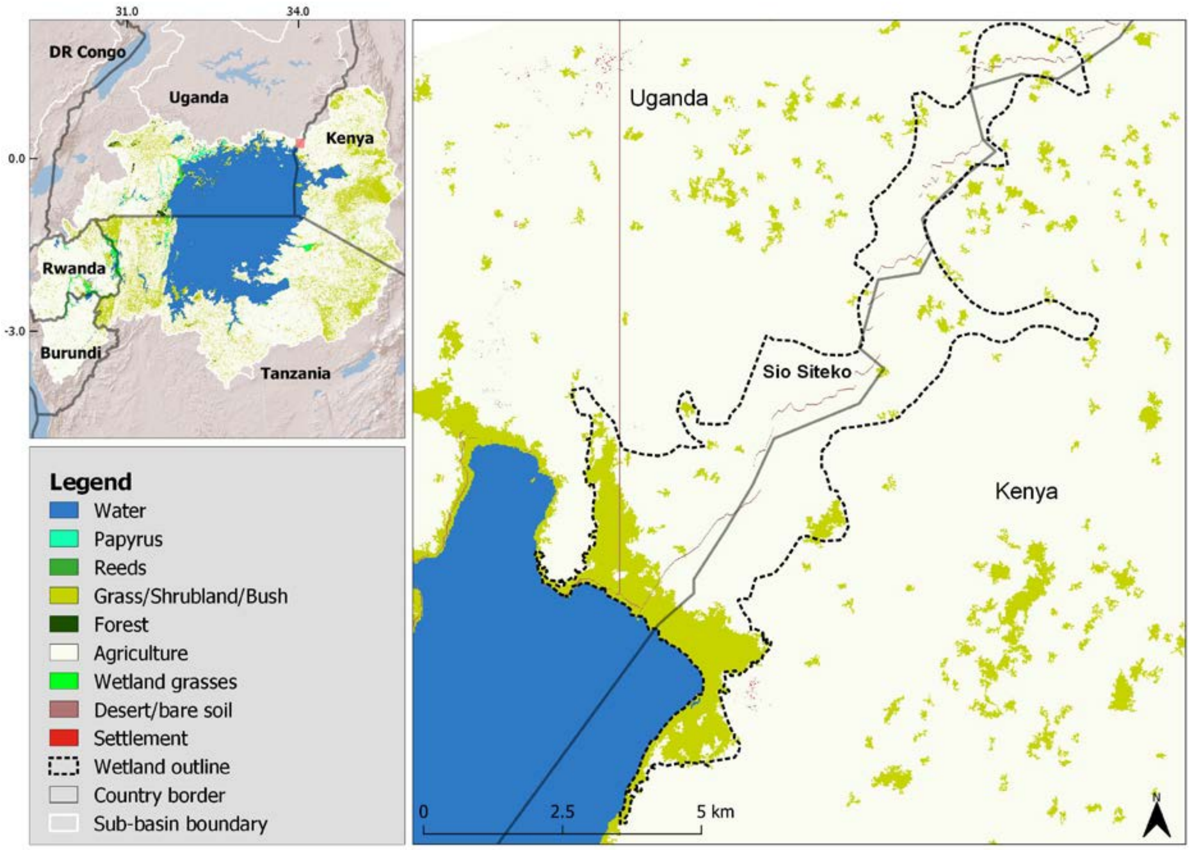

Figure 22 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

Change Trajectories 1985-2015

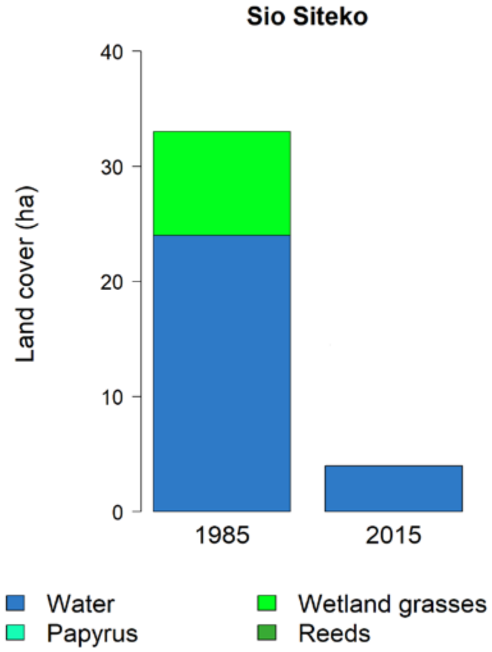

Figure 23 Land cover in 1985 and 2015

Table 12 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	24	4	-83
Papyrus	0	0	0
Wetland grasses	9	0	-100
Reeds	0	0	0
Total area*	3021	3021	0

* Total area based on all 9 land cover classes

LV. Mara Wetland

5. Mara

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 Town: 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 sub-basins 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, woolly-necked 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-to-pay. 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 million) 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). The ecosystem services identified for the Mara wetland are further presented in WP 3: Ecosystem Service Assessment.

Classification

Inland Wetland

L Permanent inland delta
M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools
U Non-forested peatlands

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.

Land Use and Land Cover

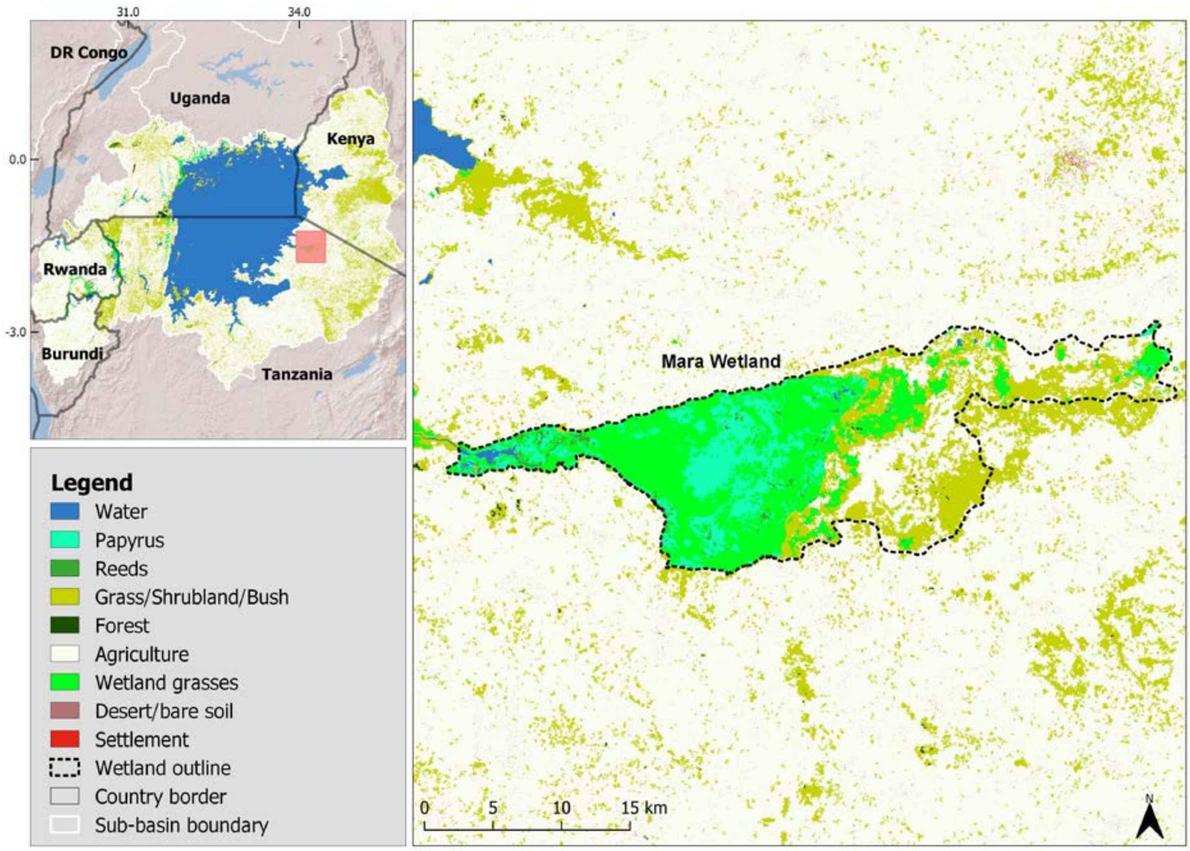

Figure 24 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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 1985-2015

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.

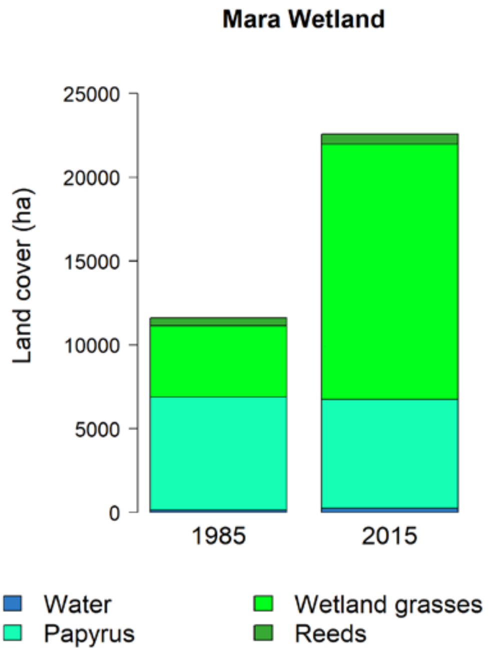

Figure 25 Land cover in 1985 and 2015

Table 13 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	133	248	86.5
Papyrus	6749	6509	-3.6
Wetland grasses	4256	15215	257.5
Reeds	477	589	23.5
Total area*	40582	40582	0.0

* Total area based on all 9 land cover classes

LV. Kagera Wetlands

Overview

Covering an area of 60,000 km^2 the Kagera River basin stretches across four countries, Burundi, Rwanda, Tanzania and Uganda. The Kagera River is the major tributary to Lake Victoria often named the source of the Nile. The Kagera drains the mountains of Rwanda and Burundi, flowing north through a shallow swampy valley containing large and small lakes, before turning east near Kakitumba to flow to Lake Victoria. The river enters the lake through a valley swampland near the midpoint of the western shore.

Climate

Three climatic zones characterize the basin (humid, sub-humid and semi-arid). Mean annual temperature is 15–18 ^oC upstream and 21–30 ^oC 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 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). Lake Mburo supports two endangered cichlid fishes *(Astatotilapia aeneocolor* and *A. oregosoma)* which have gone extinct in the main lakes including Lake Victoria (Byaruhanga & Kigoolo, 2005b).

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 form 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). The ecosystem services identified for the Kagera Wetlands are further presented in WP 3: Ecosystem Service Assessment.

6. 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

Overview

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-eastern to north-western 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 crosse.s 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*.

Wetland Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
O Permanent freshwater lakes (over 8 ha)
P Seasonal/intermittent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
Xf Freshwater, tree-dominated wetlands

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. Around the park, the land belongs to private individuals. The Ruvubu National Park is part of a project entitled "Improvement of Management Effectiveness of Protected Areas of Burundi" financed by UNDP / GEF which will focuses on: (i) the establishment of basic infrastructure and tourist trails, (ii) management plans, guards training, and income-generating activities for local populations (REMA, 2009; Rufuguta, 2013a).

Table 14 Protected area related to the wetland

Name	Type*	Designation Year
Ruvubu National Park (Parc national de Ruvubu)	National Park (II)	1980

*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)*

Land Use and Land Cover

Within the protected area, cultivation is prohibited, but hunting and the collection of medicinal plants is allowed. In the larger basin area, there is production of mostly legumes and cereals such as corn. Cattle breeding is also common. The swamps in the deep high valleys above the Ruvubu River are so dense and their water levels so variable that agriculture is not possible. However, the shallow valleys are largely given over to cultivation. These valleys tend to be flooded for half the year, but rather dry for the other half (Rufuguta, 2013a).

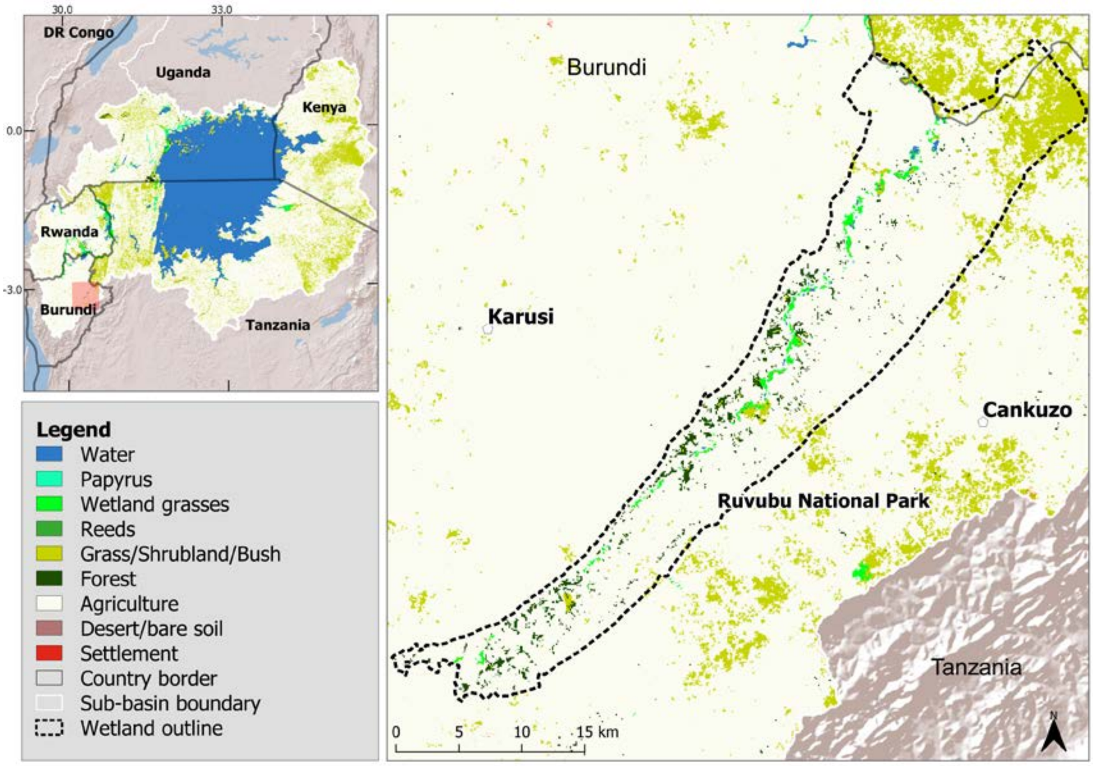

Figure 26 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

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

Change Trajectories 1985-2015

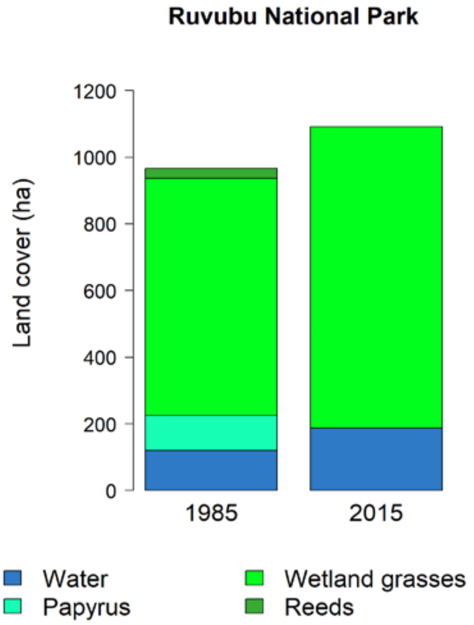

Figure 27 Land cover in 1985 and 2015

Table 15 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	120	187	55.8
Papyrus	105	0	-100.0
Wetland grasses	711	904	27.1
Reeds	31	0	-100.0
Total area*	57706	57705	0.0

* Total area based on all 9 land cover classes

7. The Ruvyironza River

Name: Ruvyironza River (Luvironza River)
Country: Burundi
Coordinates: 3°30'S / 29°54'E
Altitude: 1,300 – 1,800 m a.s.l.
Area: 2 km²
Nearest Town: Gitega
International Importance: Ramsar, Important Bird Area

Overview

The Ruvyironza (Luvironza) rises at 3°44'S/29°47'E at an elevation close to 1950 m a.s.l. on the high dorsal east of Lake Tanganyika. It flows north over a boggy plateau, where *Sphagnum* sp. grows with *Drosera madagascariensis, Loudetia phragmitoides, Lycopodium carolinianum, Rhynchospora brownii, Utricularia appendiculata* and *Xyris angularis.* Such bogs are common above 1,700 m, but may also occur at the heads of valleys down to 1,500 m. The Ruvyironza eventually turns northeast and descends below 1,500 m into a deep valley, in which it receives several tributaries, including the Karuzi River on the left bank, and after this becomes known as the Ruvubu (Hughes & Hughes, 1992).

Classification

M Permanent rivers/streams/creeks
U Non-forested peatlands

Land Use and Land Cover

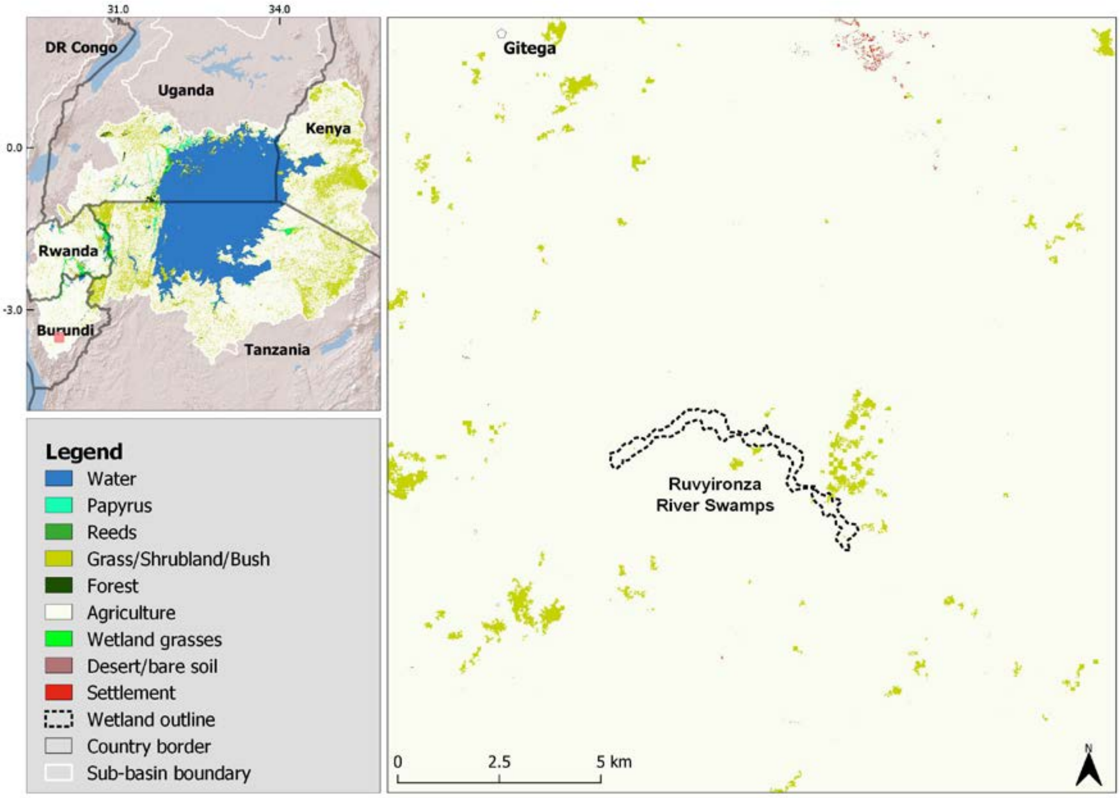

Figure 28 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

8. 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

Overview

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 to 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 Akanyaru 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) and Mwungere (20 ha). 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 for agricultural. 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 quartzito-schistous, also associated with quartzitic ridges, to the south-east. These hard stone outcrops become even more abundant and are more strongly folded downstream of Rweru 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).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

U Non-forested peatland

Xf Freshwater, tree-dominated wetlands

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.

Table 16 Protected area related to the wetland

Name	Type	Designation Year
Foret de Murehe	Protected Landscape	Not reported

Land Use and Land Cover

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).

Change Trajectories 1985-2015

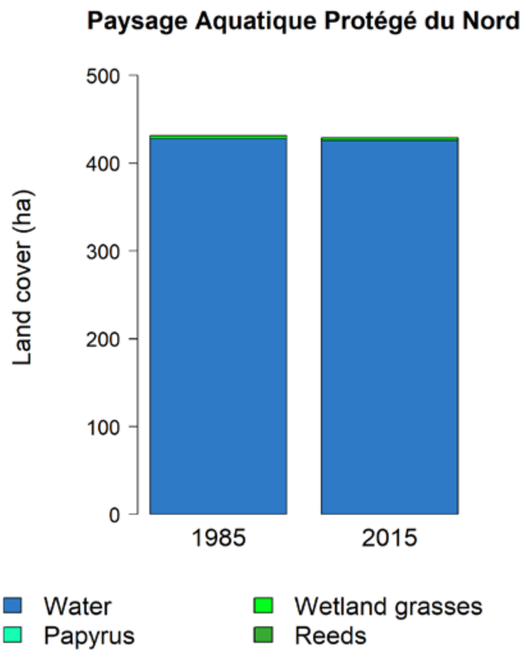

Figure 29 Land cover in 1985 and 2015

Table 17 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	428	426	-0.5
Papyrus	0	0	0.0
Wetland grasses	3	3	0.0
Reeds	0	0	0.0
Total area*	513	512	-0.2

* Total area based on all 9 land cover classes

9. Lake Cohoha South

Name: Lake Cohoha South (Cyohoha, Tshohoha)
Country: Burundi, Rwanda
Coordinates: 2°20' - 2°35' S / 29°58' - 30°11' E
Altitude: 1,350 m a.s.l.
Area: 61 km²
Nearest Town: Kirundo
International Importance: Ramsar, Transboundary Wetland

Overview

Lake Cohoha stretches across a 27 km long valley which is 0.4 to 2.3 km wide. The average depth of the lake is 7 m, varying 5-7 m towards the north and 8- 10 m in the south. The lake branches into numerous valleys to its north and south, which are 0.4 to 8 km long. Some of these tributaries are bifid or even ramified several times, especially in the southern part. The boundary between Rwanda and Burundi runs through Lake Cohoha South for 22 km, and about 25% of the lake surface is in Rwanda. Lake Cohoha South receives water mainly from rainfall and tributaries in the south-east. North-westerly the lake is connected to the Akanyaru River through a dense marsh, so water moves only very slowly from the lake to the river. During low-waters there is almost no connection between the river and the lake. In the rainy season the river floods and the lake level rises by approximately one meter. Apart from exceptional floods, the average annual fluctuations of the level of Akanyaru does not make it possible to flood the marsh all the way to the lake (Nzigidahera, 2007).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

U Non-forested peatland

Xf Freshwater, tree-dominated wetlands

Land Use and Land Cover

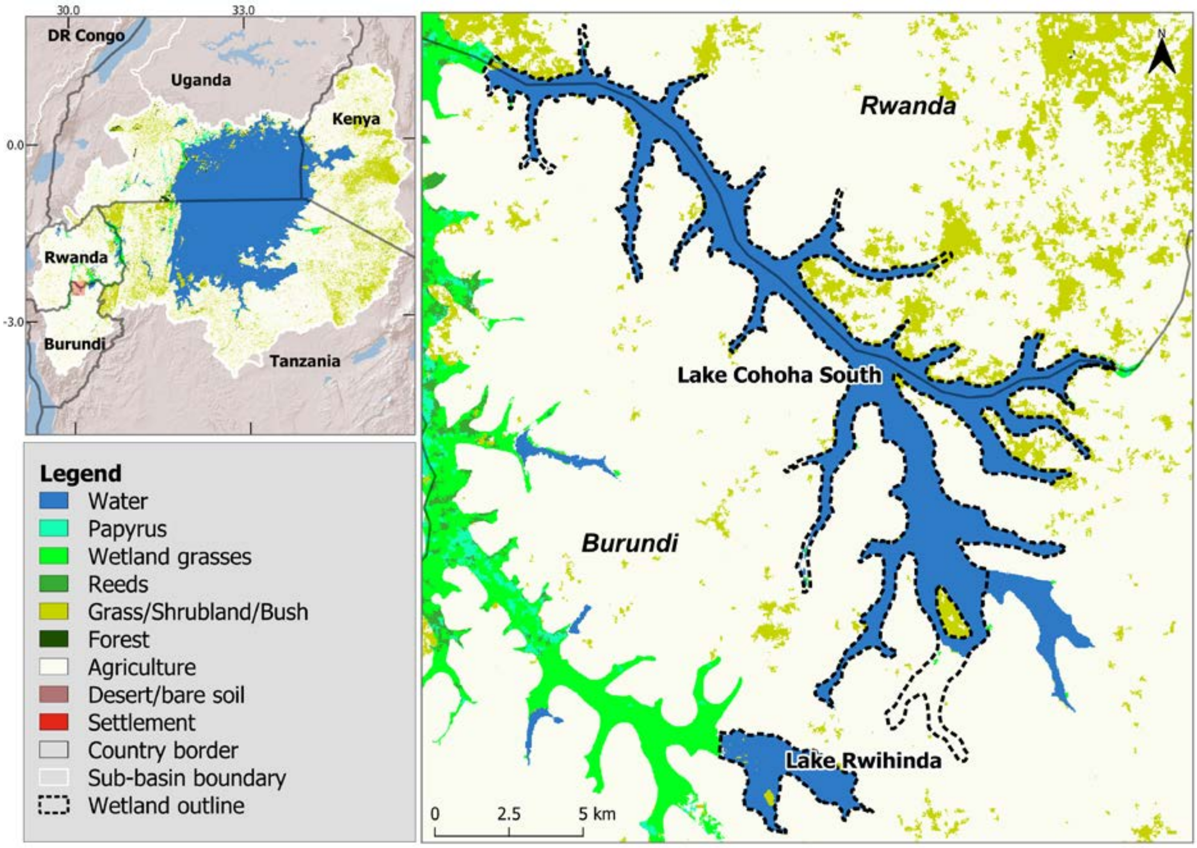

Figure 30 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

The marshes bordering the lake have largely been transformed for the cultivation of crops such as rice, beans, maize, peanuts and cassava. The cultivation of crops follows a zonation pattern from the lakeshores to areas uphill from the lake. This zonation pattern is different on the Rwandan and Burundian lakeshores. In Rwanda there is a 50 m wide buffer zone right after the marshes comprising trees such as *Grevillea robusta, Cassia spectabilis, Markhamia lutea, Leucena* and *Cedrela*. In Burundi banana plantations often replace these forested buffer strips (Nzigidahera, 2007).

Change Trajectories 1985-2015

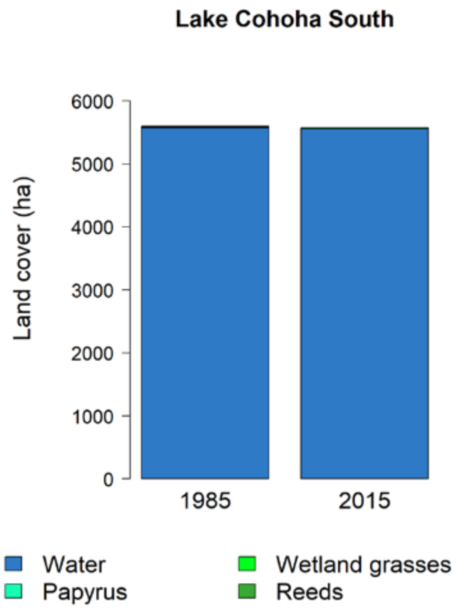

Figure 31 Land cover in 1985 and 2015

Table 18 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	5575	5553	-0.4
Papyrus	3	3	0.0
Wetland grasses	15	16	6.7
Reeds	3	3	0.0
Total area*	6216	6216	0.0

* Total area based on all 9 land cover classes

10. Lake Rwihinda

Name: Lake Rwihinda
Country: Burundi
Coordinates: 2°32'-2°34'S/30°03'-30°06'E
Altitude: 1,480 m a.s.l.
Area: 7 km²
Nearest Town: Kirundo
International Importance: Ramsar, Important Bird Area

Overview

Lake Rwihinda is a shallow water body close to the Rwandan border orientated in SE-NW. It is 6 km long and 2.5 km wide at the south-eastern end. Lake Rwihinda is a managed nature reserve and was known in the past as “Lac aux Oiseaux” (Lake of Birds). The lake itself is 425 ha and part of an Important Bird Area, which stretches over an area of 8,000 ha including the swamps of Nyavyamo and the lakes Narungazi and Gitamo. This site held large numbers of breeding water birds in the past such as African darter (*Anhinga rufa*), black egret (*Egretta ardesiaca*) and black-headed heron (*Ardea melanocephala*). As a result of decreasing water levels, fishing and agriculture, large numbers are rarely observed now. Other key species are the papyrus yellow warbler (*Chloropeta gracilirostris*) and papyrus gonolek (*Laniarius mufumbiri*). There are human settlements surrounding the lake, hence pressure upon it from fishing and the demand for agricultural land are extremely high (Nkezabahizi & Manirambona, 2009).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland
Xf Freshwater, tree-dominated wetlands

Land Use an Land Cover

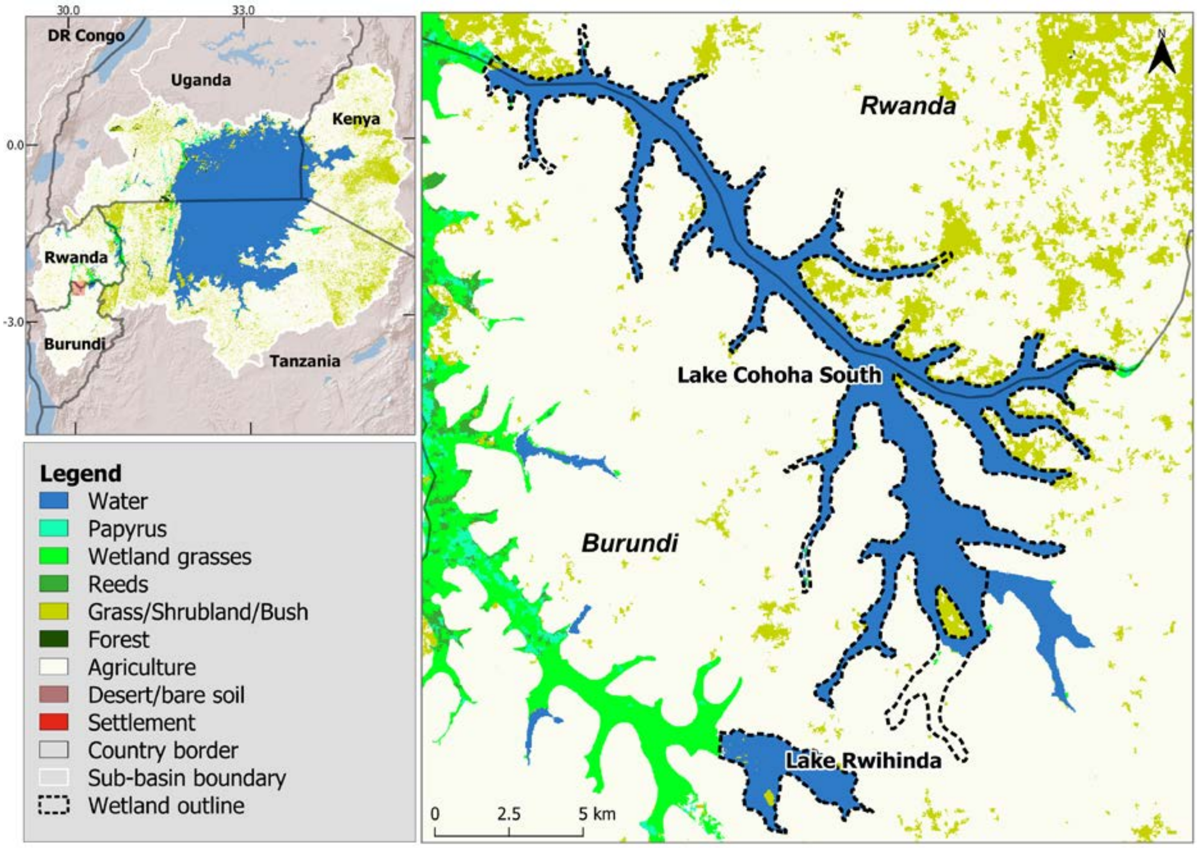

Figure 32 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

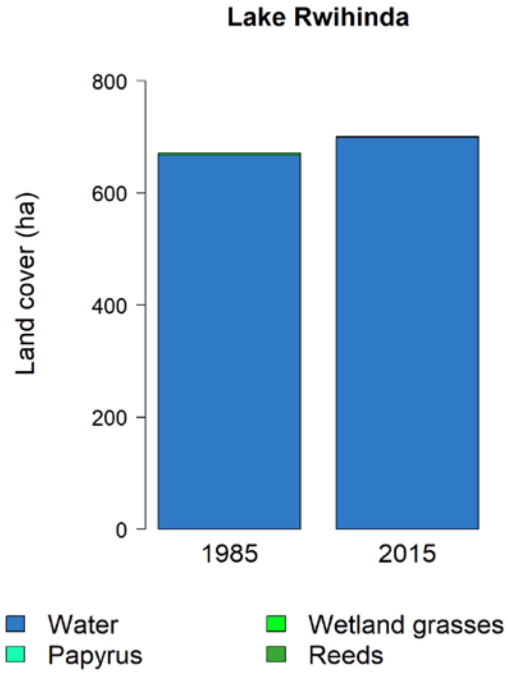

Figure 33 Land cover in 1985 and 2015

Table 19 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	668	700	5
Papyrus	0	0	0
Wetland grasses	3	1	-67
Reeds	0	0	0
Total area*	726	726	0

* Total area based on all 9 land cover classes

11. Lake Kanzigiri

Name: Lake Kanzigiri
Country: Burundi
Coordinates: 2°26' -2°29' S/30°21 ' -30°23 'E
Altitude: 1490 m a.s.l.
Area: 20 km²
Nearest Towns: Kirundo, Ngara

Overview

Lake Kanzigiri is 8 km long and 2 km wide aligned in SW-NE direction. At the southern end, it is fed by the Kabanga and Runombe Rivers through swampland. At the northern part, Lake Kanzigiri is connected to Lake Rweru through a valley covered by swamps. Most of Lake Kanzigiri's western shores are forested land. The lake, surrounded by farmland, is used for fishing (Hughes & Hughes, 1992).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland
Xf Freshwater, tree-dominated wetlands

Land Use and Land Cover

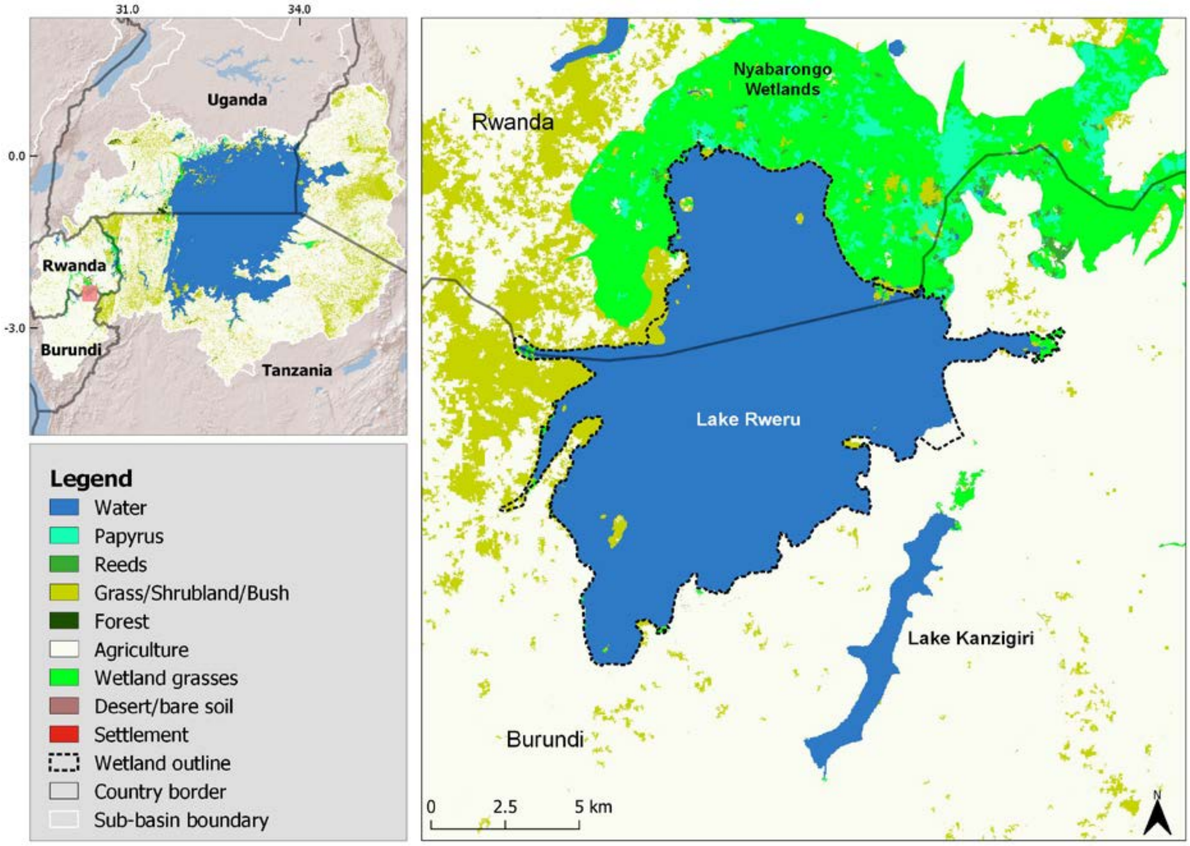

Figure 34 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

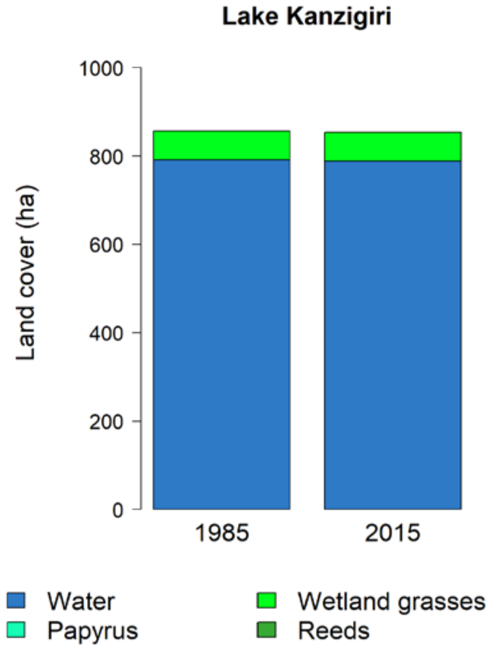

Figure 35 Land cover in 1985 and 2015

Table 20 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	791	788	0
Papyrus	0	0	0
Wetland grasses	65	66	2
Reeds	0	0	0
Total area*	2020	2022	0

* Total area based on all 9 land cover classes

12. Lake Rweru

Wetland Name: Lake Rweru (Rugwero)
Country: Burundi/ Rwanda
Coordinates: 2°21'-2°28' S/30°16' -30°22 'E
Altitude: 1750 m a.s.l.
Area: 136 km²
Nearest Town: Muyinga
International Importance: Transboundary Wetland

Overview

This shallow lake (2-4 m deep) lies at the southern end of the Mugesera Rweru Lake/Swamp complex and its northern end reaches into Rwanda. The Rweru Lake is 15 km long and 8 km wide at its maximum water level. Water levels however can vary considerably between dry and wet season. Extensive swamplands can be found in surrounding the western, northern and north-eastern shores whereas the southern and southwestern shores are forested.

Lake Rweru is fed by streams from the central plateau of Burundi and from Lake Kanzigiri in the south. From the north it receives water from the Nyawarungu River. The outlet of Lake Rweru forms the source of the Kagera River. The Kagera River flows eastwards along the border between Burundi and Rwanda where the Ruvubu River joins its course. Eventually the Kagera River discharges into Lake Victoria in Uganda.

At Rweru Lake, the low-level mark is lower than the shallow water which delimits its discharge system. Even though the water level in the Nyabarongo River is lower than that of the lake, there is no straight flow between the two water bodies. The lake runs towards the Kagera River as of the rise of water of the beginning of the rainy season. In March-April, the level of the river goes up more quickly and exceeds that of the lake. The flow is then reversed and it is the river which runs towards the lake, feeding the entire surrounding marshy zone. With the fall of water levels, from June to August, the lake runs again towards Nyabarongo River, initially through the marsh (Nzigidahera, 2007).

The invasive water hyacinth (*Eichhornia crassipes*) is prevalent in the Rwanda portion of Lake Rweru during the rainy season. However, it is known that the water hyacinth trans-located by the lake waters has not yet established extensive mats (LVBC, 2011b). Water hyacinth mats on Lake Rweru in Burundi are introduced through flooding of River Kagera.

Classification

<u>Inland Wetland</u>

O	Permanent freshwater lakes (over 8 ha)
Tp	Permanent freshwater marshes/pools
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils
U	Non-forested peatland
Xf	Freshwater, tree-dominated wetlands

Land Use and Land Cover

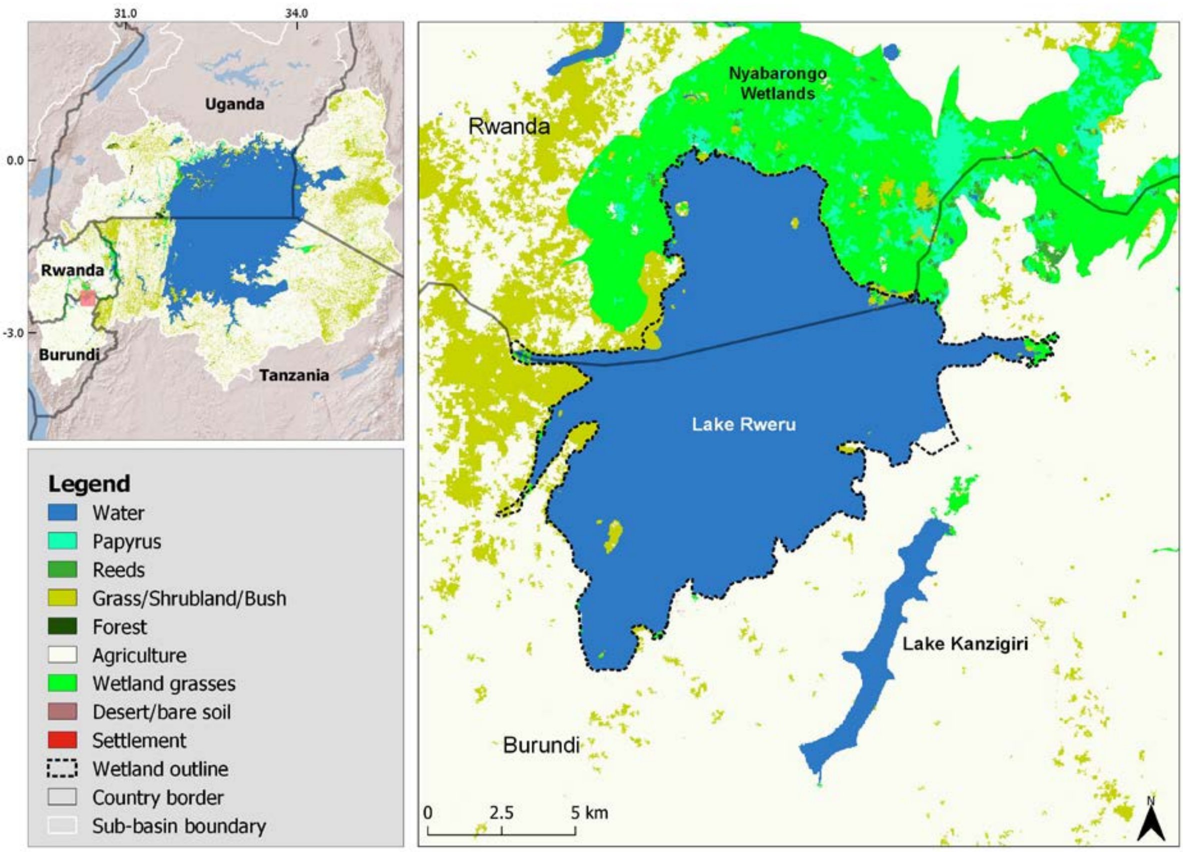

Figure 36 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

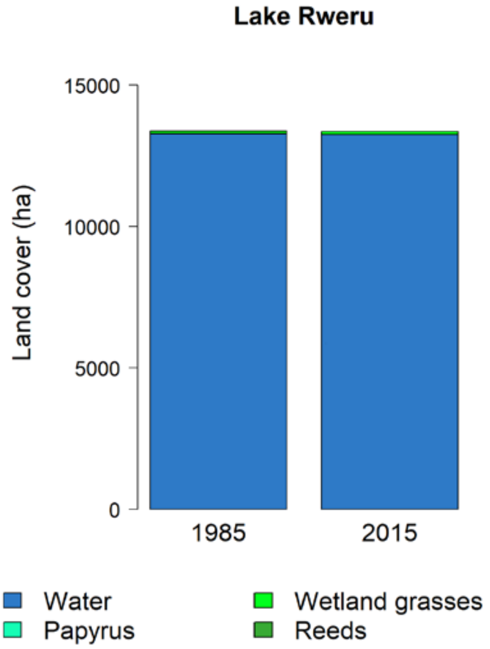

Figure 37 Land cover in 1985 and 2015

Table 21 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	13275	13251	-0.2
Papyrus	1	1	0.0
Wetland grasses	92	101	9.8
Reeds	0	0	0.0
Total area*	13640	13641	0.0

* Total area based on all 9 land cover classes

13. Akanyaru Swamps Burundi

Name: Akanyaru River, Kanyaru River
Country: Burundi, Rwanda
Coordinates Swamps: 2°46'S/29°50'E
Altitude Source: 1,350 m a.s.l.
Area: 27 km²
Nearest Town: 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).

Classification

Inland Wetland

M Permanent rivers/streams/creeks
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland

Land Use and Land Cover

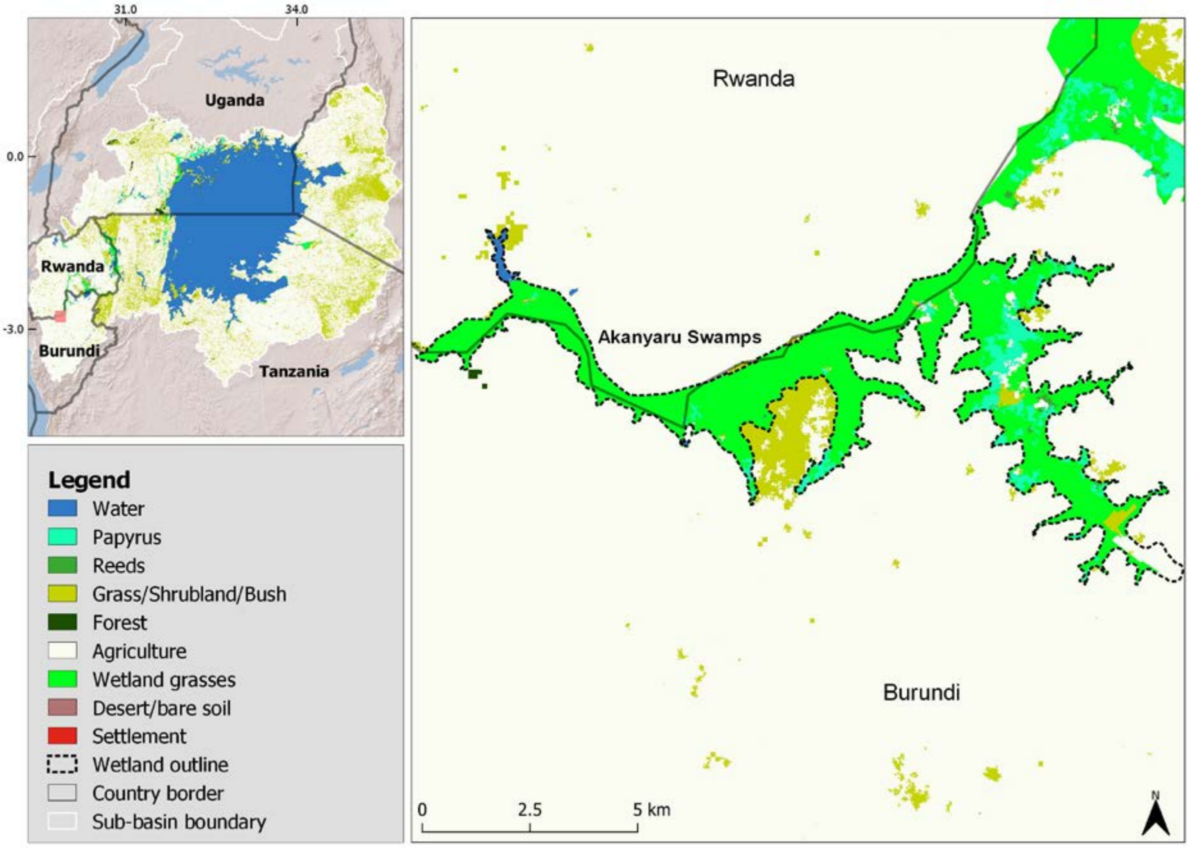

Figure 38 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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.

Change Trajectories 1985-2015

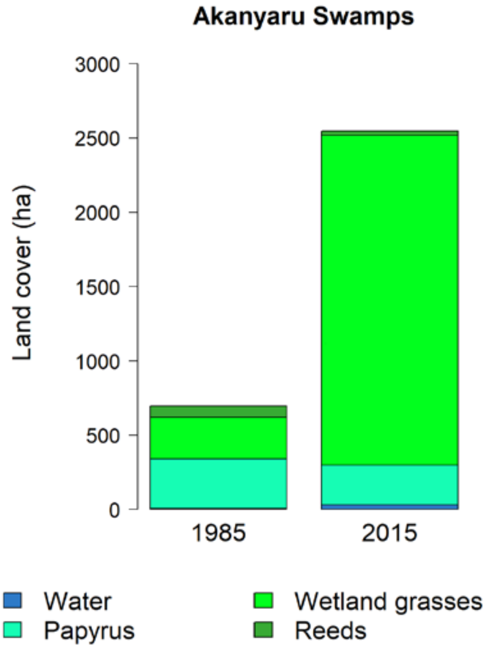

Figure 39 Land cover in 1985 and 2015

Table 22 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	7	31	342.9
Papyrus	332	267	-19.6
Wetland grasses	280	2220	692.9
Reeds	77	27	-64.9
Total area*	2720	2721	0.0

* Total area based on all 9 land cover classes

14. Akanyaru River Swamps in Rwanda

Name: Akanyaru River, Kanyaru River
Country: Burundi, Rwanda
Coordinates Swamps: 2°46'S/29°50'E
Altitude: 1,370 m a.s.l.
Nearest Towns: Gitarama, Nyanza
Area: 267 km²
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).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland

Land Use and Land Cover

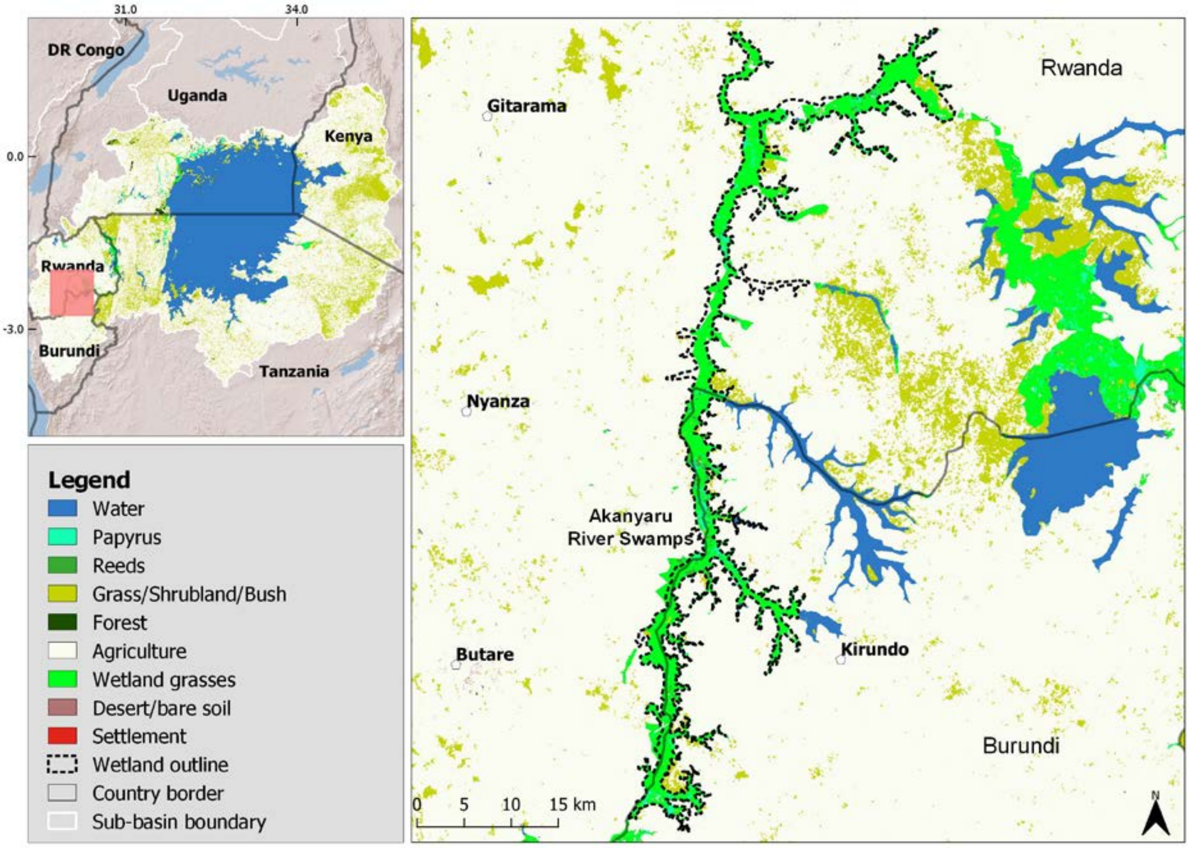

Figure 40 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

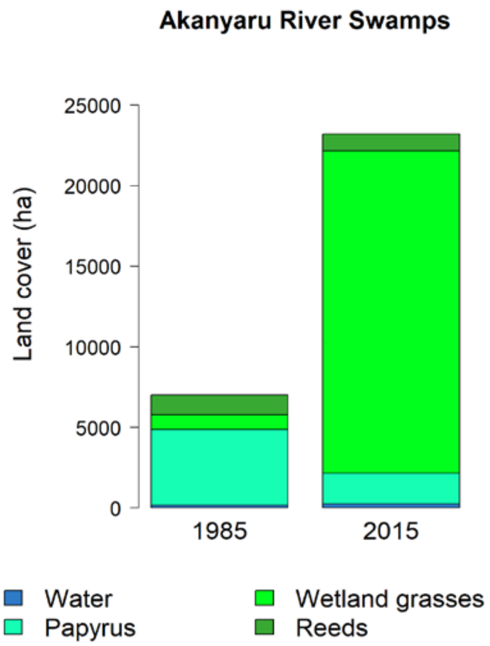

Figure 41 Land cover in 1985 and 2015

Table 23 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	187	257	37.4
Papyrus	4691	1908	-59.3
Wetland grasses	914	20010	2089.3
Reeds	1237	1021	-17.5
Total area*	26760	26761	0.0

* Total area based on all 9 land cover classes

15. Lake Cohoha North

Name: Lake Cohoha North (Tshohoha, Cyohoha)
Country: Rwanda
Coordinates: 2°14'-2°19' S/30°05 '-30°09 'E
Altitude: 1,450 m a.s.l.
Area: 9 km²
Nearest Town: Kigali
International Importance: Important Bird Area

Overview

Lake Cohoha North is situated entirely in Rwanda. The lake is fed at its southern end by a river from Burundi, and drains from its north-eastern end through 10 km of permanent swamps to the Akanyaru River. The lake occupies the floor of a triangular basin at 1450 m a.s.l., situated between two low undulating ridges oriented SW-NE and NW-SE. Its effluent river passes between these hills at the narrow western end of the basin. The shallow lake is 12 km long and about 1 km wide, with an open water surface of 1200 ha at high water. It is fringed at the waterside by papyrus, and peripheral vegetation. Agriculture is locally intensive on the floodplains of the affluent and effluent rivers, and in places around the lake margin where it has been possible to drain the swamps (Hughes & Hughes, 1992).

Classification

<u>Inland Wetland</u>

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

U Non-forested peatland

Land Use and Land Cover

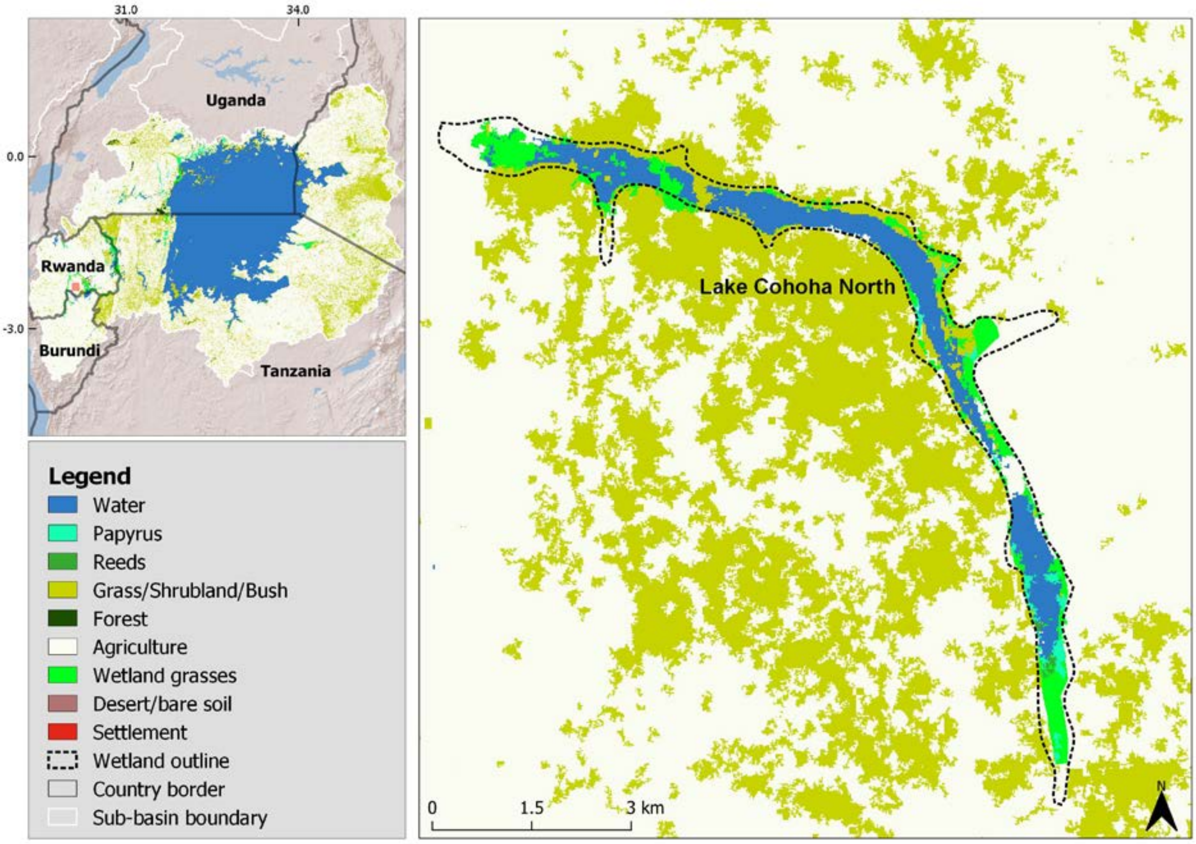

Figure 42 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

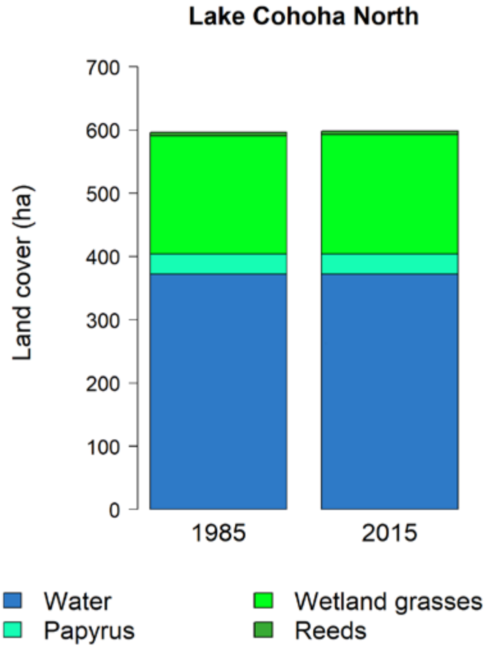

Figure 43 Land cover in 1985 and 2015

Table 24 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	372	372	0.0
Papyrus	32	32	0.0
Wetland grasses	187	189	1.1
Reeds	5	5	0.0
Total area*	921	922	0.1

* Total area based on all 9 land cover classes

16. Rugezi Marsh

Name: Rugezi Marsh
Country: Rwanda
Coordinates: 01°21’- 01°36’S / 29°49’- 29°59’E
Altitude: 2,050 m a.s.l.
Area: 61 km²
Nearest Towns: Byumba
International Importance: Ramsar site, Important Bird Area

Overview

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 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 km^2) and Lake Ruhono (2.8 km^2) 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).

Classification

Inland Wetland

U Non-forested peatlands

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).

Land Use and Land Cover

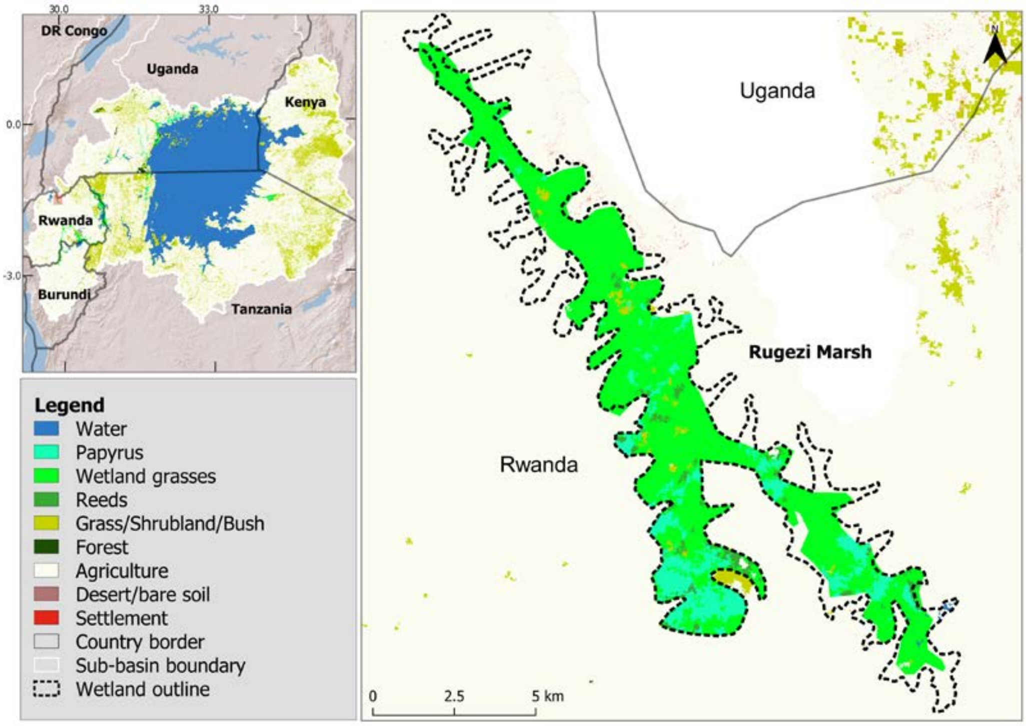

Figure 44 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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 km^2. Due to population increase the steep hillsides and the low hillsides adjacent to the swamp are used for farming. Consequently runoff and erosion increased in 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 1985-2015

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).

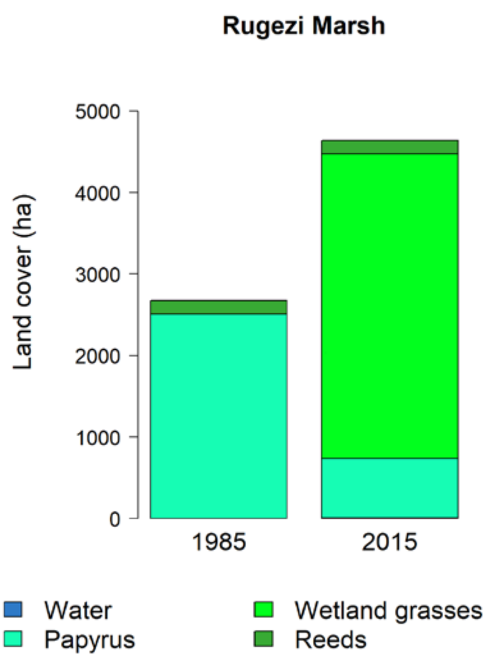

Figure 45 Land cover in 1985 and 2015

Table 25 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	8	N.A.
Papyrus	2508	729	-70.9
Wetland grasses	0	3735	N.A.
Reeds	167	164	-1.8
Total area*	6058	6059	0.0

* Total area based on all 9 land cover classes

17. Lake Burera

Name: Lake Burera (Bulera)
Country: Burundi
Coordinates: 1°23'4 °30' S/29°45'-29°49'E
Altitude: 1,860 m a.s.l.
Area: 50 km²
Nearest Towns: Ruhengeri

Overview

Lake Burera is situated on the southern slopes of Mt. Muhavura in north western Rwanda. It lies on an altitude of 1862 m a.s.l., is 12 km long and reaches 8 km in width. In the lake there are two small islands. The lake is fed by 6 streams the largest affluents are the Kabga and Kageri rivers, and the Hondo River which drains the Rugezi Swamp and flows through the Rusumo Fall. The Lake drains from its southwestern extremity to Lake Ruhondo (Hughes & Hughes, 1992).

Physical features

The surface area of Lake Burera is approximately 47 km^2 and the catchment area is 580 km^2. The approximate depth of the lake is 163-169 m with a number of underground caves. The Lake receives 50 % of its inflow from the Rugezi Marsh. Lakes Burera and Ruhondo are connected through the 440 meter long Ntaruka River, which has a potential head of 102 m. This steep gradient offers the good conditions for power production. Therefore during the colonial period the first ever hydropower pant in Rwanda was built on Ntaruka River using Lake Burera as a reservoir (Hirwa & Maniragaba, 2017).

There is not a lot of information available concerning Lake Burera and the lake is also not within the boundaries of the Rugezi-Burera-Ruhondo Ramsar site. Due to the proximity and connectedness of Rugezi-Burera-Ruhondo all three lakes and wetlands are believed to host a similar fauna and flora.

In 1991 the cyprinid fish *Rastrineobola argentea* was introduced to Lake Burera to develop a flourishing fishery. Later the fish was also found in Lake Ruhondo. Fishermen estimate catches to be 40 t/year from Lake Bulera and about 20 t/year in Lake Ruhondo (Isumbisho et al., 2011). In addition there is tilapia cage culture in both lakes. In Lake Burera there are more than 200 tilapia cages.

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

U Non-forested peatlands

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil

Land Use and Land Cover

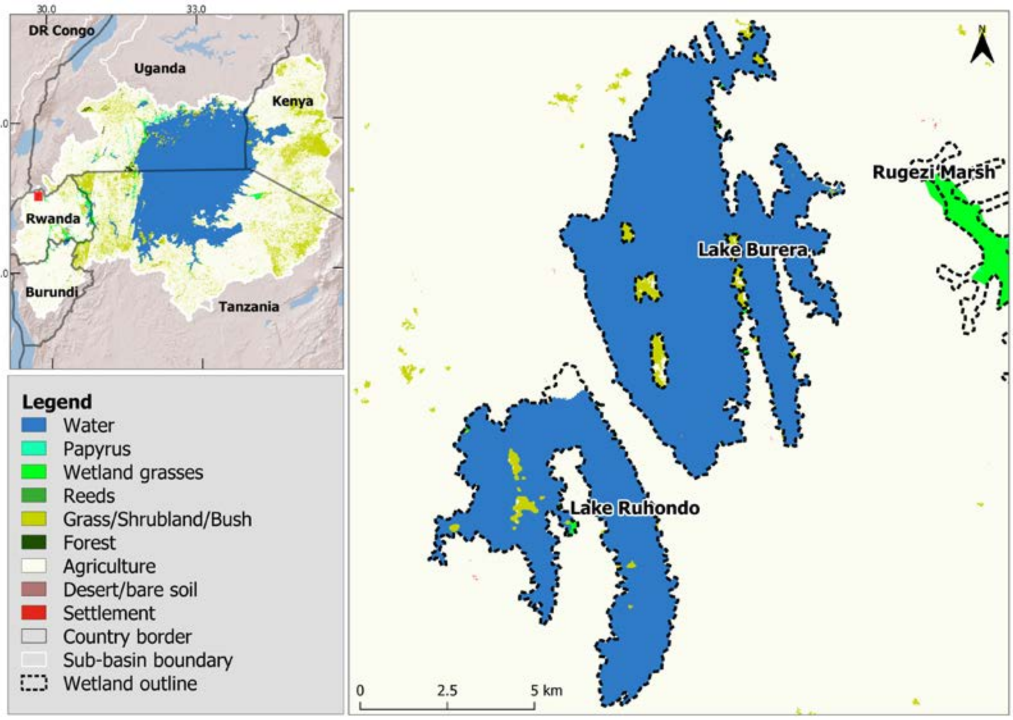

Figure 46 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

Water levels in lakes Burera and Ruhondo have fallen up to 50 % of average depth by 2004, due to the impact of cultivation and cattle grazing in the upstream Rugezi wetlands. Since then the Government of Rwanda has increased conservation measures around the lakes and Rugezi wetland, which was declared a protected area in 2008. Due to low water levels in Lake Burera combined with high energy demand the hydropower plant was shut down several times since 1985 (Hirwa & Maniragaba, 2017). Fluctuating water levels due to hydropower plant operation can have large negative effects on habitats and subsequently biodiversity of wetlands, which in turn affects local communities who use wetland resources.

Change Trajectories 1985-2015

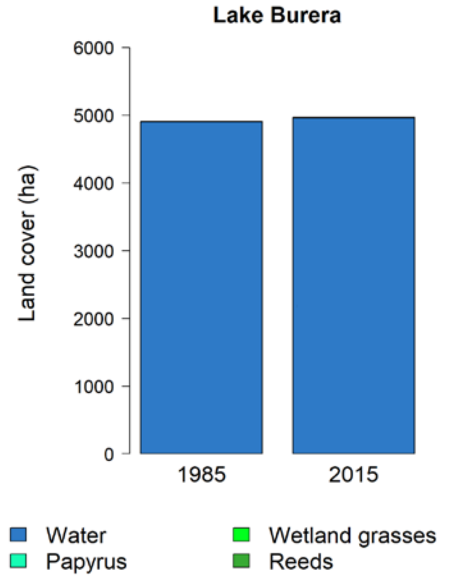

Figure 47 Land cover in 1985 and 2015

Table 26 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	4900	4958	1.2
Papyrus	3	0	-100.0
Wetland grasses	3	8	166.7
Reeds	2	0	-100.0
Total area*	5143	5142	0.0

* Total area based on all 9 land cover classes

18. Lake Ruhondo

Name: Lake Ruhondo (Luhondo)
Country: Burundi
Coordinates: 1°28 '-1°33 ' S/29°42 '-29°46 'E
Altitude: 1,860 m a.s.l.
Area: 27 km²
Nearest Towns: Ruhengeri

Overview

Lake Ruhondo lies on 1764 m a.s.l. and is shaped like an inverted `V'. Its eastern arm is 9 km long and reaches 3 km in width. In addition to the overflow from Lake Bulera, it receives water from 4 other streams, of which the Gasura is the most important. There is a swamp at the northern end of the lake, i.e. at the apex of the 'V'. It drains to the southwest via the Mukungwa River, a tributary of the Nyabarongo. A hydroelectric power station has been constructed where the Mukungwa leaves the lake, therefore the lake is important for Rwanda's economy. Both lakes, Ruhondo and Burera are very young, a fact reflected by their poor floras and faunas. (Hughes & Hughes, 1992).

Physical features

There is not a lot of information available concerning Lake Burera and the lake is also not within the boundaries of the Rugezi-Burera-Ruhondo Ramsar site. Due to the proximity and connectedness of Rugezi-Burera-Ruhondo all three lakes and wetlands are believed to host a similar fauna and flora. Lake Ruhondo has a maximum depth of 68 m. The lake's surface area is 26.6 km^2 and its catchment area is 198 km^2 (Isumbisho et al., 2011)

In 1991 the cyprinid fish *Rastrineobola argentea* was introduced to Lake Burera to develop a flourishing fishery. Later the fish was also found in Lake Ruhondo. Fishermen estimate catches to be 40 t/year from Lake Burera and about 20 t/year in Lake Ruhondo (Isumbisho et al., 2011). In addition there is tilapia cage culture in both lakes.

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

U Non-forested peatlands

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil

Land Use and Land Cover

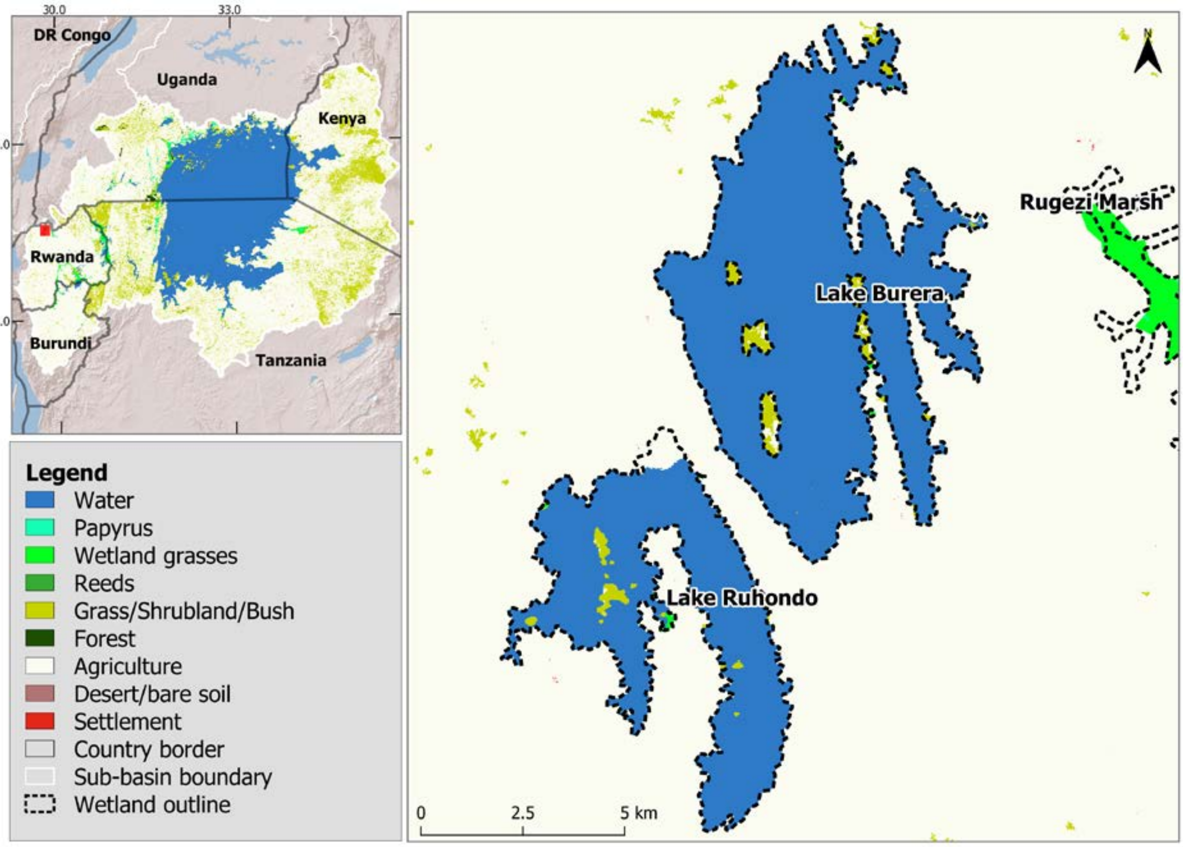

Figure 48 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

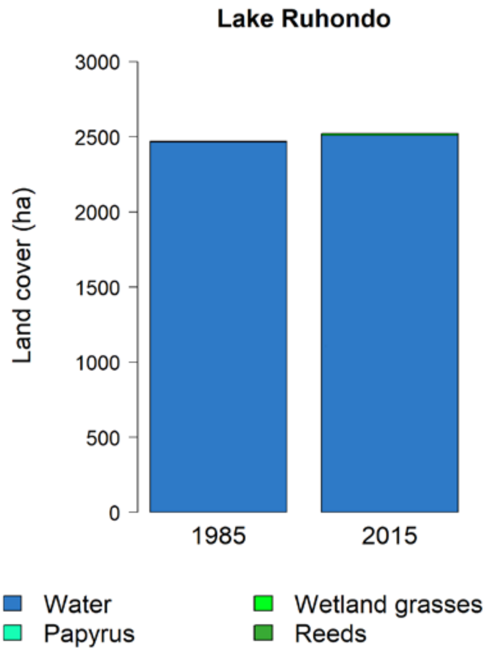

Figure 49 Land cover in 1985 and 2015

Table 27 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985	2015	Change

	(ha)	(ha)	1985-2015 (%)
Water	2465	2509	1.8
Papyrus	5	0	-100.0
Wetland grasses	1	10	900.0
Reeds	1	0	-100.0
Total area*	2669	2668	0.0

* Total area based on all 9 land cover classes

19. Kamiranzovu Swamp

Wetland 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

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 and hosts distinct flora, especially endemic orchids 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 to trial 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).

Classification

U Non-forested peatlands
Va Alpine wetlands

Management Status

Table 28 Protected area related to the wetland

Name	Type*	Designation Year
Nyungwe	National Park (IV)	1933

*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)*

Land Use and Land Cover

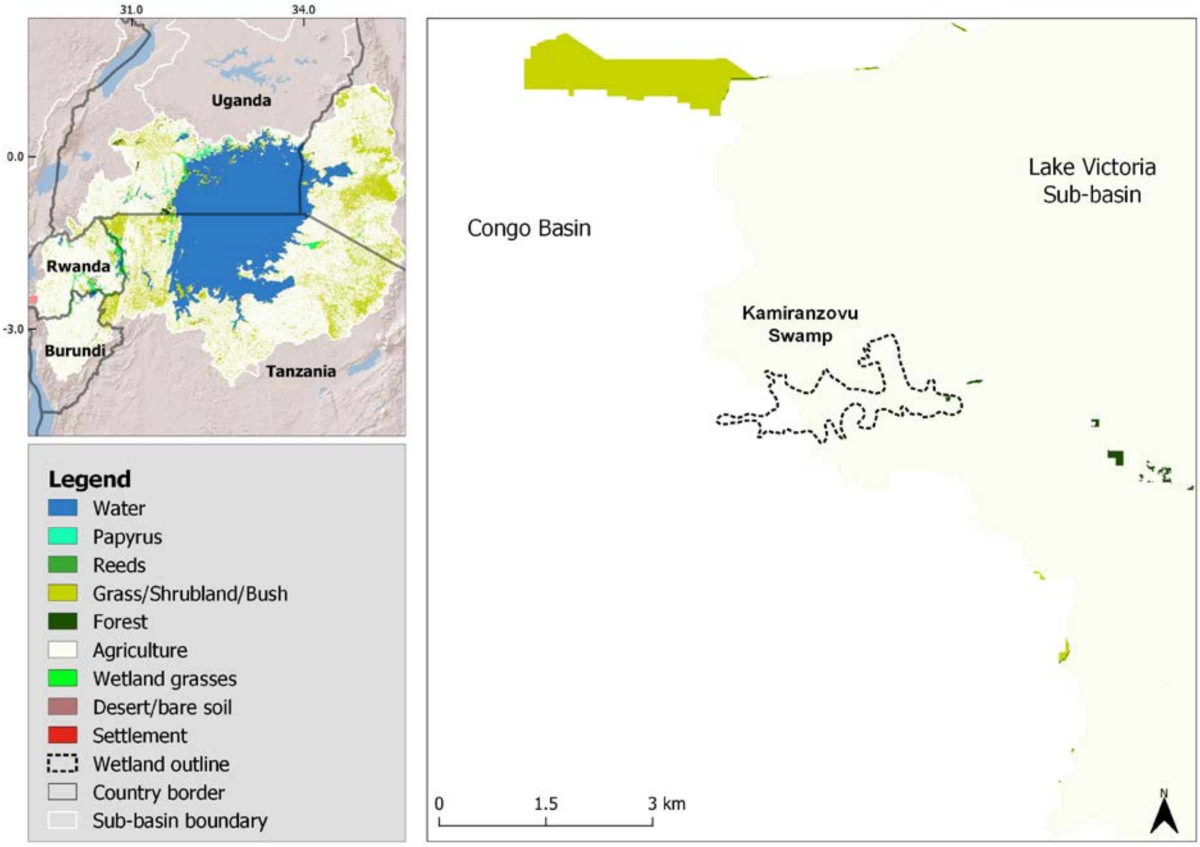

Figure 50 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

20. Lake Muhazi

Wetland Name: Lake Muhazi (Mohasi)
Country: Rwanda
Coordinates: 1°49 '-1°54 ' S / 30°11 '-30°30 'E
Altitude: 1,480 m a.s.l.
Area: 33 km²
Nearest Town: Kigali

Overview

This lake is 40 km long and has a mean width close to 1 km, with a maximum width of 2 km and a mean depth of 3-5 m (REMA, 2009). It occupies the floor of a system of valleys, tributary to a main valley aligned E-W, and extends into the tributary valleys as a series of 13 narrow arms. Much of the lake shore is swampy and there are swamps at the heads of all 13 arms. The lake is fed by the Mohagumbo River at the eastern end, and by 13 other small streams. It drains from the western end to the Nyabugogo River (Hughes & Hughes, 1992).

Physical features

Lake Muhasi lies in a mountainous area. The lake covers an area of about 34 km^2 and the catchment area is 830 km^2. The lake is the main source of water for domestic and agricultural use in the area. The lake is important for tourism, which is fairly developed in the area. The government is planning extensive high value developments around the lake. There are some mining activities in the nearby town of Rwamagana (Nhapi et al., 2012).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
U Non-forested peatland

Land Use and Land Cover

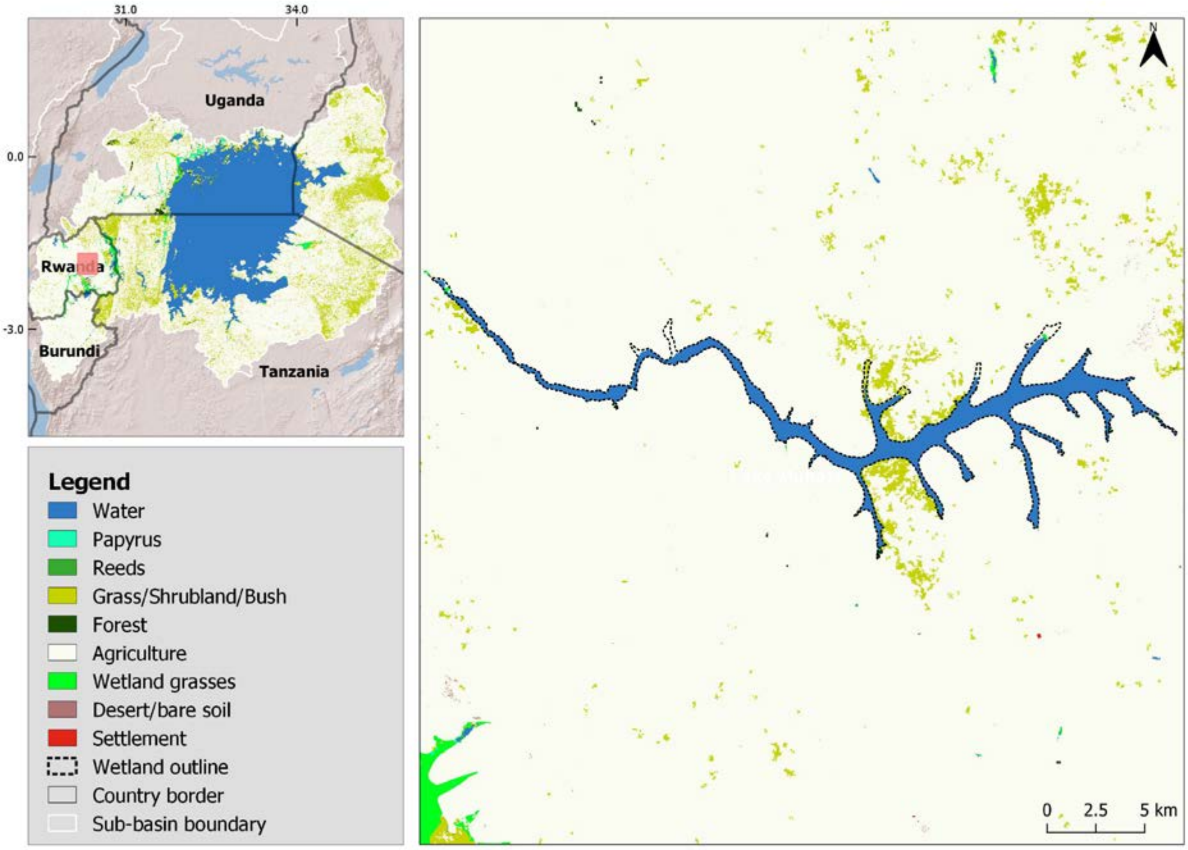

Figure 51 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

The invasive plant species *Protopterus aethiopicus* was introduced in Lake Muhazi in 1989 (REMA, 2009). Nhapi et al. (2012) found that cadmium and lead exceeded WHO drinking water limits in the lake, however no point source pollution could be clearly identified.

Change Trajectories 1985-2015

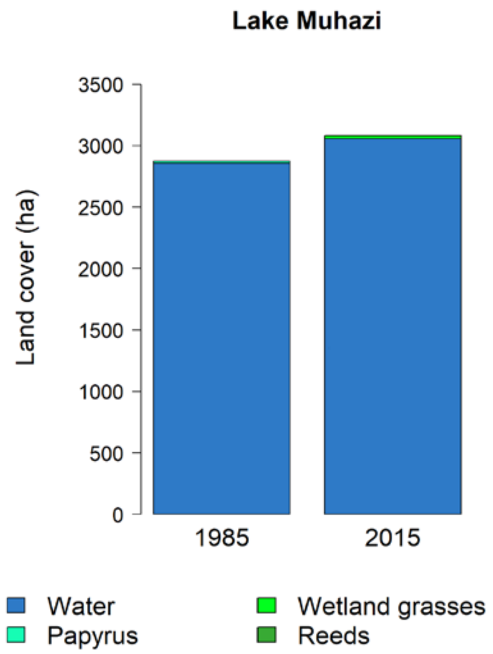

Figure 52 Land cover in 1985 and 2015

Table 29 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	2856	3057	7.0
Papyrus	18	0	-100.0
Wetland grasses	0	23	N.A.
Reeds	2	0	-100.0
Total area*	3322	3321	0.0

* Total area based on all 9 land cover classes

21. Nyabarongo Wetlands

Name: Nyabarongo wetlands
Country: Rwanda
Coordinates: 2°04'-2°28'S/30°12'-30°27'E
Altitude: c. 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).

Land Use and Land Cover

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 it 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).

Change Trajectories 1985-2015

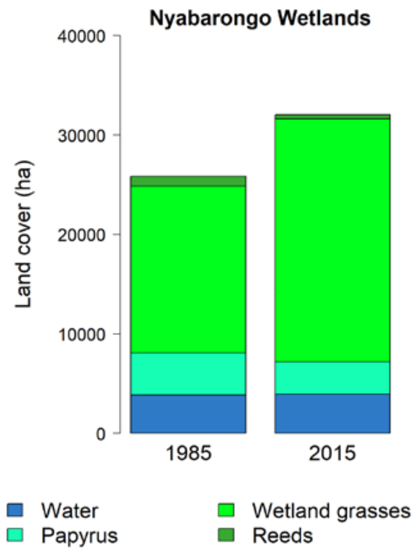

Figure 53 Land cover in 1985 and 2015

Table 30 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	3862	3943	2.1
Papyrus	4221	3277	-22.4
Wetland grasses	16770	24424	45.6
Reeds	1020	384	-62.4
Total area*	34080	34080	0.0

* Total area based on all 9 land cover classes

22. Lake Mugesera

Wetland Name: Lake Mugesera
Country: Rwanda
Coordinates: 2°04 ' -2°13 ' S/30°18 ' -30°27 'E
Altitude: 1,750 m a.s.l.
Area: 51 km²
Nearest Towns: Kigali, Kibungo
International Importance: Important Bird Area

Overview

Lake Mugesera lies in the upper (north-eastern) end of the Mugesera-Rweru Swamp Complex. This lake is fed by the Bubindi, Gitinga, Mwambu, Nyaruvoma and Rwazurasu rivers and ten other minor streams, which flood twice a year. These rivers originate on hilly ridges to the north, east and south of the lake, north of Kibungu, while the southern swamps near Lake Rweru receive several similar streams from hills in the east, south of Kibungu. Lake Mugesera is in a main basin oriented NNE-SSW, with 4 arms running roughly eastwards separated by ridges of low hills (Hugehs & Hughes, 1992). The soil is mostly organic, with less developed peat (REMA, 2009). The lake is important for fisheries but invasive fish such as *Astatoreochromis alluandi, Schilbe mystus* and *Cyprinus carpio* were introduced into Lake Mugesera (REMA, 2009). These fish these have spread to all the water bodies of the Kagera complex. Even though it is hypothesized that water from the Nyabarongo river could pollute the Lake, Houbraken et al. (2017) could not detect any agricultural pesticides in the lake water.

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
U Non-forested peatland

Land Use and Land Cover

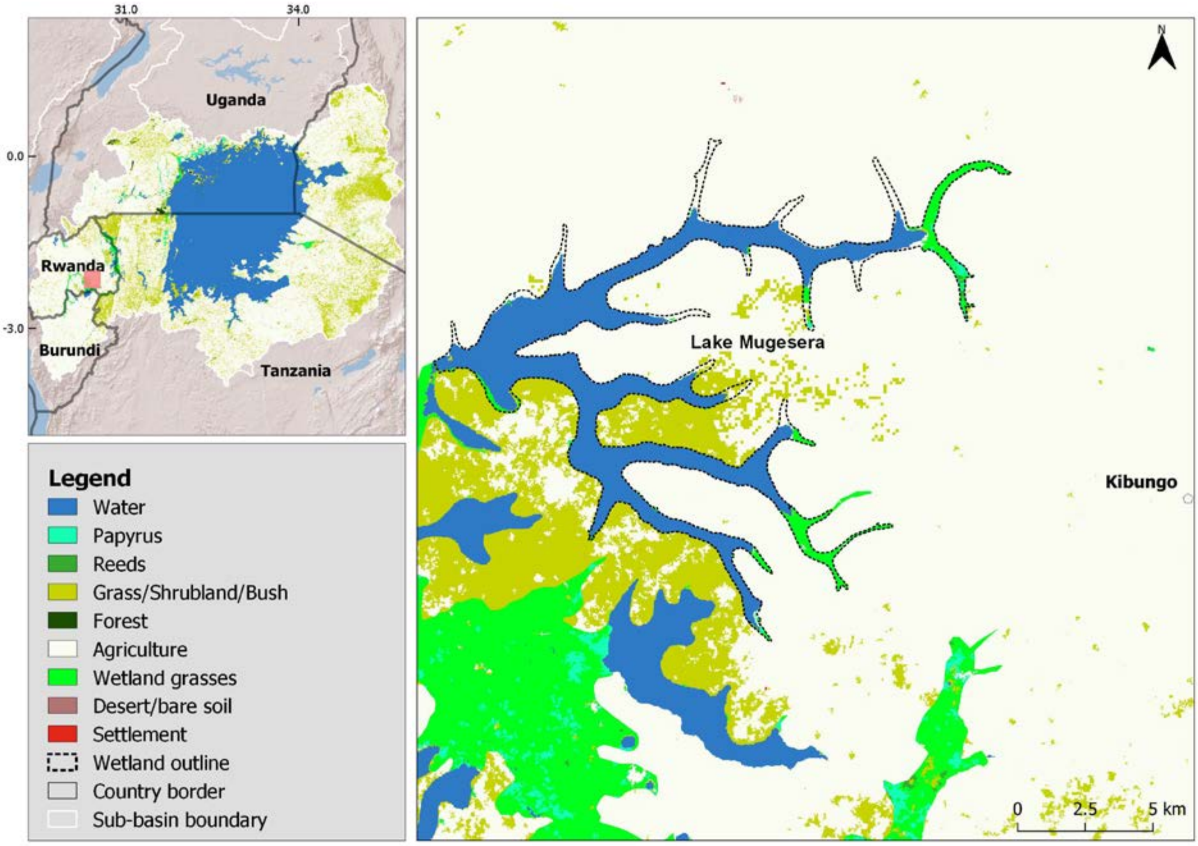

Figure 54 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

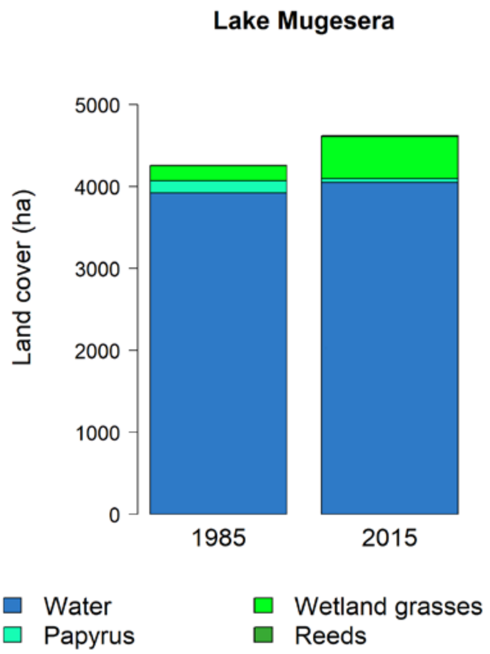

Figure 55 Land cover in 1985 and 2015

Table 31 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	3923	4050	3.2
Papyrus	147	47	-68.0
Wetland grasses	180	512	184.4
Reeds	9	9	0.0
Total area*	5139	5138	0.0

* Total area based on all 9 land cover classes

23. Kagera Swamps and Lakes

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

Overview

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 km^2.

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 un-named, 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).

Classification

Inland Wetland

- M Permanent rivers/streams/creeks
- N Seasonal/intermittent/irregular rivers/streams/creeks
- P Seasonal/intermittent freshwater lakes
- O Permanent freshwater lakes
- Tp Permanent freshwater marshes/pools
- Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil
- U Non-forested peatlands

Managemnet Status

A part of the Kagera Swamp lies within the Kagera National Park, which has recently been reduced from an area of 2,500 ha to 1,000 km^2. 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 km^2 is an Important Bird Area referred to as 'Kagera Swamps' (BirdLife International, 2019).

Table 32 Protected area related to the wetland

Name	Type*	Designation Year
Akagera	National Park (II)	1934

*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)*

Land Use and Land Cover

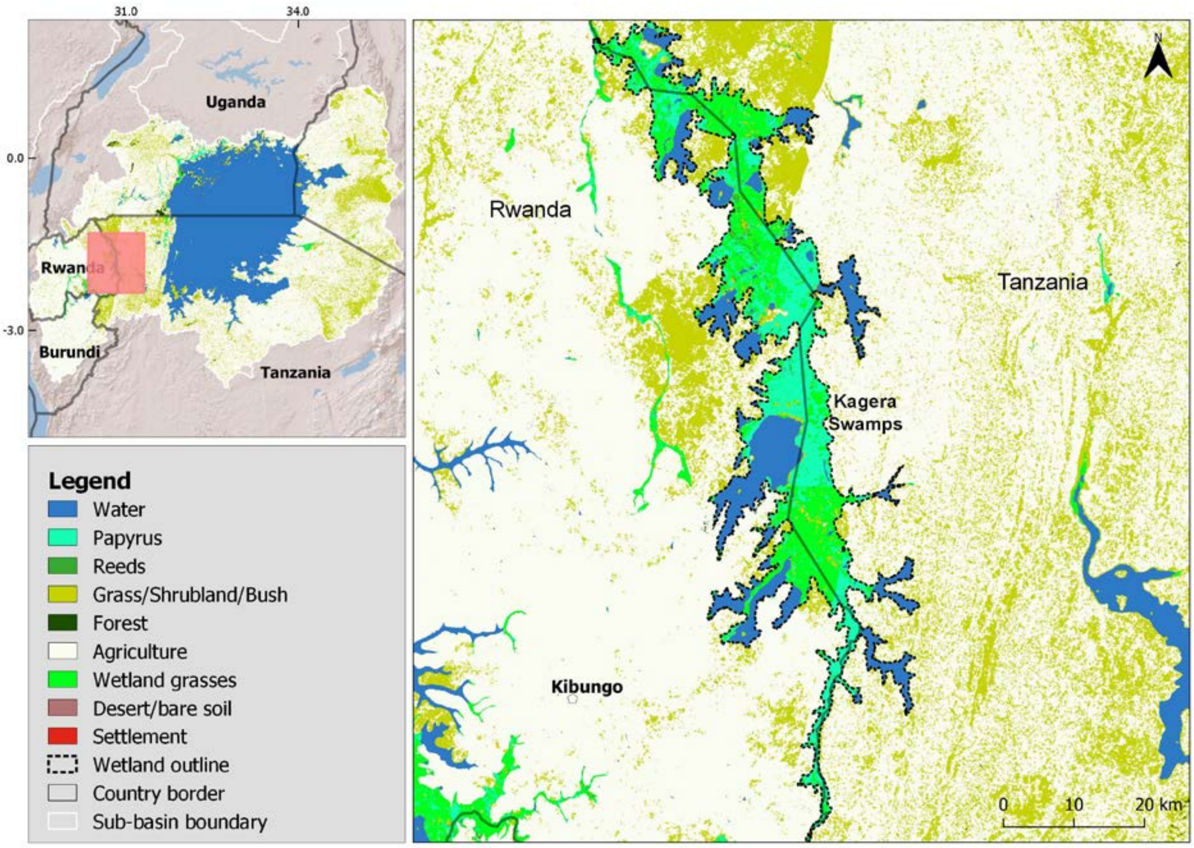

Figure 56 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

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).

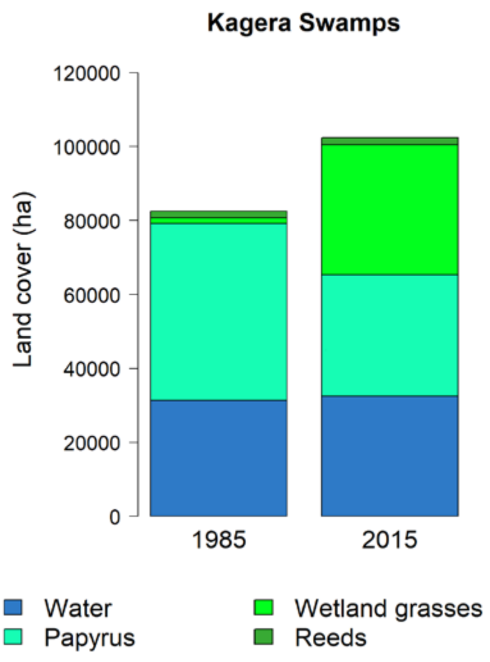

Figure 57 Land cover in 1985 and 2015

Table 33 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	31280	32474	3.8
Papyrus	47939	32879	-31.4
Wetland grasses	1454	35188	2320.1
Reeds	1865	1809	-3.0
Total area*	106022	106021	0.0

* Total area based on all 9 land cover classes

24. Lake Mburo-Nakivali System

Name: Lake Mburo-Nakivali Wetland System (The Kijanebalola Lake/Swamp Complex)
Country: Uganda
Coordinates: 1°10 ' -1°34 'N / 0°50 '-31°25 'E 5
Altitude: 1,226-1,250 m a.s.l.
Area: 369 km²
Nearest Towns: Mbarara
International Importance: Ramsar, Important Bird Area

Overview

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 system lies in shallow valleys of various tributaries of the Kagera River and consists of a central wetland and several lakes. 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 via the Kagera 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).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

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 Minenkye where the Park's headquarters are located (Byaruhanga & Kigoolo, 2005b).

Table 34 Protected area related to the wetland

Name	Type*	Designation Year
Lake Mburo	National Park (II)	1982
Kyalwamuka	Forest Reserve	1967
Kijanebalola	Forest Reserve	1967

*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)*

Land Use and Land Cover

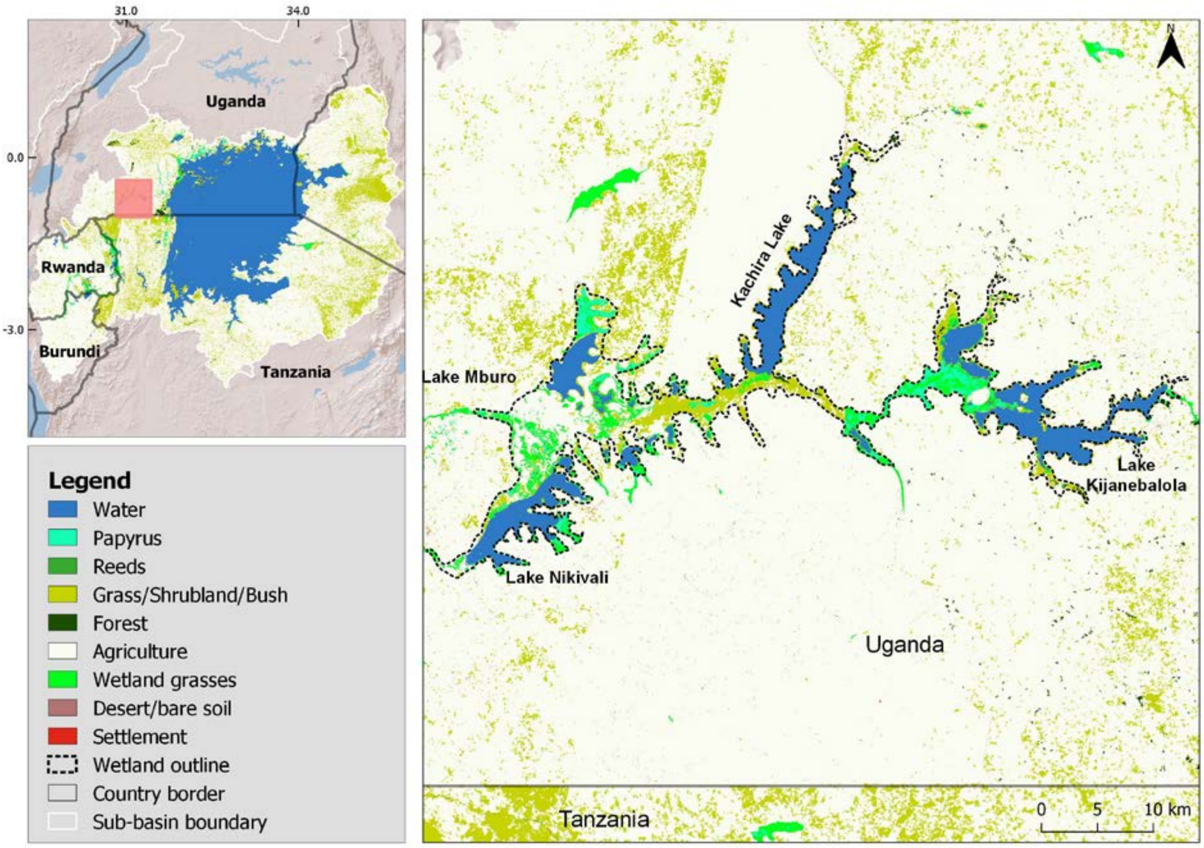

Figure 58 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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 1985-2015

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 present size (Byaruhanga & Kigoolo, 2005b).

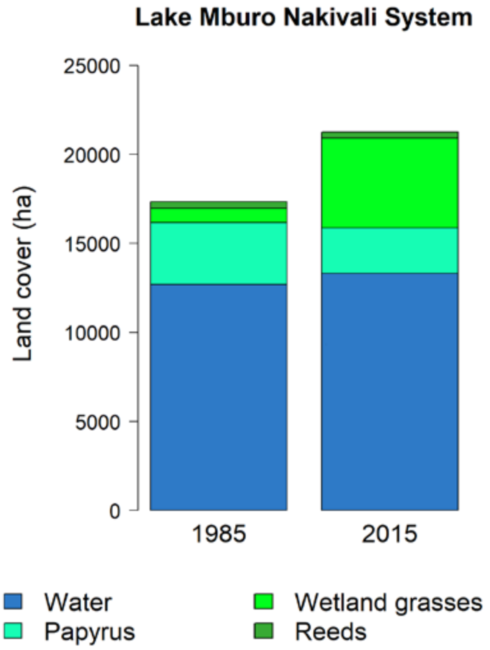

Figure 59 Land cover in 1985 and 2015

Table 35 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	12692	13302	4.8
Papyrus	3461	2565	-25.9
Wetland grasses	820	5042	514.9
Reeds	370	333	-10.0
Total area*	37128	37129	0.0

* Total area based on all 9 land cover classes

25. SAMUKA

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 km^2
Nearest Towns: Masaka, Bukoba
International Importance: Ramsar, Important Bird Area

Overview

SAMUKA complex borders Uganda-Tanzania National boundary to the southwestern shores of Lake Victoria in Sango Bay the Southern part of Uganda within the sub counties of Kyebe, Kakuuto, Kasasa and Kabira in Rakai district as well as in the subcounty of Kyanamukaka in Masaka district. It is located 25 kms from Rakai Town. Musambwa Island is also located in Kyebe sub county Rakai District and lies about 3 km from the Sango Bay shoreline.

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 are considered to belong to the Sango series, covering the entire shoreline of Lake Victoria and virtually the whole of Kyebe and parts of Kakuuto sub-counties. 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).

Classification

Inland Wetland

N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes (over 8 ha)
P Seasonal/intermittent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Management Status

Table 36 Protected area related to the wetland

Name	Type	Designation Year
Kikuru	Forest Reserve	Not reported
Rushwezi	Forest Reserve	Not reported

Land Use and Land Cover

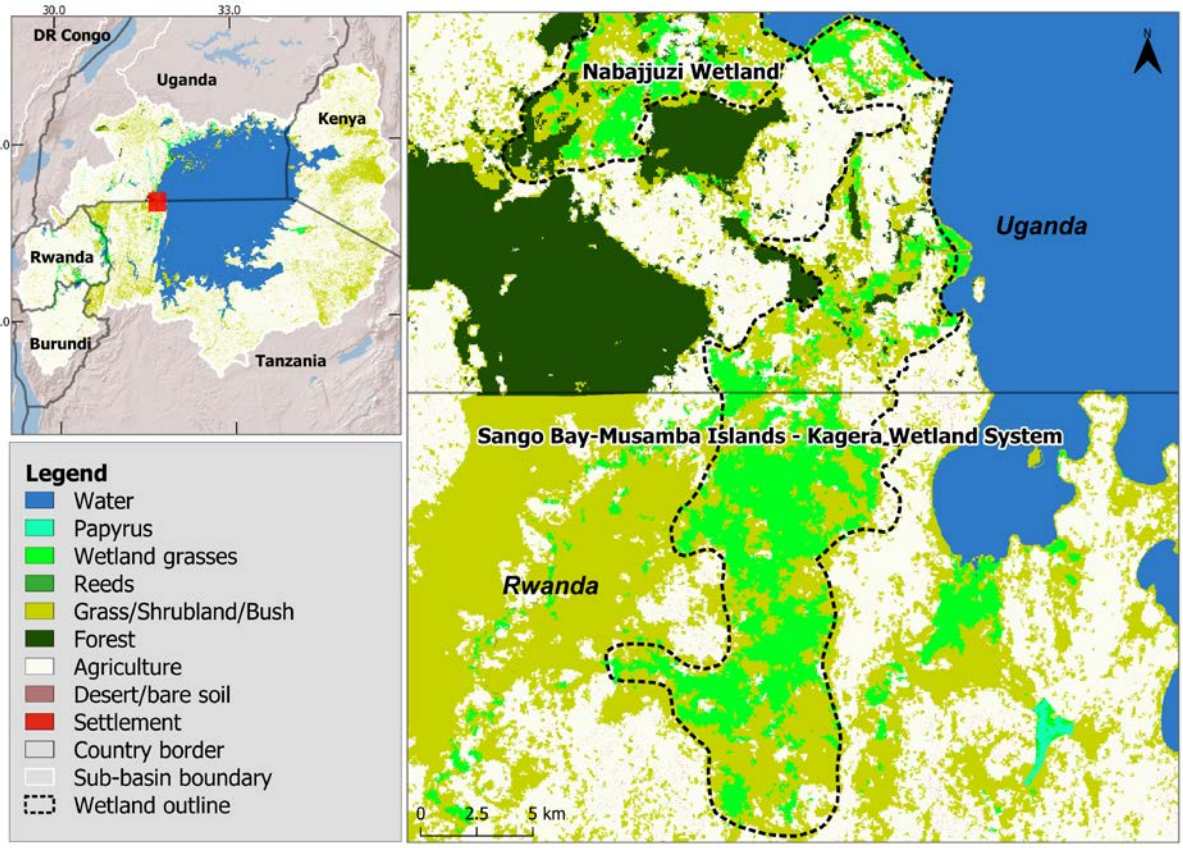

Figure 60 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

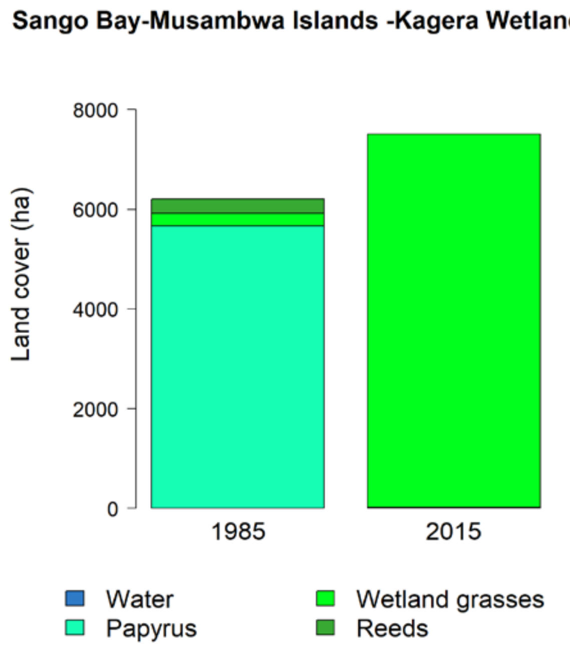

Figure 61 Land cover in 1985 and 2015

Table 37 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	6	20	233.3
Papyrus	5661	0	-100.0
Wetland grasses	252	7484	2869.8
Reeds	290	0	-100.0
Total area*	22252	22253	0.0

* Total area based on all 9 land cover classes

LV. 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 in the form of beaches, bays, estuaries and inlets. 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 weland group 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, spotted-necked 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.

26. Lake Wamala

Wetland 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 Town: Mityana

Overview
Lake Wamala is one of the six most important sources of fish in Uganda. About 785 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 maximum 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 km^2) is therefore usually separated from the Katonga Basin (Hughes & Hughes, 1992).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

U Non-forested peatland

Management Status

Table 38 Protected area related to the wetland

Name	Type	Designation Year
Walugondo	Forest Reserve	1948
Bulondo	Forest Reserve	1963
Kajonde	Forest Reserve	1963
Kasa	Forest Reserve	1932
Wamasega	Forest Reserve	1948

Land Use and Land Cover

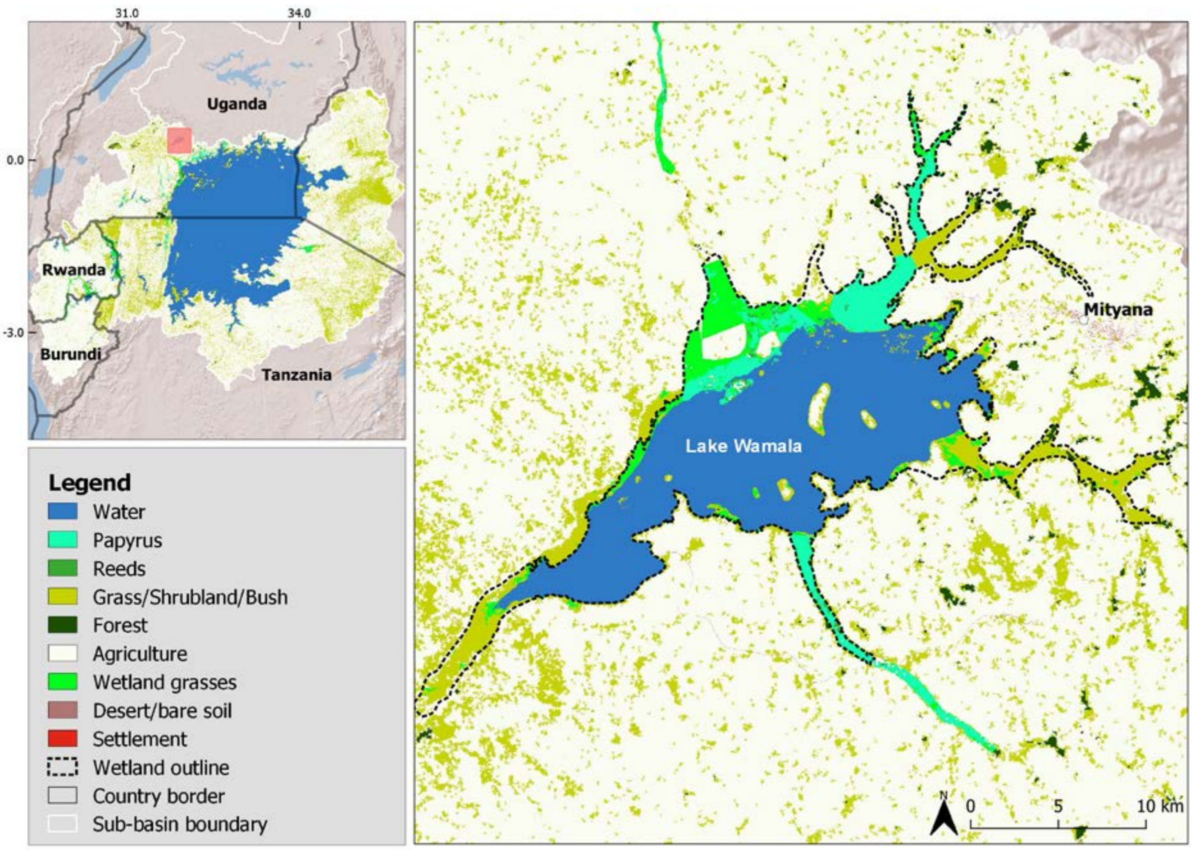

Figure 62 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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 1985-2015

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).

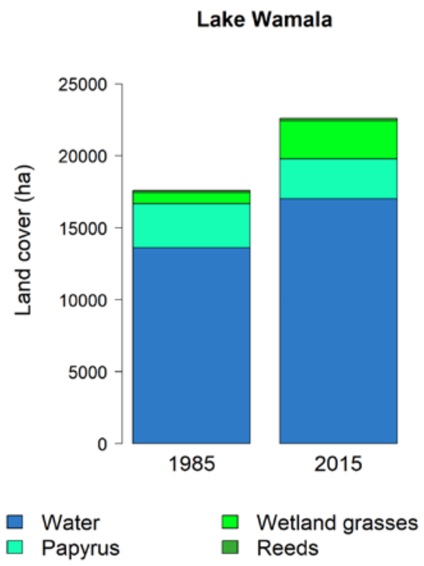

Figure 63 Land cover in 1985 and 2015

Table 39 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	13620	17011	24.9
Papyrus	3060	2780	-9.2
Wetland grasses	757	2636	248.2
Reeds	149	173	16.1
Total area*	28394	28393	0.0

* Total area based on all 9 land cover classes

27. Nabajjuzi Wetland

Name: Nabajjuzi Wetland System
Country: Uganda
Coordinates: 31°33' – 31°49'E / 0°27' – 0°05'S
Altitude: 1,200 – 1,300 m a.s.l.
Area: 170 km²
Nearest Town: Masaka
International Importance: Ramsar, Important Bird Area

Overview

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 years 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 yellow 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 floodplainsThe local community has initiated eco-tourism activities in the wetland (Byaruhanga & Kigoolo, 2005h).

Classification

Inland Wetland

Tp Permanent freshwater marshes/pools
P Seasonal/intermittent freshwater lakes
M Permanent rivers/streams/creeks
Xf Swamp forest

Management Status

Table 40 Protected area related to the wetland

Name	Type	Designation Year
Namalala	Forest Reserve	1932
Tero	Forest Reserve	1932
Kigona	Forest Reserve	1932

Land Use and Land Cover

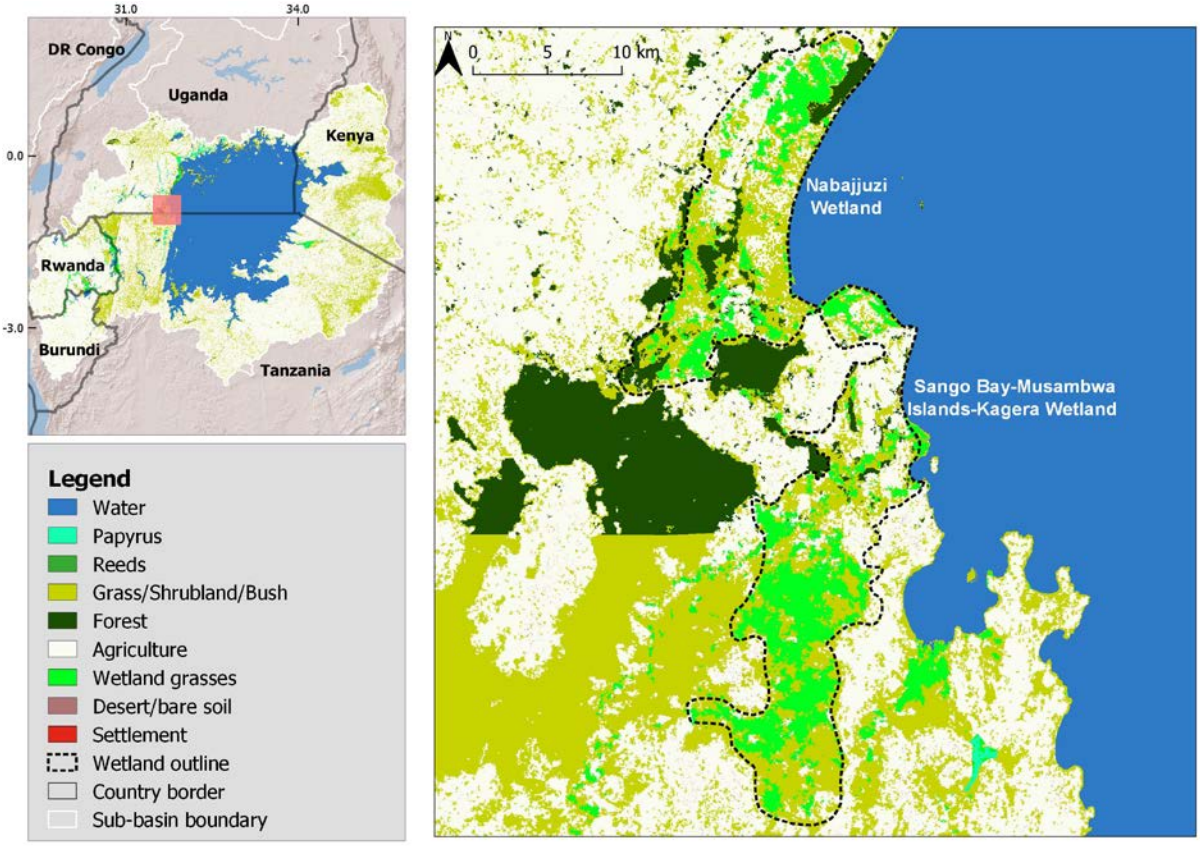

Figure 64 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

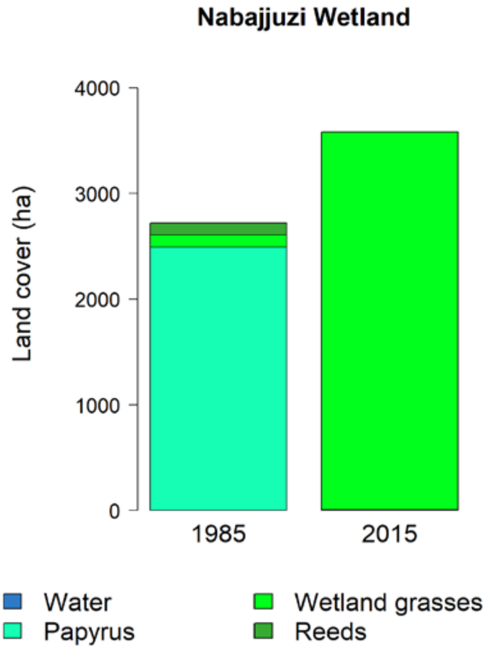

Figure 65 Land cover in 1985 and 2015

Table 41 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1	6	500.0
Papyrus	2489	0	-100.0
Wetland grasses	116	3573	2980.2
Reeds	112	0	-100.0
Total area*	17012	17012	0.0

* Total area based on all 9 land cover classes

28. 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.
Area: 146 km²
Nearest Towns: Masaka
International Importance: Ramsar, Important Bird Area

Overview

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 Kayanja 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).

Classification

Inland Wetland

O	Permanent freshwater lakes (over 8 ha)
Tp	Permanent freshwater marshes/pools
Ts	Seasonal/intermittent freshwater mashes/pools

Land Use and Land Cover

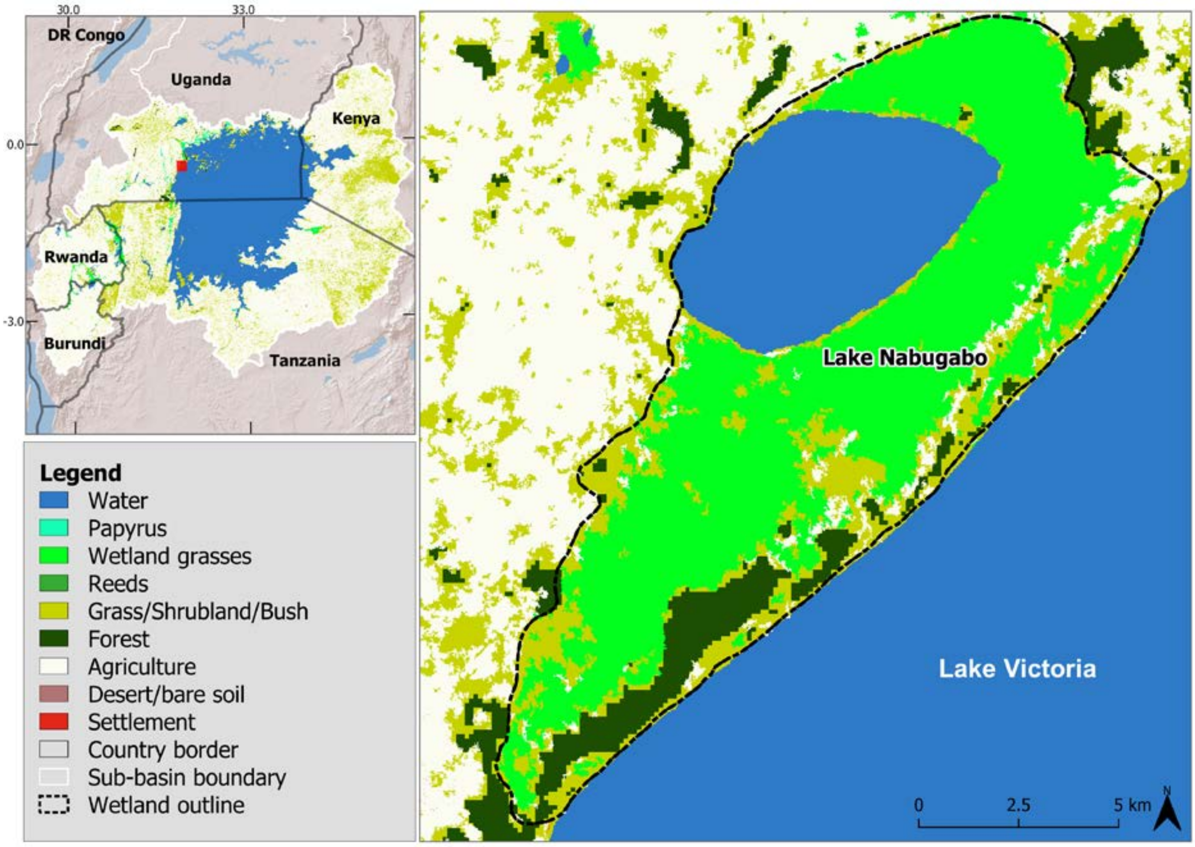

Figure 66 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

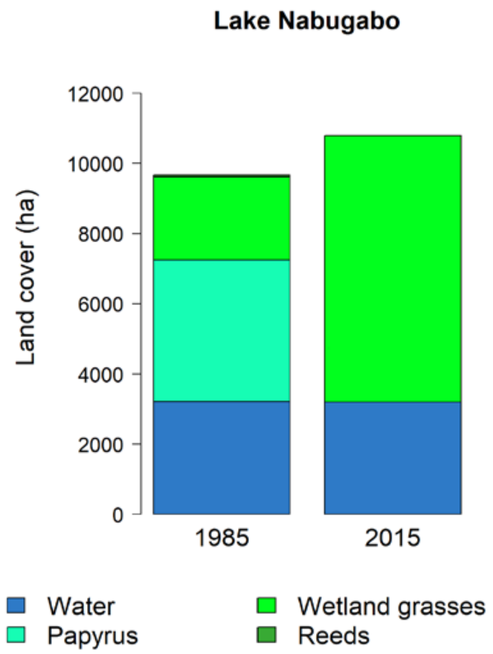

Figure 67 Land cover in 1985 and 2015

Table 42 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	3220	3207	-0.4
Papyrus	4028	0	-100.0
Wetland grasses	2376	7579	219.0
Reeds	48	0	-100.0
Total area*	14630	14632	0.0

* Total area based on all 9 land cover classes

29. 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.
Area: 226 km²
Nearest Towns: Entebbe, Mpigi
International Importance: Ramsar, Important Bird Area

Overview

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).

Classification

Inland Wetland

Tp Permanent freshwater marshes/pools

O Permanent freshwater lakes (over 8 ha)

Management Status

Table 43 Protected area related to the wetland

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)*

Land Use and Land Cover

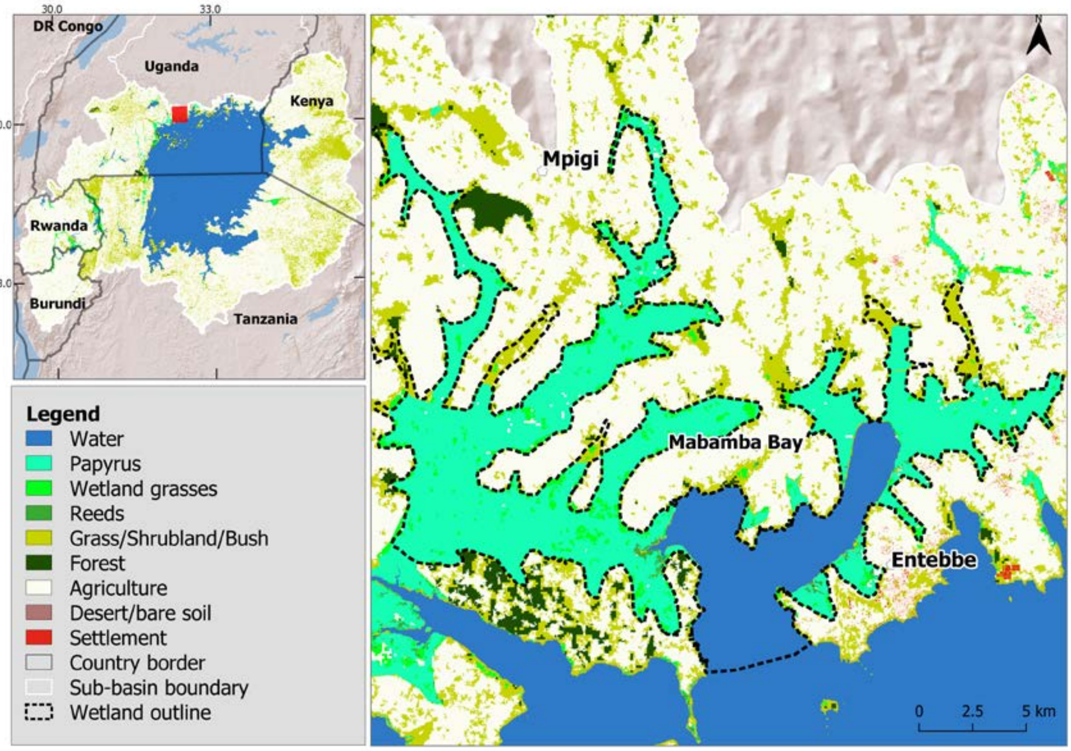

Figure 68 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

<u>Change Trajectories 1985-2015</u>

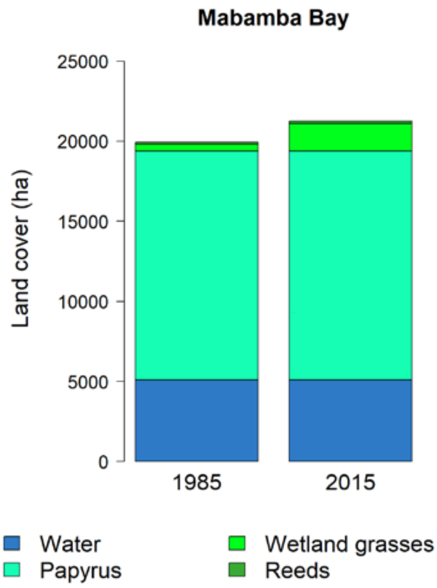

Figure 69 Land cover in 1985 and 2015

Table 44 Land cover in 1985 and 2015 and percentage of change

	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	5113	5103	-0.2
Papyrus	14280	14280	0.0
Wetland grasses	405	1726	326.2
Reeds	132	132	0.0
Total area*	22882	22881	0.0

* Total area based on all 9 land cover classes

30. 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 km^2
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 near-threatened 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, 2005e).

Classification

Inland Wetland

Tp Permanent freshwater marshes/pools
P Seasonal/intermittent freshwater lakes
O Permanent freshwater lakes (over 8 ha)
M Permanent rivers/streams/creeks

Land Use and Land Cover

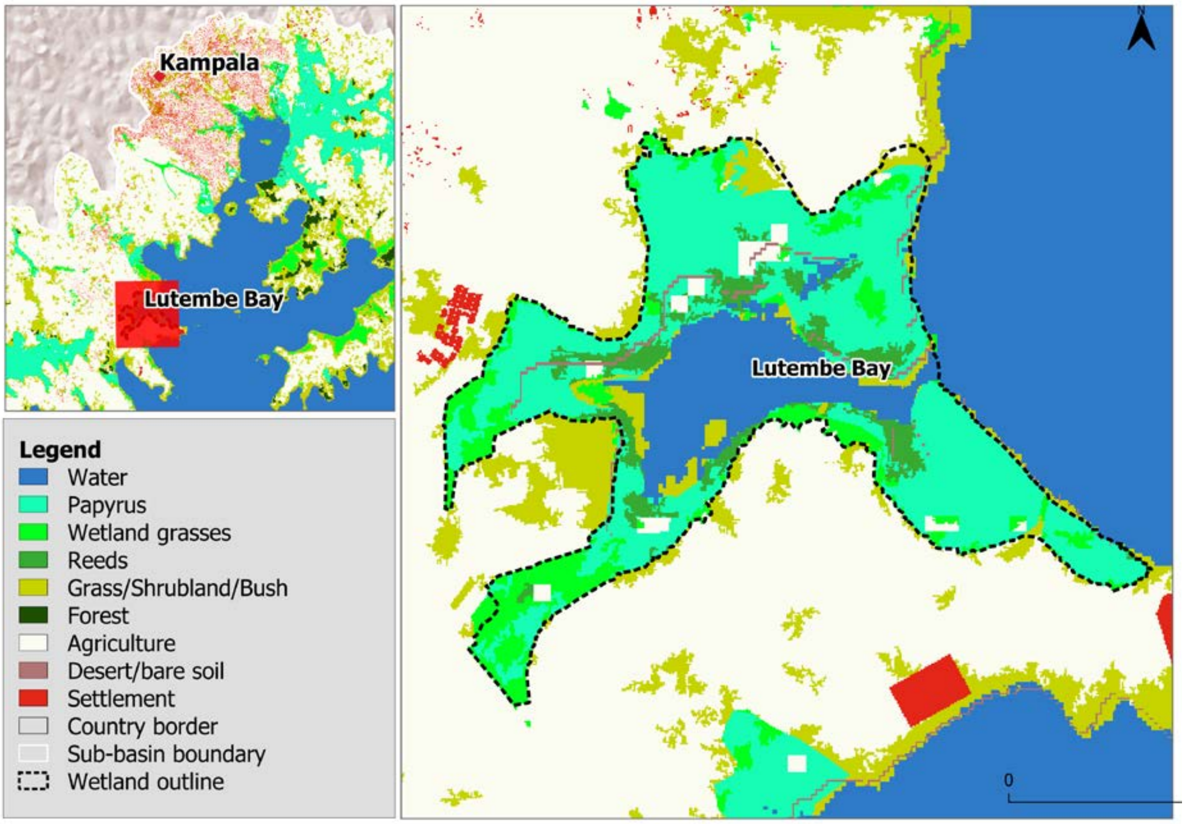

Figure 70 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Nutrinet loading from the Nakivubo Catchemnt, which includes the district of the city of Kampala is high. Therefore 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).

Change Trajectories 1985-2015

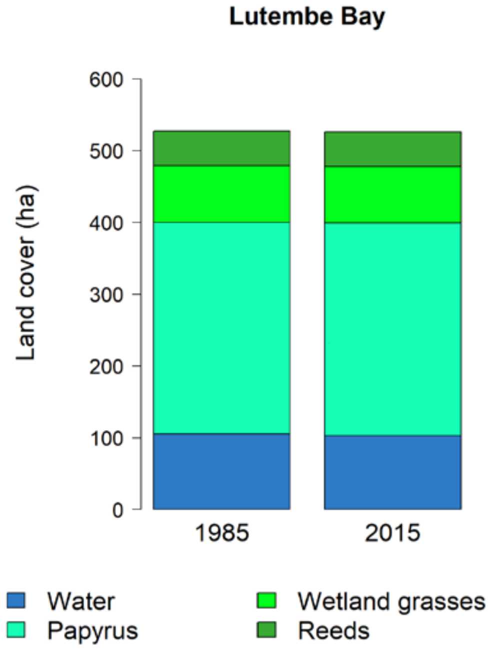

Figure 71 Land cover in 1985 and 2015

Table 45 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	105	103	-1.9
Papyrus	295	296	0.3
Wetland grasses	79	79	0.0
Reeds	48	48	0.0
Total area*	585	585	0.0

* Total area based on all 9 land cover classes

31. Winam Gulf

Name: Winam Gulf (Kisumu Bay, Kavirondo Gulf, Nyanza Gulf, Lake Nyanza Gulf)
Country: Kenya
Coordinates: 0°30'N-3°12 ' S/31°37 ' -34°53 'E
Altitude: 1134 m a.s.l.
Area: 1,438 km²
Nearest Towns: Kisumu, Kendu Bay
International Importance: Important Bird Area (Dunga Swamp, Koguta Swamp)

Overview

Winam Gulf is a shallow bay on the eastern side of Lake Victoria and lies entirely in Kenya. It is 550 km long shoreline is fringed by papyrus wetlands. Winam Gulf has a total area of 1,400 km^2 a mean depth of 7 m and a maximum depth of 30 m (Misigo & Suzuki, 2018). The port town of Kisumu lies on the eastern edge of the bay and Mbita marks the western end of Winam Gulf. The gulf is connected to the main lake through the approximately 5 km broad Rusinga Channel.

Physical Features

Multiple rivers including Nyando River, Sondu-Miriu, Awach-Kibuon, Awach-Tende and Kibos enter Winam Gulf determining the biochemical properties of this bay. Freshwater renewal time in the gulf is three years, due to its shallowness and extensive inputs from rivers. These five major tributaries discharge approximate 7.5 mio m^3/day into Winam Gulf (Misigo & Suzuki, 2018). The shoreline of Winam Gulf is fringed with papyrus wetlands. The Nyando Wetland as well as a number of smaller wetlands e.g. swamp Kibos, Nduru, the Kusa Swamps and Dunga Wetland are part of Winam Gulf. The Dunga Swamp is a small papyrus wetland located a little bit off Kisumu covering approximately 1000 ha.

The gulf's basin is highly populated and land is used for subsistence agriculture as well as industries. Phaeozems, Nitisols and Acrisols are common soil types in the Winam Gulf Basin. Deforestation, land degradation and flash floods lead to higher runoff and therefore sediment input into the gulf. Hence the water in the gulf is highly eutrophic and turbid. River Awach-Tende and Awach-Kibuan discharge approximately 1.60 mg/L per day total nitrogen into Winam Gulf (Misigo & Suzuki, 2018). These nitrogen and phosphorous loads are highest between April and May but within the Gulf nutrient dynamics are driven by strong currents. Cyanobacteria algae blooms occur between June and August. These blooms have resulted in fish kills and the shutdown of drinking water supply, as some cyanobacteria species produce toxins which pose health risks for livestock and communities who rely on water from Winam Gulf for drinking and sanitation. Winam Gulf is relatively well studied concerning water quality, phytoplankton distribution and hydrodynamics (Gichuki et al., 2012; Misigo & Suzuki, 2018; Okely et al., 2010; Simiyu et al., 2018).

The gulf is infested by water hyacinth (*Eichhornia crassipes*). This invasive species exhibits a periodic cyclical pattern of decline and proliferation. Introduced to Lake Victoria in the late 1980s, Winam Gulf was one of the most severely affected areas in Lake Victoria during a water hyacinth outbreak in 1998. More than 17, 000 ha of the gulf were covered with water hyacinth (Albright et al., 2004). However, until 2005 water hyacinth almost disappeared again in the Gulf. In more recent years, water hyacinth covers an average area of 5,000 ha in Winam Gulf (Ongore et al., 2018). Water hyacinth alters light availability, oxygen concentration and nutrient availability. Thereby tolerant species such as hippo grass and its associated vegetation is favoured and formerly dominant macrophytes such as *Azolla nilotica* are outcompeted (Gichuki et al., 2012). The Dunga and Kotuga swamps on the shoreline of Winam Gulf are both Important Bird Areas (BirdLife International, 2019)

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland **Management Status**

Table 46 Protected area as part of the wetland

Name	Type*	Designation Year
Ndere	National Park (II)	1986
Kisumu Impala	National Sanctuary (IV)	1992

*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)*

Land Use and Land Cover

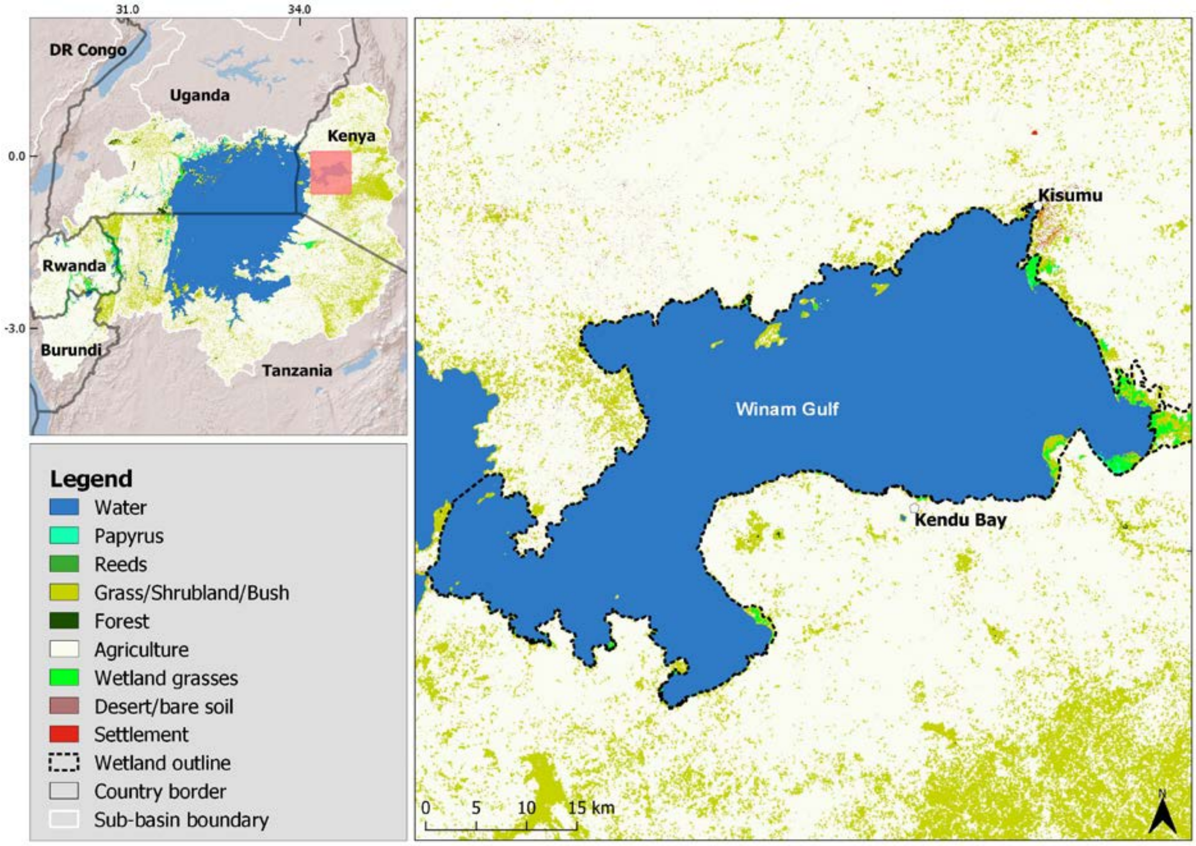

Figure 72 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

Though the main tributaries of Winam Gulf (Yala, Nzoia, Sio, and Nyando) sediments and water enriched with nutrients from industry and agriculture in the respective catchments is washed into Winam Gulf. Land use change, deforestation and frequent flash floods increase erosion and sediment input. This results in a highly eutrophic system, with turbid water. These conditions are favourable for water hyacinth proliferation which in turn impacts aquatic fauna and flora. Anoxic water below water hyacinth mats is unfavourable for fish populations and jeopardizes artisanal fisher folk's livelihoods. In addition large mats of water hyacinth obstruct access to shorelines and landing sites for fishermen. Marine transportation and hydroelectric power production is thereby also inhibited (Albright et al., 2004; Simiyu et al., 2018; Ongore et al., 2018).

Change Trajectories 1985-2015

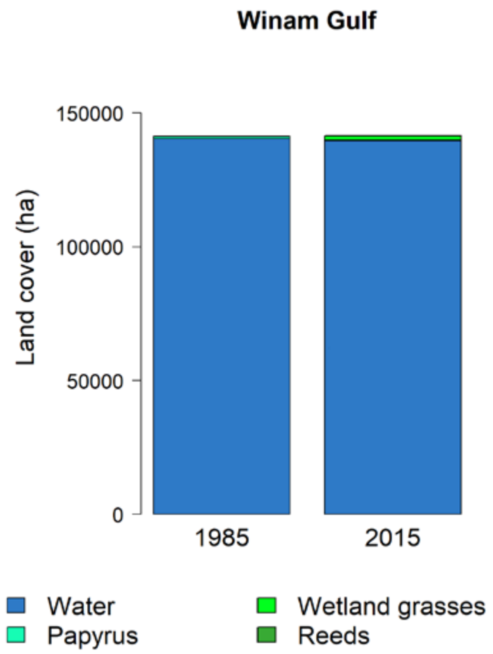

Figure 73 Land cover in 1985 and 2015

Table 47 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	140447	139616	-0.6
Papyrus	685	191	-72.1
Wetland grasses	147	1605	991.8
Reeds	72	22	-69.4
Total area*	144175	144176	0.0

* Total area based on all 9 land cover classes

3.1.2 Victoria Nile

Overview

The seasonal and wetlands in the Victoria Nile Sub-basin 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 non-timber 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.

Land Cover

Table 48 Land cover change in the Victoria Nile Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	3244	3227	-0.5
Papyrus	1116	1093	-2.0
Wetland grasses	649	2196	238.2
Reeds	203	14	-93.1
Total area*	85771	85771	0.00

* Total area based on all 9 land cover classes

VN. Lake Kyoga

Overview

Lake Kyoga is a shallow, large lake surrounded by wetlands and lakes to the east. The maximum depth of Lake Kyoga is 5.7 m and most of the lake is less than 3 m deep. Kyoga is a natural lake with lacustrine swamp wetlands approximately 1,720 km2. The eastern end inflows are from Mount Elgon and the northern province of Uganda, Karamoja. The western part of the lake receives the main inflow from Lake Victoria, via the Victoria Nile. The outflow, Kyoga Nile, falls over 400 m before joining the outflow from Lake Albert (Green, 2009b; NEMA, 2008; Rebelo & McCartney, 2012)

Climate

The climate at Lake Kyoga, Bisina and Opeta is tropical and is influenced by the air currents such as the southeast and northeast monsoons. The area experiences a uni-modal low rainfall, in contrast to the bimodal pattern of the south and west of Uganda. Rainfall is erratic, variable and highly localized. In general higher rainfall occurs in the first rainy season of October to December than in the second one from March to May.

At Kibale station the total annual rainfall can range from just under 500 to 1200 mm/year (Byaruhanga & Kigoolo, 2005a). Mean annual minimum temperatures at Lake Bisina and Opeta range from 15 to 17.5 ^{o}C and mean maximum temperature from 30-32.5 ^{o}C. Higher temperatures are experienced in the westerly plains. Because of this temperature range, the evapotranspiration ranges between 1750-1900 mm (NEMA (National Environmental Management Authority), 2017).

Biological features

There are 40 taxa in the Lake Kyoga system that have an IUCN threat status of interest. In total there are 30 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, Lates niloticus and Pistia stratiotes* are important alien species in the wetland group. Lake Kyoga is of international importance with regards to the conservation of endemic wetland species and its high concentration of endemic cichlid fish species. Over 46 fish species are sheltered by Lake Kyoga, along with numerous crocodiles. Lake Kyoga satellite lakes such as Bisina and Opeta are important refuges for the endemic fish species as they have not yet been invaded by the Nile Perch.

The vegetation of Kyoga is complex with a fringe of *Cyperus papyrus* (papyrus) which also occurs as floating islands and areas where the water is less than 3 m deep are covered by *Nymphea spp*. *Eichhornia crassipes* (water hyacinth) invaded Lake Kyoga in approximately 1988 and has influenced the distribution of some of the submerged plants such as *Ceratophyllum* and *Myriophyllum* (Green, 2009b; Rebelo & McCartney, 2012).

The fauna of Lake Kyoga includes *Tragelaphus spekii* (Sitatunga), *Crocidura mourisca* (northern swamp musk shrew), *Lutra maculicollis (*spotted-neck otter), *Alilax oaludinosus* (marsh mongoose), *Cercooithecus aethiops* (vervet monkey), *Hippopotamus amphibius* (hippopotamus), *Pelomy hopkinsi* (papyrus rat), *Colobus satanas (*black-and-white Colobus Monkey), *Erythrocebus patas (*red hussar monkey), *Kobus kob (*white-eared kob), *and Ourebia ourebi (*oribi) (Rebelo & McCartney, 2012).

Ecosystem Services

Lake Kyoga provides an important habitat for wildlife, and several regulating services like water flow and erosion regulation, water purification, maintains soil fertility, climate and natural hazard regulation. Lake Kyoga also provides food in the forms of fish, game, and fodder for livestock and farmland, as well as fresh water, medicinal products, raw materials for construction and handcrafts, and water as a means of transportation (Karanja et al., 2001) The ecosystem services identified for Lake Kyoga are further presented in WP 3: Ecosystem Service Assessment.

32. Lake Bisina

Wetland Name: Lake Bisina; Lake Salisbury
Country: Uganda
Coordinates: 1°37'6.32"N / 33°57'12.95"E
Altitude: 1,045 m a.s.l.
Area: 178 km²
Nearest Towns: Kumi Town , Soroti
International Importance: Ramsar, Important Bird Area

Overview

Lake Bisina is located in the north eastern part of Uganda in the districts of Nakapiripirit, Sironko, Katakwi and Kumi. Lake Opeta drains into Lake Bisina through a marshy wetland area. Lake Bisina is a Ramsar site and part of an Important Bird Area.

Physical Features

Lake Bisina is oriented EW and is 30 km long and up to 9 km wide, with a maximum surface area of 210 km^2 at high water. It drains from its western end through swamps, to the Okere system which leads in diffuse fashion to the swamps at the head of the Mpologoma Arm of Lake Kyoga. Lake Bisina 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. Through a thick swamp, Lake Bisina receives water from Lake Opeta. Bisina has few affluents, the largest is the seasonal Apedura River, which rises to the north on the slopes of Mt. Akim (Byaruhanga & Kigoolo, 2005a).

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 ^oC and mean maximum temperature from 30 -32.5 ^oC. 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).

Classification

Inland Wetland

O	Permanent freshwater lakes (over 8 ha)
Tp	Permanent freshwater marshes/pools
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils
U	Non-forested peatland

Land Use and Land Cover
The area is mainly used by the Karimojong and the Pokot people for grazing their animals in the dry season.

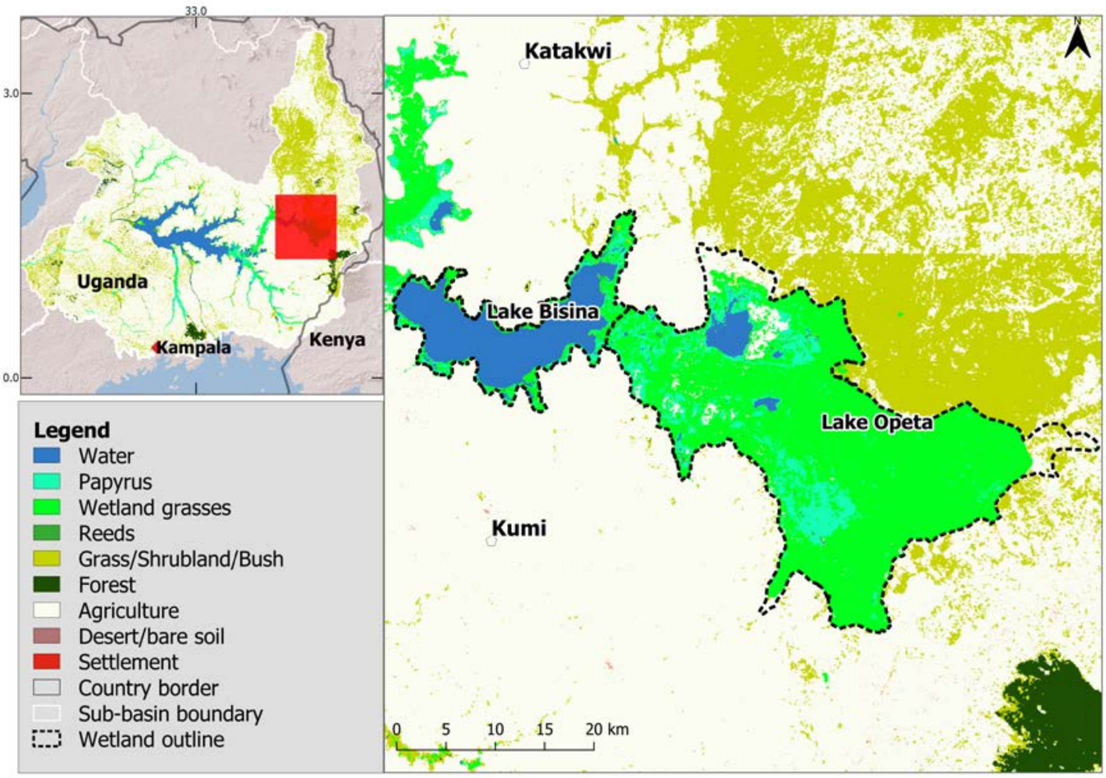

Figure 74 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Drivers of Change
Overfishing and use of damaging fishing methods as a result of commercial fishery requires implementation of conservation measures. Hunting for the sitatunga is of conservation concern. Threats from the catchments area unsustainable farming methods and low environmental awareness. Habitat degradation as a result of grazing is also a potential threat to the system (Byaruhanga & Kigoolo, 2005a).

Change Trajectories 1985-2015

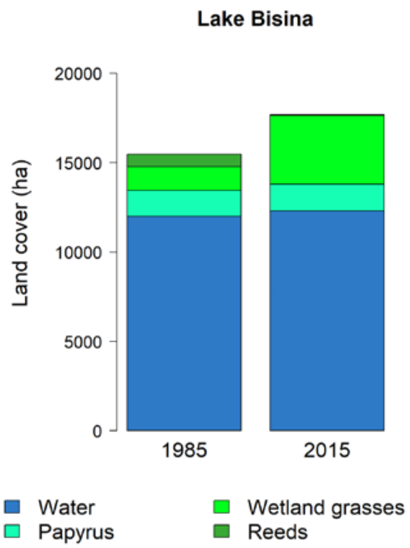

Figure 75 Land cover in 1985 and 2015

Table 49 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	12001	1230	2.5
Papyrus	1442	1497	3.8
Wetland grasses	1334	3839	187.8
Reeds	695	37	-94.7
Total area*	178370	178370	0.0

* Total area based on all 9 land cover classes

33. Lake Opeta

Wetland 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 km^2. 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 ^{o}C and mean maximum temperature from 30 -32.5 ^{o}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).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)

Tp Permanent freshwater marshes/pools

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

U Non-forested peatland

Land Use and Land Cover

The area is mainly used by the Karimojong and the Pokot people for grazing their animals in the dry season.

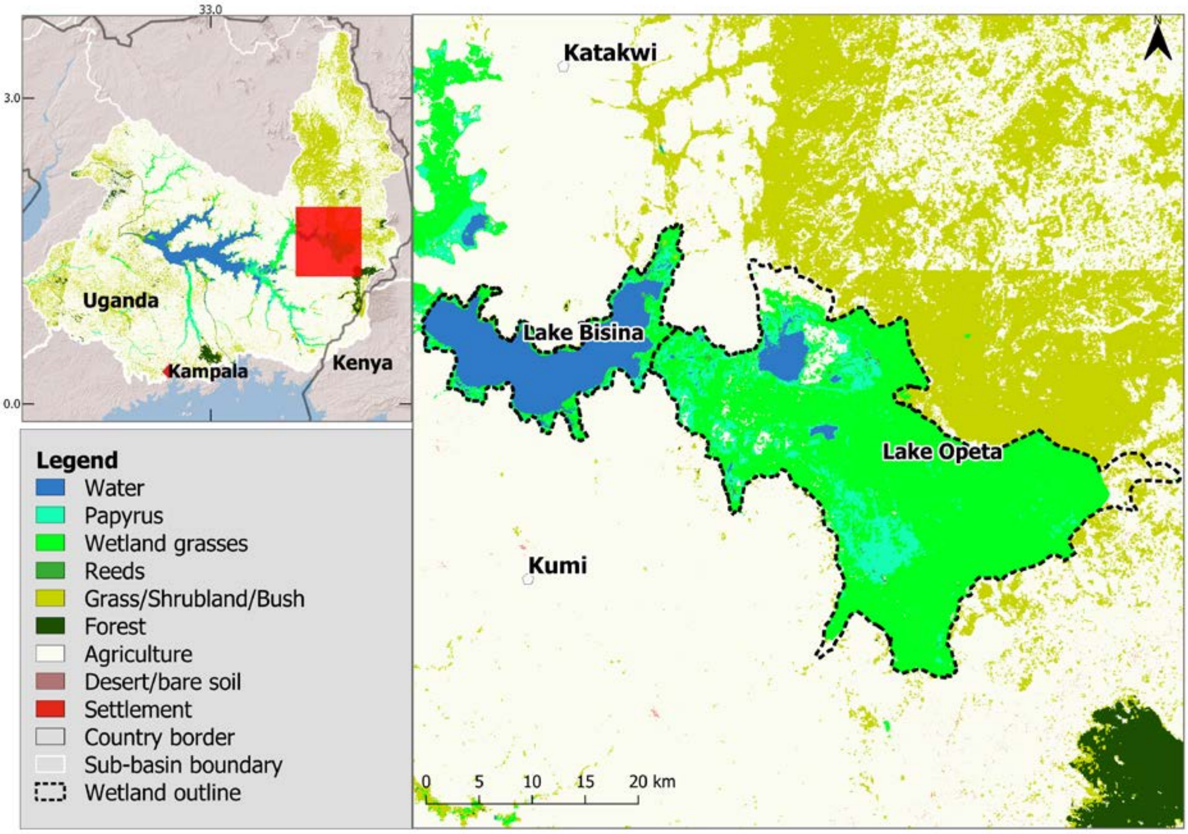

Figure 76 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

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 long-term impact on the ecology and character of the area (Byaruhanga & Kigoolo, 2005d).

Change Trajectories 1985-2015

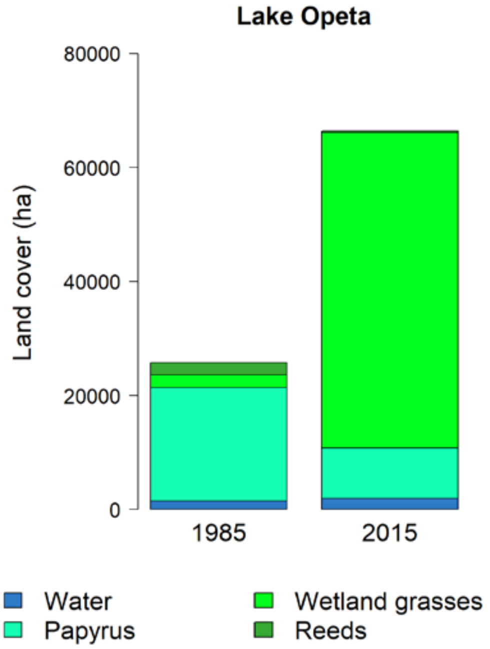

Figure 77 Land cover in 1985 and 2015

Table 50 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1510	1934	28.1
Papyrus	19910	8886	-55.4
Wetland grasses	2192	55246	2420.4
Reeds	2183	282	-87.1
Total area*	721990	721990	0.0

* Total area based on all 9 land cover classes

34. Kyoga/Kwania Lake/Swamp Complex Lake Nakuwa Wetland System Ramsar Site

Wetland 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, Namasajerl, 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).

Classification

Inland Wetland

O	Permanent freshwater lakes (over 8 ha)
Tp	Permanent freshwater marshes/pools
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils

Management Status

Table 51 Protected area related to the wetland

Name	Type	Designation Year
Sala	Forest Reserve	1965
Oduarata	Forest Reserve	1965
Monikakinei	Forest Reserve	1965
Lumoto	Forest Reserve	1965
Kagwara	Forest Reserve	1948
Buyenvu	Forest Reserve	1965
Buwola	Forest Reserve	1968
Bululu Hill	Forest Reserve	1965
Bugaali	Forest Reserve	1965
Budunda	Forest Reserve	1965

Land Use and Land Cover

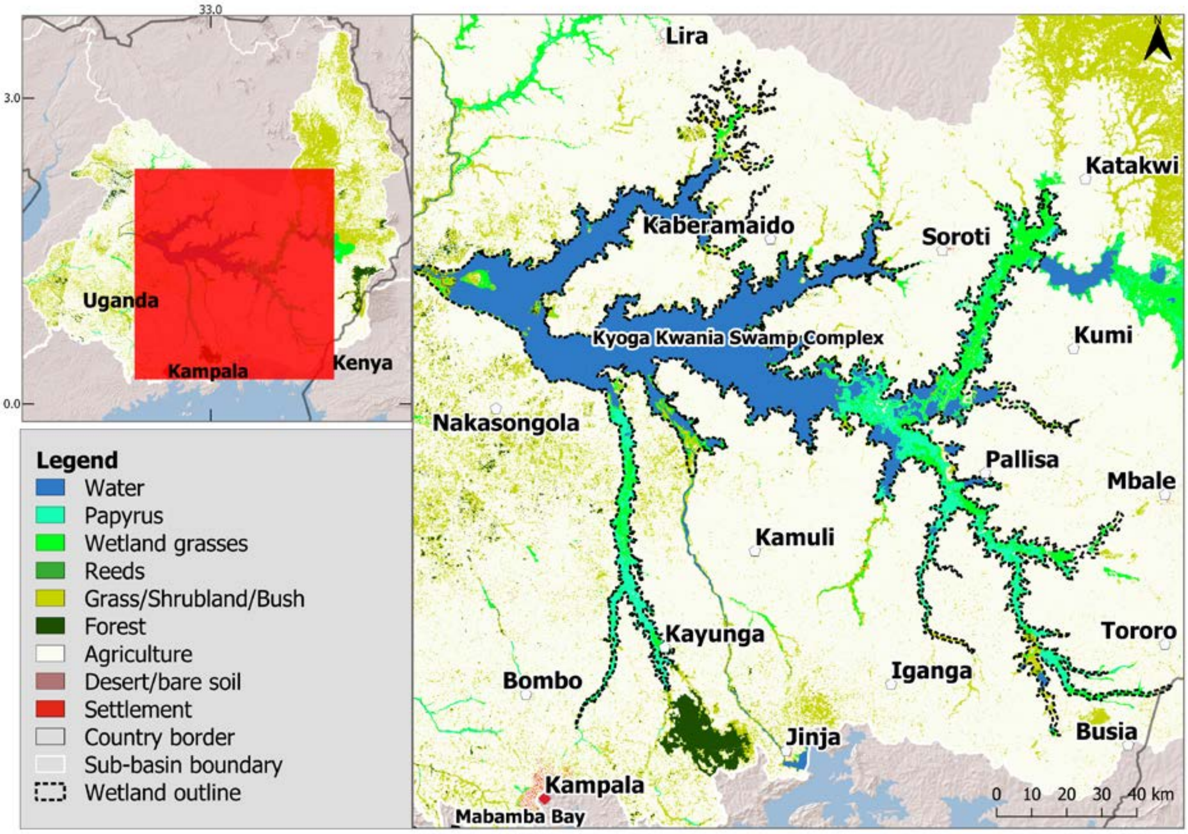

Figure 78 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Change Trajectories 1985-2015

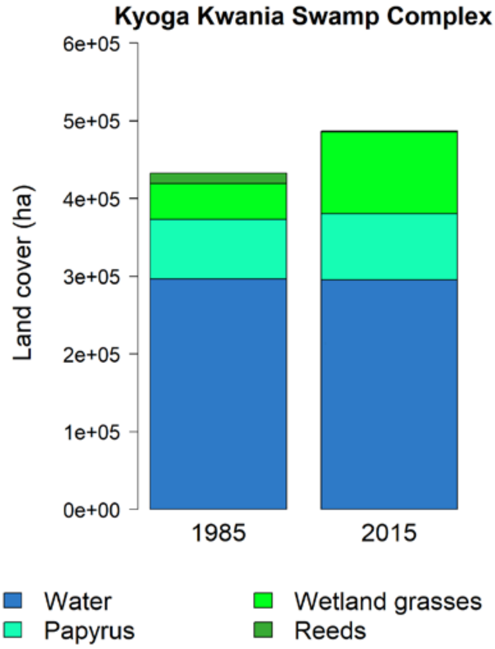

Figure 79 Land cover in 1985 and 2015

Table 52 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	296719	295478	-0.4
Papyrus	76658	85252	11.2
Wetland grasses	45780	105141	129.7
Reeds	13837	824	-94.0
Total area*	546103	546104	0.0

* Total area based on all 9 land cover classes

3.1.3 Lake Albert

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 Mai 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 this sub-basin 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.

Table 53 Land cover change in the Lake Albert Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	8201	8223	0.3
Papyrus	296	217	-26.7
Wetland grasses	253	534	111.2
Reeds	59	3	-95.3
Total area*	74920	74920	0.3

* Total area based on all 9 land cover classes

LA. Semliki Wetlands

Overview

The Semliki River is the largest river in the Lake Albert Basin. It provides drainage from the Ruwenzori Range it is a major contributor to Lake Albert. The river originates in Lake Edward, flows for 230 km and discharges into Lake Albert at its southern end. Lake Edward is connected to Lake George on its north eastern side by the Kazinga Channel. The Semliki Wetlands have both natural lakes and lacustrine swamps, and riverine and floodplain wetlands (Green, 2009a).

Climate

The climate of the Semliki Wetland group is tropical, affected by seasonal movements of the intertropical convergence zone and by altitude and topography. There are two rainy seasons each year from March to May and from October to November. The mountain range in the Lake Albert Basin influences the distribution of rain. Most of the plains at the foot of the range lie in a rain shadow. 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).

Biological features

There are 72 taxa in the Semliki Wetland group that have an IUCN threat status of interest. In total there are 36 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 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 *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 Lakes Kivu and Edward where *P. pectinatus* is most common. The river stretch between the Murchison Falls and the Lake Albert River Delta hosts one of the biggest Nile crocodile populations in the world. The vulnerable African elephant can also be found in the Murchison National Park. The Murchison 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 the lake and the delta is important (Byaruhanga & Kigoolo, 2005g). The Queen Elisabeth National Park (Lake George and Edward) is one of the most popular National Parks in Uganda for birdwatchers as it lists more than 600 species, the highest number recorded in any IBA in Uganda and probably the highest of any protected area in Africa (Ministry of Environment Protection, 1990).

Lake Albert and Lake Victoria share a few common fish species, however in general the fish fauna of Lake Albert is very different to Lake Victoria and Lake 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 & 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). Due to its high altitude the flora and fauna of the Rwenzori wetlands differs from the lakes in the sub basin and is therefore described separately.

Ecosystem Services
The Murchinson-Semliki forests play an important role for 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 Rwenzori greatly benefits from the runoff from the range as well as direct rainfall, which is regulated by the mountains. There are irrigation schemes, hydro power stations and domestic water supplies, both locally and internationally, resulting out of this basin. Other regulating and supporting services include maintenance of soil fertility, and natural hazard and climate regulation (Akwetaireho et al., 2011; Byaruhanga & Kigoolo, 2005g; Uganda Wildlife Authority, 2008)

Besides all Semliki Wetlands 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 Murchison Falls Wetland support important indigenous fish species, which differ from Lake Victoria. The wetlands act as a nursery for fish, which are commercially important for fishermen (Byaruhanga & Kigoolo, 2005g).

The Murchison Falls -Semliki region is also important for cultural, recreational and educational values (Akwetaireho et al., 2011). The Victoria Nile Delta, as part of a national park is a touristic area and an attractive destination for birdwatchers (Byaruhanga & Kigoolo, 2005g). The ecosystem services identified for the Semliki Wetlands are further presented in WP 3: Ecosystem Service Assessment.

35. 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 km^2. It is Uganda's largest and most valuable basin and gives rise to big rivers that feed into Lake George, Edward and Albert and later into 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).

Classification
<u>Inland Wetland</u>
M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatlands; includes shrub or open bogs, swamps, fens.
Va Alpine wetlands; includes alpine meadows, temporary waters from snowmelt.
Vt Tundra wetlands; includes tundra pools, temporary waters from snowmelt.
Xf Freshwater, tree-dominated wetlands

Management Status

The Rwenzori Mountains National Park is a stated 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).

Table 54 Protected area related to the wetland

Name	Type*	Designation Year
Rwenzori Mountains	National Park (II) World Heritage Site	1991 1994
Virunga	National Park (II) World Heritage Site	1991 1994

*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)*

Land Use and Land Cover

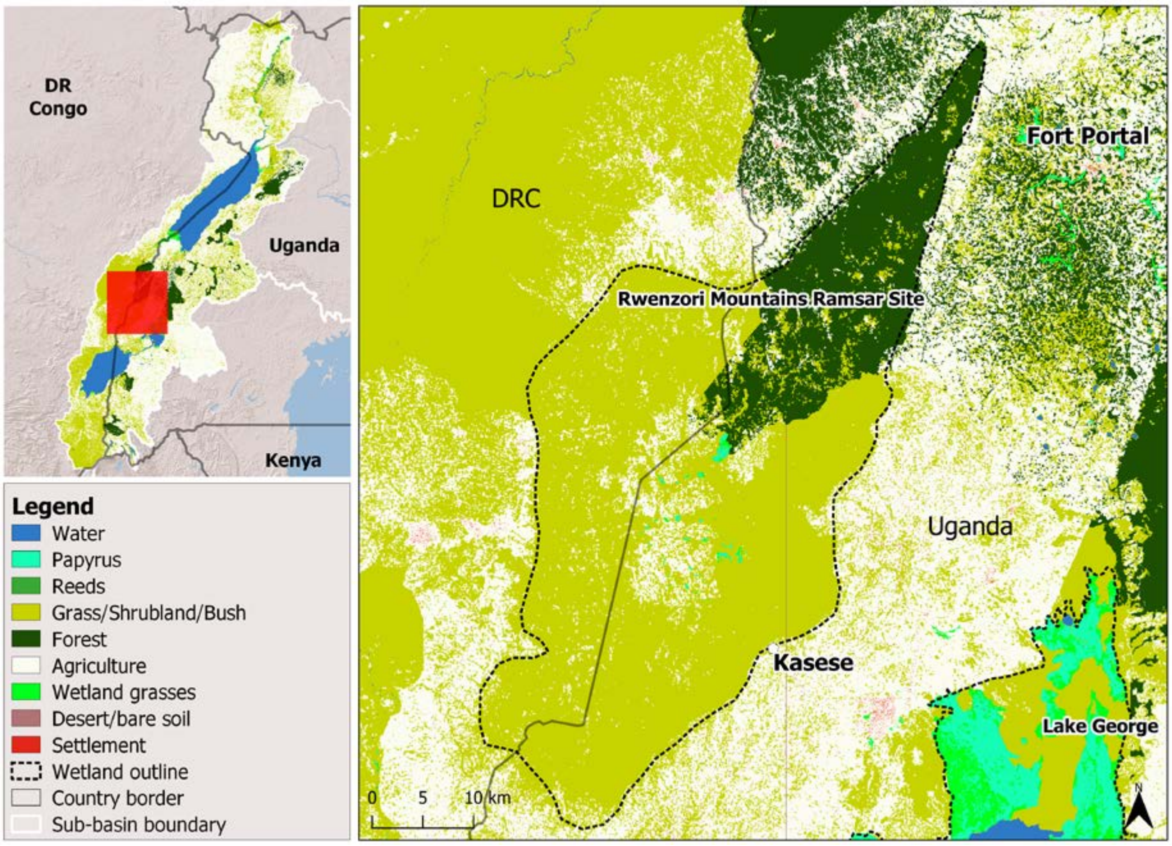

Figure 80 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

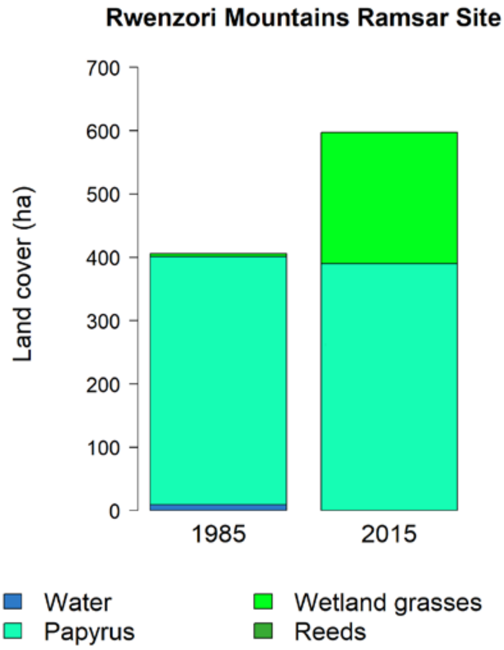

Figure 81 Land cover in 1985 and 2015

Table 55 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	9	0	-100.0
Papyrus	392	390	-0.5
Wetland grasses	5	207	4040.0
Reeds	0	0	0.0
Total area*	159359	159359	0.0

* Total area based on all 9 land cover classes

36. Lake George

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).

Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Xf Freshwater, tree-dominated wetlands
Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Management Status

Table 56 Protected area related to the wetland

Name	Type*	Designation Year
Queen Elisabeth	National Park (II) UNESCO-MAB Biosphere Reserve	1952 1979
Kazinga	Wildlife Sanctuary (VI)	1959
Kyambura	Wildlife Reserve (III)	1965
Kisangi	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)*

Land Use and Land Cover

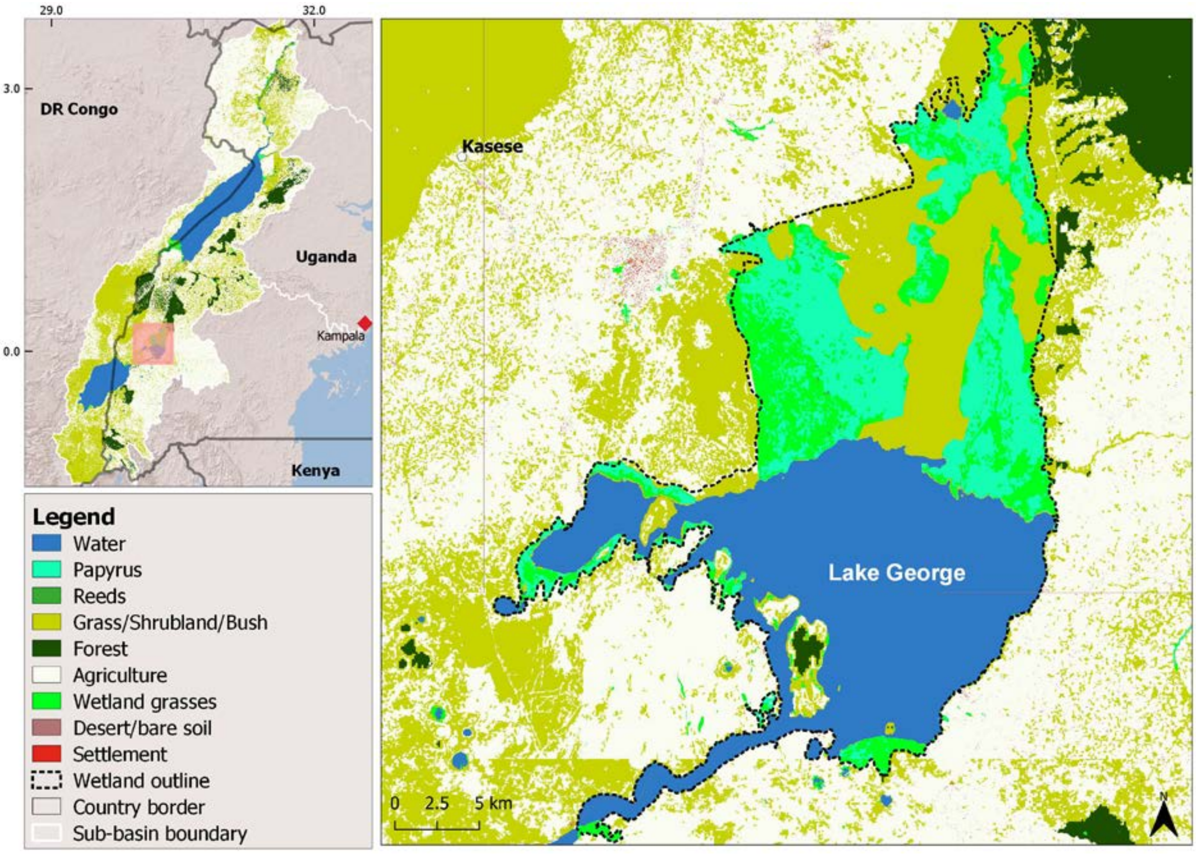

Figure 82 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Change Trajectories 1985-2015

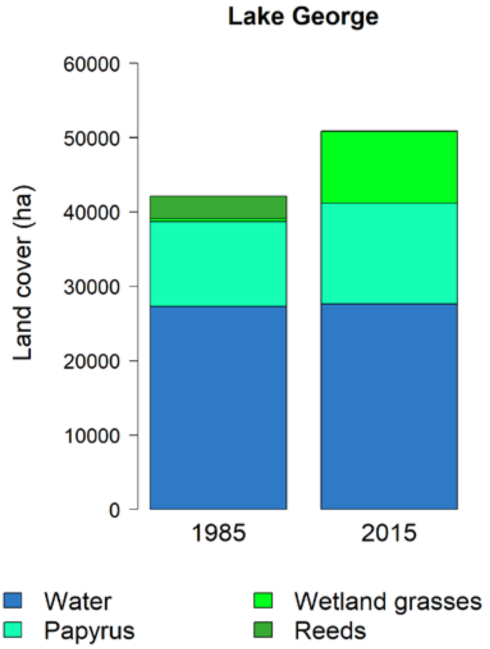

Figure 83 Land cover in 1985 and 2015

Table 57 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	27287	27615	1.2
Papyrus	11436	13551	18.5
Wetland grasses	382	9652	2426.7
Reeds	2997	39	-98.7
Total area*	66232	66233	0.0

* Total area based on all 9 land cover classes

37. Lake Edward

Name: Lake Edward
Country: Uganda, DRC
Coordinates: 29°35'29'' E / 0°24'26.74"S
Altitude: 913 m a.s.l.
Area: 2,396 km²
Nearest Towns: Katwe
International Importance: Important Bird Area (Virunga and Queen Elisabeth National Park), Transboundary Wetland

Overview

Lake Edward is 76 km long with a maximum width of 39 km. Just over 29% of its surface is situated in Uganda, the rest of the lake is situated in the Democratic Republic of Congo. The lake is connected to Lake George by the Kazinga Channel, 36 km long and about 1 km wide. Lake Edward reaches a maximum depth of 112 m, just 5 km from the western shore, above which the land rises precipitously to a high plateaux, over 2000 m a.s.l, carrying mountain peaks over 3000 m. By contrast the lake floor slopes up gradually to the Ugandan shore. There are extensive swamps at the mouths of the Ishasha and Chiruruma Rivers covering about

14,000 ha. The Ugandan part of the lake is part of the Queen Elisabeth National Park, whereas the western shore in DR Congo is part of the Virunga National Park. Both of these national parks are Important Bird Areas. There are numerous fishing communities on the shores of Lake Edward, amongst them Katwe town (Hughes & Hughes, 1992).

Physical Features

Lake Edward has numerous affluent streams, the most important is the Nyamugasani River from the Ruwenzori Mountains and the Ishasha, Rutshuru and Rwindi Rivers from the Virunga Massif and the Rwanda Highlands. Further inflow, estimated at 1,650 million m^3/year, comes from Lake George, which also drains the Ruwenzori Range and to the east shares a watershed with Lake Victoria. However, flow through the Kazinga Channel is very sluggish, along a gradient of 1:80 000 over the first 24 km. The junction of the waters between Lakes Edward and George is indicated by a change in colour and chemistry, and can usually be seen in the Kazinga Channel. The position of this boundary oscillates up and down the channel over a distance of about 3 km. Lake Edward discharges into the Semliki River, and thence to Lake Albert and the Nile. Water spills over a rock shelf at the northern extremity of the lake, which functions as a natural weir (NEMA, 2017; NBI, 2009).

Classification

Inland Wetland

M Permanent rivers/streams/creeks

N Seasonal/intermittent/irregular rivers/streams/creeks

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Xf Freshwater, tree-dominated wetlands

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Management Status

Table 58 Protected area related to the wetland

Name	Type*	Designation Year
Queen Elisabeth	National Park (II) UNESCO-MAB Biosphere Reserve	1952 1979
Kazinga	Wildlife Sanctuary (VI)	1959
Virunga	National Park (II) World Heritage Site	1991 1994

*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)*

Land Use and Land Cover

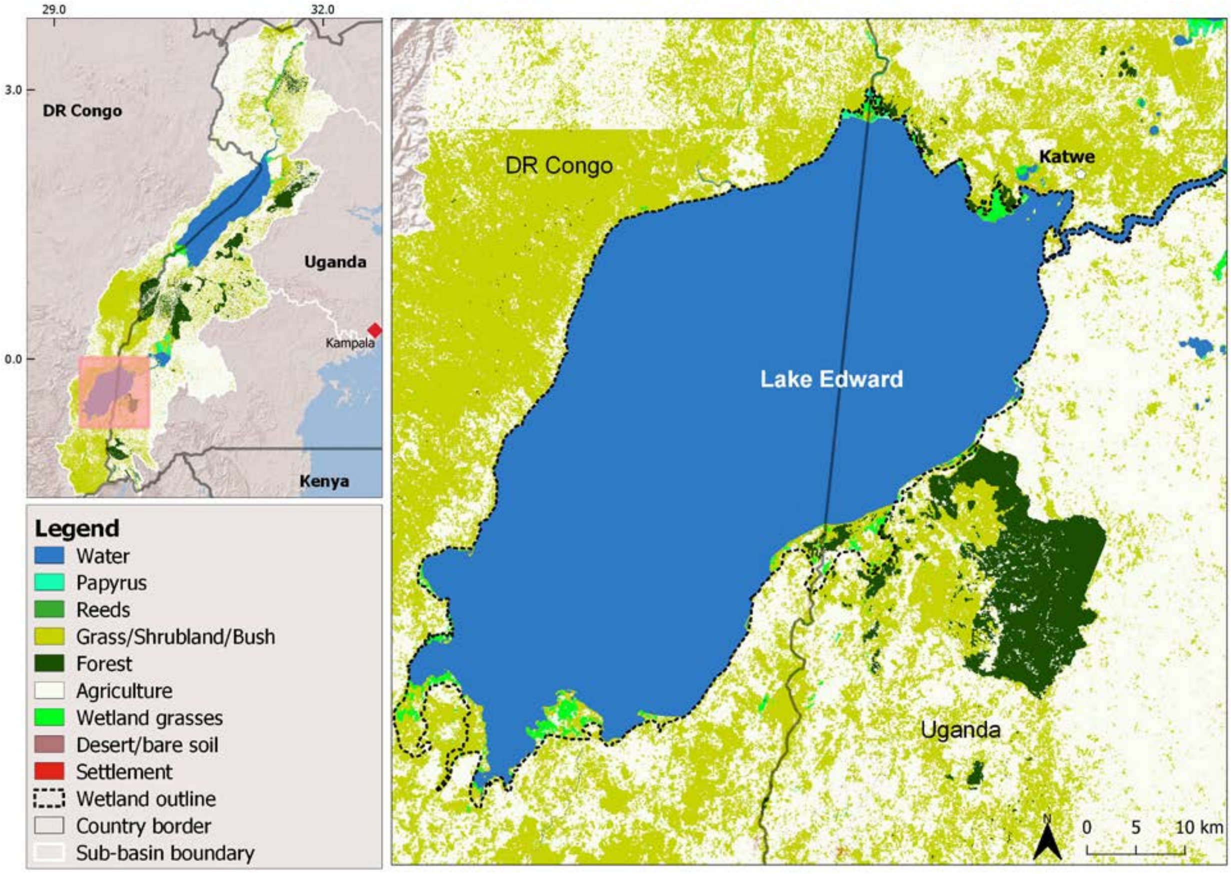

Figure 84 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

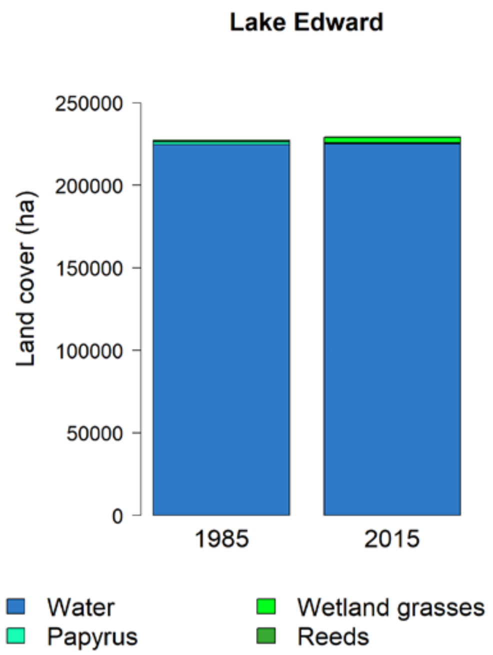

Figure 85 Land cover in 1985 and 2015

Table 59 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	224820	225353	0.2
Papyrus	1536	318	-79.3
Wetland grasses	198	3298	1565.7
Reeds	821	108	-86.8
Total area	239552	239552	0.0

* Total area based on all 9 land cover classes*

38. 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 in for many kilometres, and a large area, centred upon the oxbows of the abandoned river course, is poorly drained and comprises hydromorphic soils. Farther back upstream, smaller swamps occur along the Semliki at numerous isolated sites, mostly where tributaries enter the main stream (Hughes & Hughes, 1992; NEMA, 2017).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
P Seasonal/intermittent freshwater lakes

Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.

Management Status

Table 60 Protected area related to the wetland

Name	Type*	Designation Year
Semuliki	National Park (II)	1993

*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)*

Land Use and Land Cover

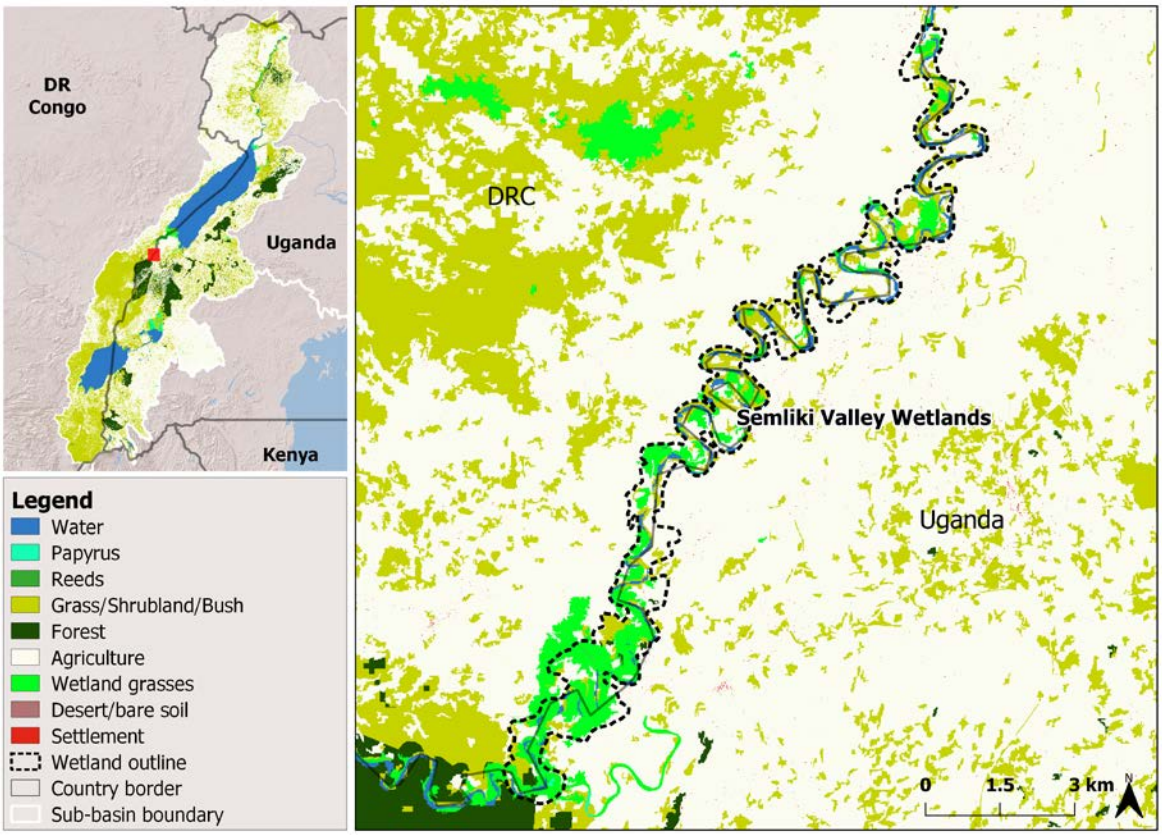

Figure 86 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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, 2017).

Change Trajectories 1985-2015

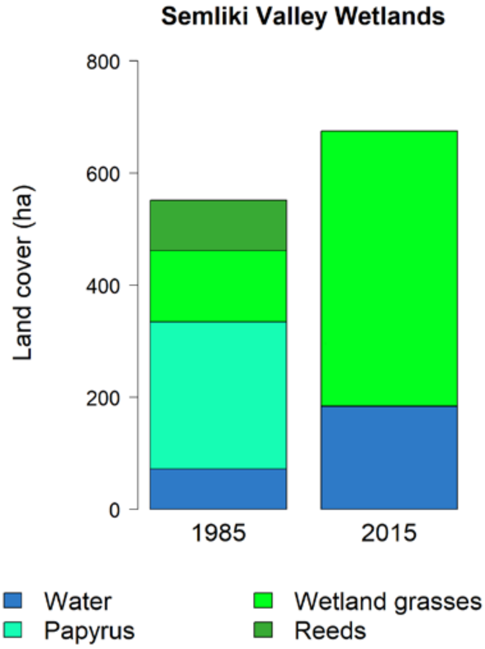

Figure 87 Land cover in 1985 and 2015

Table 61 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	72	184	155.6
Papyrus	263	1	-99.6
Wetland grasses	127	490	285.8
Reeds	90	0	-100.0
Total area*	1690	1689	-0.1

* Total area based on all 9 land cover classes

39. Lake Albert-Murchison Falls-Albert Delta Wetland System

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: 5,871 km²
Nearest Towns: Masindi, Bunia, Pakwach
International Importance: Ramsar, Important Bird Area, Transboundary Wetland

Overview

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 the 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).

Classification

M Permanent rivers/streams/creeks
O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Management Status

Table 62 Protected area related to the wetland

Name	Type*	Designation Year
Murchison Falls	National Park (II)	1952
Ntoroko-Kanara	Wildlife Sanctuary (VI)	Not reported
Toro Semliki	Wildlife Reserve (III)	1929
Kabwoya	Wildlife Reserve (III)	Not reported
Bugungu	Wildlife Reserve (III)	1968
Karuma	Wildlife Reserve (III)	1964
Kaiso Tonya	Community Wildlife Managemnet Ares (VI)	2002
Rwengara	Community Wildlife Managemnet Ares (VI)	2002

**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)*

Land Use and Land Cover

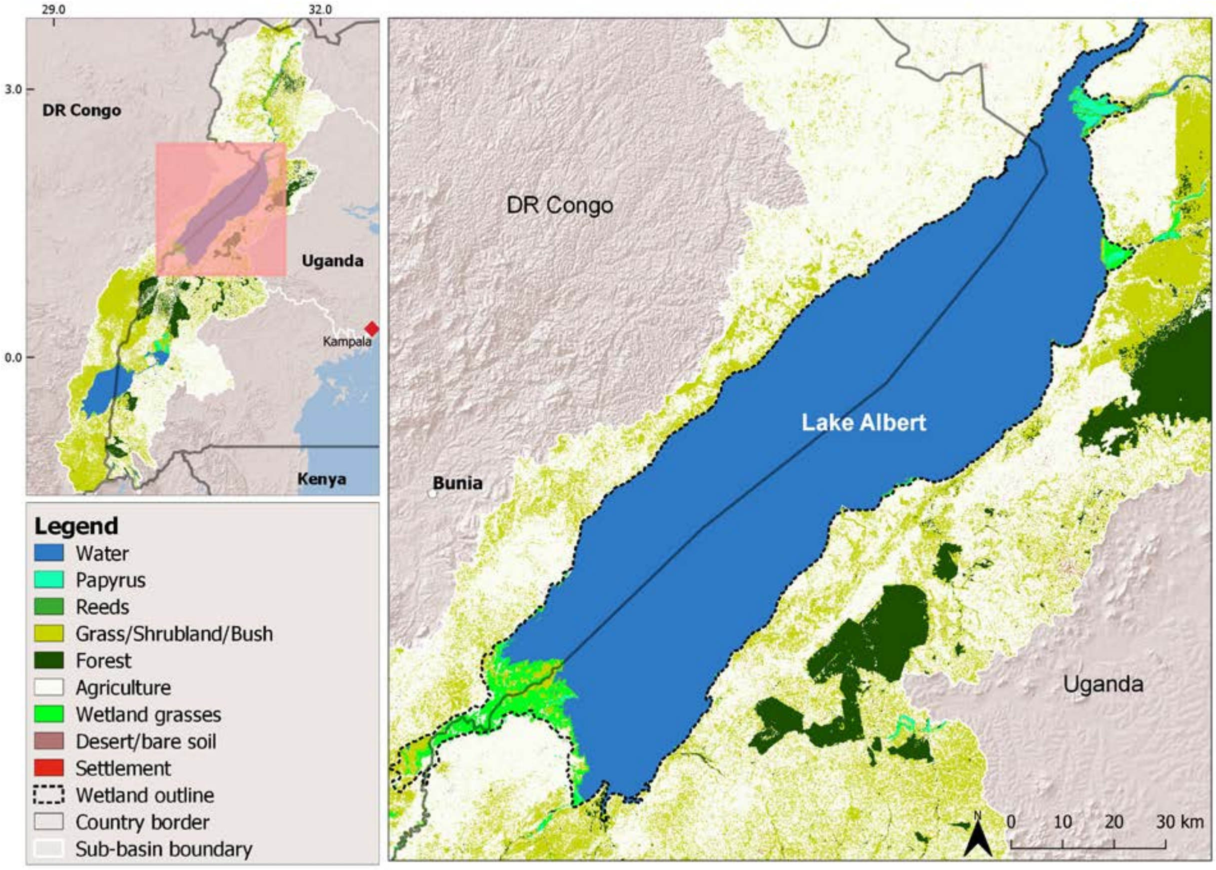

Figure 88 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

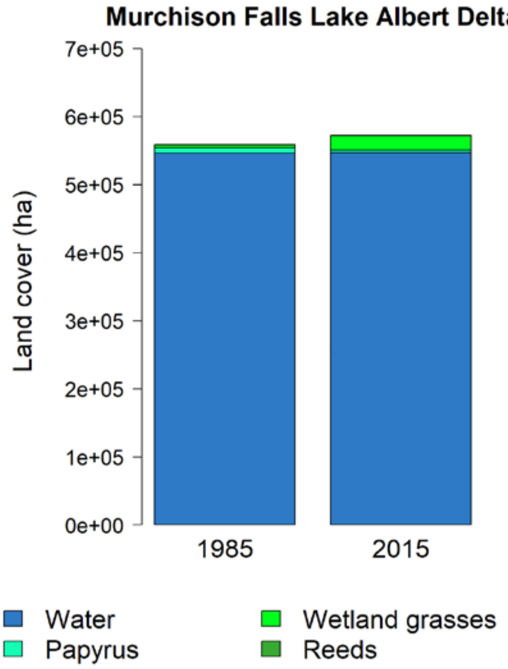

Figure 89 Land cover in 1985 and 2015

Table 63 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	546522	546632	0.0
Papyrus	7631	4235	-44.5
Wetland grasses	3759	21564	473.7
Reeds	1233	14	-98.9
Total area*	588414	588412	0.0

* Total area based on all 9 land cover classes

40. Lake Bunyonyi System

Name: Lake Bunyonyi, Lake Bunyoni
Country: Uganda
Coordinates: 1°17'36"S / 29°55'02 "E
Area: 51 km²
Altitude: 1950 m a.s.l.
Nearest Towns: Kabale town, Mbarara

Overview

Lake Bunyonyi is located in the south western Uganda, close to the border of Rwanda, between two districts Kisoro and Kabale. Lake Bunyonyi was formed when a steep-sided dendritic valley system was blocked by volcanic activity about 18,000 BP. It covers about 6,100 ha and is fed at its southern end by the Kabirita River from Rwanda and by numerous affluents from the surrounding hills. The lake is 25 km long, 7 km wide at maximum, and oriented roughly SE-NW. It has a maximum depth of 44 m and contains 23 small islands.

Physical Features

Swamps surrounding the lake and along the river extend back up the Kabirita for 8 km, and are present at the heads of 25 of the little arms of the lake. Upwarping in the area has led to the curious situation where streams in steep-sided mountain valleys flow very sluggishly, sometimes with the creation of watersheds midway along rivers. Thus Lake Bunyonyi drains sluggishly from its northern end to the Ruhuhuma (Ruvuma) Swamp which lies on a watershed from where streams flow both east and west.

The Ruhuhuma Swamp is 10 km long from EW and covers a little more than 4000 ha at an altitude of 1940 m a.s.l. The eastern part of the swamp drains by a short stream to the swampy upper course of the Ishasha River, which rises in Rwanda and flows north and northwest to Lake Edward and the Nile. A strip of permanent swamp, 40 km long and about 1 km wide, accompanies the Ishasha from the Rwanda border northwards to a point just beyond the confluence with the effluent from the Ruhuhuma Swamp, so that a permanent wetland of 4000 ha is situated here. The western part of the swamp drains to Lake Mutanda (1°10'-1°16'S/29°39'- 29°42'E).

Lake Mutanda is 9 km long and 2.5 km wide and contains one large island. It has an open water surface of 1,600 ha and is fed by short streams which enter the northern end. It discharges from the southwestern corner via the Kako River and the Tshengere Swamp (1°14'S/29°32'E) in DR C to the Rutshuru River and thence to Lake Edward and the Nile. Lake Muanga or Muhele (1°13'S/29°44'E) is situated about 1800 m a.s.l., just to the east of Lake Mutanda. It has a maximum depth of 7.5 m, a length of 3 km and a width of 1 km.

Classification

Inland Wetland

O Permanent freshwater lakes

M Permanent rivers/streams/creeks

Tp Permanent freshwater marshes/pools

Management Status

Table 64 Protected area related to the wetland

Name	Type*	Designation Year
Muko	Forest Reserve	1948

*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)*

Land Use and Land Cover

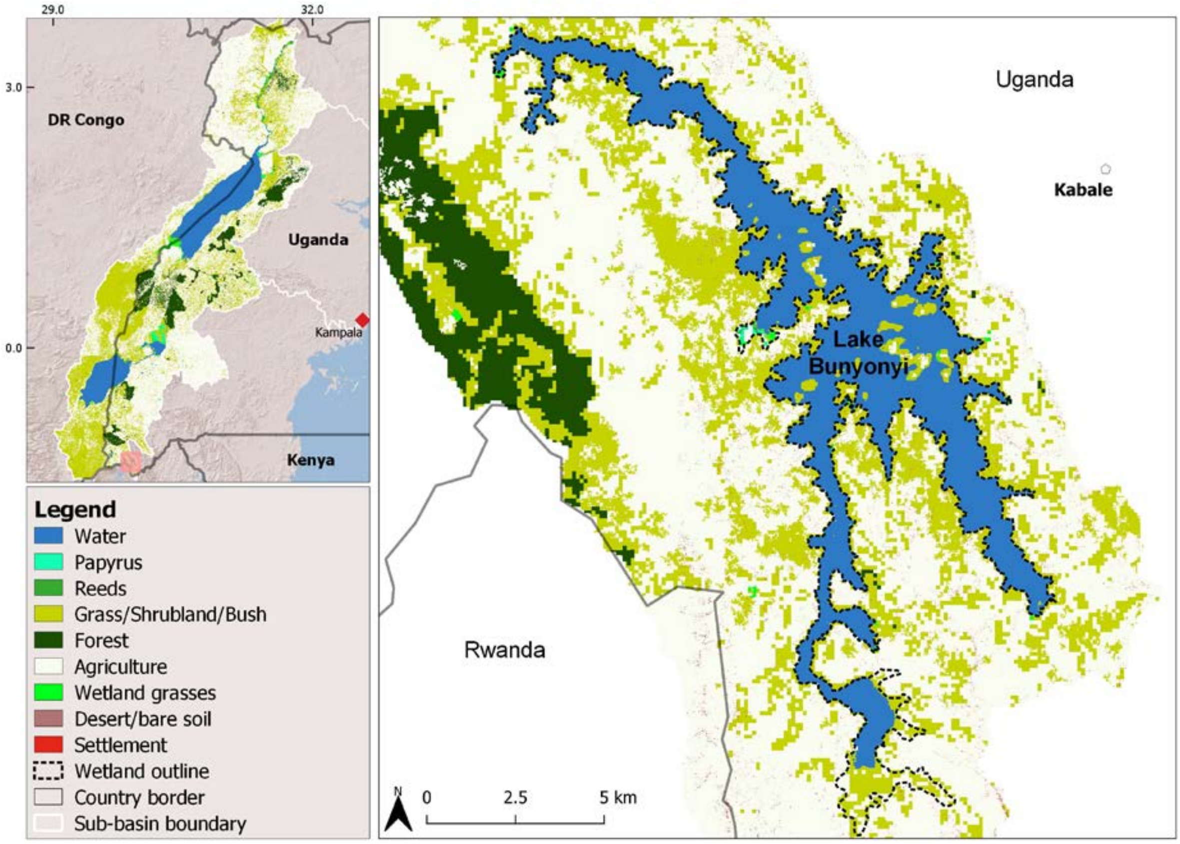

Figure 90 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Change Trajectories 1985-2015

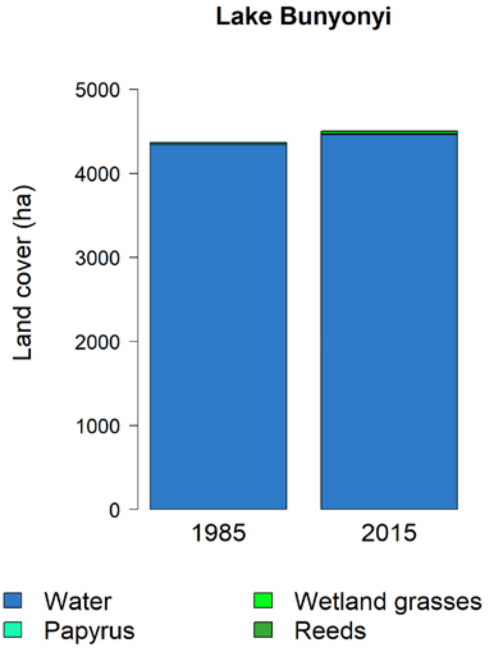

Figure 91 Land cover in 1985 and 2015

Table 65 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	4343	4463	2.8
Papyrus	22	10	-54.5
Wetland grasses	1	24	2300.0
Reeds	3	4	33.3
Total area*	5141	5142	0.0

* Total area based on all 9 land cover classes

3.1.4 Bahr el Jebel

Overview

After exiting Lake Albert the Nile flows northwards into South Sudan and is known as the Bahr el Jebel. The Jebel receives various inflows and at Mongalla it enters the Sudd, which is the second largest wetland in the world. The defining ecoregion of the Sudd is grassland. The Sudd lies entirely in South Sudan where it covers a vast area downstream of Lake Albert, which is characterized by permanent marsh lands, lakes and swaps, and braided system of rivers. The Bahir el Jebel River stretches from Nimule to Malakal and is the largest source of surface water and dominant contributor to water balance of this wetland system. Nearly half of the inflowing water at Mongala to the wetland is lost through evaporation in the Sudd wetland system. Although a number of studies have been conducted in an attempt to understand the hydrologic process of this wetland, it remains one of the least understood wetland in the Nile river system due to its complexity.

Climate

In the majority of the 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 Assessment.

Land Cover

Table 66 Land cover change in the Bahr el Jebel Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	531	818	53.9
Papyrus	5687	2089	-63.3
Wetland grasses	4350	8681	99.5
Reeds	1905	5520	189.8
Total area*	186875	186875	0.00

* Total area based on all 9 land cover classes

BJ. The Sudd

41. The Sudd

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 km^2
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. Downstream of Lake Albert the wetland covers a vast area, which is characterized by permanent marsh, lands and swaps, seasonal inundations and braided system of rivers. 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 dominant contributor to the water balance of the Sudd is the Withe Nile. Nearly half of the water that enters the Sudd at Mongalla is lost through evapotranspiration on its course thorough the wetland system. A number of studies, included below, have attempted to understand the hydrologic processes of this wetland. Still the complexity and vastness of the system makes it one of the least understood wetlands in the Nile River Basin.

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 km^2 (Allam et al., 2018) or relatively large areas of 105,000 km^2 (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^{o} C whereas Malakal receives temperatures between 18 and 40^{o} 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 %, respectively.

Physical features

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 No.

At Lake No, the Bahr el Jebel is joined by the Bahr el Ghazal from the west. There is an ongoing debate 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 if 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 10^6 m^3/ year, for in and outflow respectively. Overall, the wetland area doubled during the second half of the 20th century, compared to the first (Mohamed & Savenije, 2014).

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 km^3 and 20.8 km^3, 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).

<u>Wetland extend</u>
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 km^2 (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 km^2 to 90,000 km^2. Methods for estimating the wetland extent include remote sensing (Di Vittorio et al., 2018; Rebelo et al., 2012; Wilusz et al., 2017), hydrological modelling (Sutcliffe & Parks, 1999) and a combination of remote sensing of evaporation and hydrological modelling (Mohamed et al., 2004). Table 61 shows a summary of results from different studies on the extent of the Sudd.

Table 67 Comparison of monthly minimum (km^2) and maximum (km^2) estimates of Sudd flooded area over a given period of time. The study area (km^2) is the area the respective authors have defined as the boundaries for the Sudd.

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

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 river-fed 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 river-flooded grassland (16,200 km²) and seasonally rain-flooded grassland (20,000 km²). There are areas of single-species woodland mainly of *Acacia seyal* (5,400 km²) or *Balanites aegyptiaca* (5,300 km²). Mixed woodland is 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* (Nile hyacinth) causes blockages along the White Nile from the Sudd to Jebel Aulia Dam (Green & El-Moghraby, 2009). Seasonal flooding enables the growth of grasses such as *Sorghum sudanica, Echinochloa spp.* and *Oryza longistaminata,* wild rice-grass*.* This grassland is known as the 'toich'. Where the water is deeper the *Oryza longistaminata* is dominant, but needs several months (mostly up to 3) of surface water in order to flower. *Echinochloa pyramidalis* is the dominant grass with *Sporobolus pyramidalis*, *Digitaria debilis* and *Desmodium hirtum* where the flood water is shallower. The pools formed by seasonal flooding have their own separate vegetation with *Echinochloa stagnina, Glinus lotoides, Sesbania rostrate* and *Aeschynomene indica.* It is the most productive grassland type in terms of year round grazing for livestock and wildlife due to the high protein content of dead materials of wild rice grass. Within the toich there are many small seasonally flooded pools that are sources of water for domestic, livestock, and wildlife use as well as fish. Further from the channels, where rain is the main source of water, *Hyparrhenia rufa* is the main grass or *Sporobolus pyramidalis. Echinochloa haploclada* occurs where the soil is better drained and is heavily grazed by livestock. The grasslands merge into open floodplain woodland with *Acacia seyal, A. sieberiana* and *Balanites aegyptiacus* (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, A*cinonyx jubatus* (cheetah), *Addax nasomaculatus* (White addax), *Equus grevyi* (Grévy's zebra), various gazelles (*Gazella dama*, *G. dorcas*, *G. leptoceros*, *G. rufifrons*, *G. soemmerringii*), *Kobus megaceros* (Nile lechwe), and *Lycaon pictus* (African wild dog). 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 murie*i, and *Parachanna obscura*. The important species in the lakes and channels of the perennial wetland are *Synodontis schall, S. frontosus* and *Auchenoglanis biscutatis, Alestes dentex* and *Heterotis niloticus* (Witte et al., 2009).

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. Further the flooded areas are an important freshwater source for livestock during the dry season. The Sudd as a water source is also important for other wildlife during the dry season (Riak, 2006).

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 nutrient-rich floodplains to feed and breed during the seasonal floods and therefore play an important role in the life cycles of many fish species identified in the wetland (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.

Classification

<u>Inland Wetland</u>

N Seasonal/intermittent/irregular rivers/streams/creeks
M Permanent rivers/streams/creeks
P Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes
O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland

Management Status

Table 68 Protected area related to the wetland

Name	Type*	Designation Year
Badingilo	National Park (II)	1986
Shambe	National Park (II)	1985
Ez Zeraf	Game Reserve (VI)	1939
Fanyikang	Game Reserve (VI)	1939

*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)*

Land Use and Land Cover

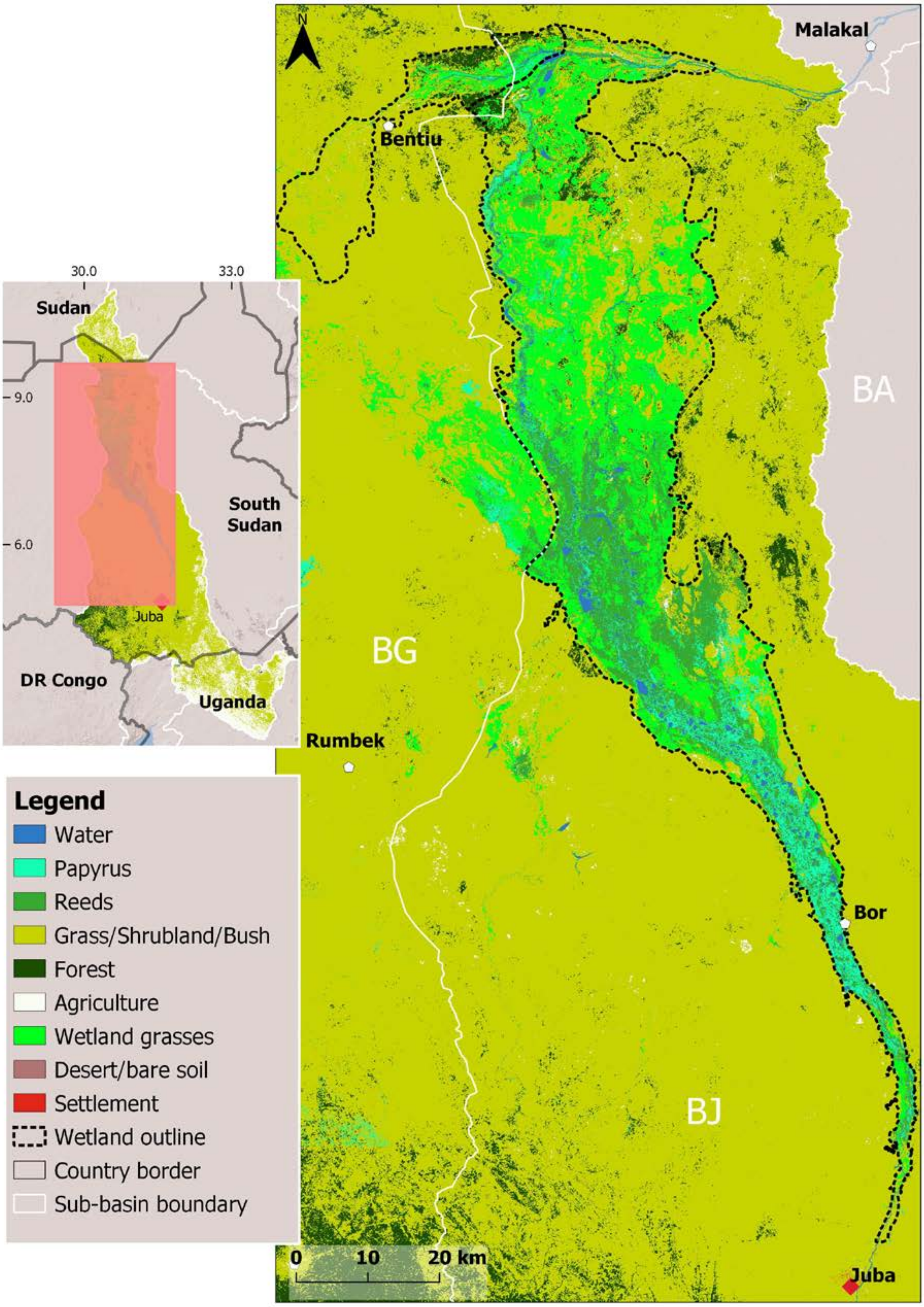

Figure 92 Location of the Sudd in the sub basin, top left corner (red square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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 executed. 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 10^9 m^3 of water from evaporating in the Sudd, which in turn would be available for downstream use. On top of this, 100,000 ha of land for agricultural purposes were planned to be gained by draining the wetland. 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).

Change Trajectories 1985-2015

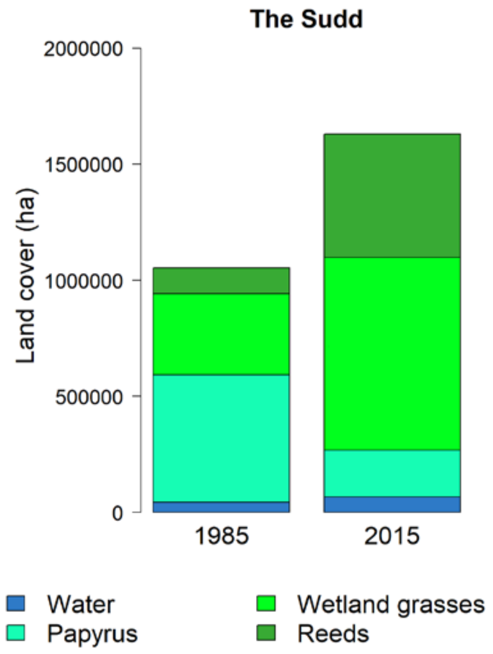

Figure 93 Land cover in 1985 and 2015

Table 69 Land cover in 1985 and 2015 and percentage of change

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

* Total area based on all 9 land cover classes

BJ. Lakes in Bahr el Jebel Basin

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

42. Lake Yirol

Wetland Name: Lake Yirol
Country: South Sudan
Coordinates: 30°29'43'' N / 6°34'13''E
Altitude: 428 m a.s.l.
Area: 11 km^2
Nearest Towns: Bor, Rumbek

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, swamp-fringed, has a peripheral floodplain and drains from its southern end to the Lau or Yei

River, which eventually peters out in the Sudd. The lake supports a small artisanal fishery, 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).

Classification

Inland Wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

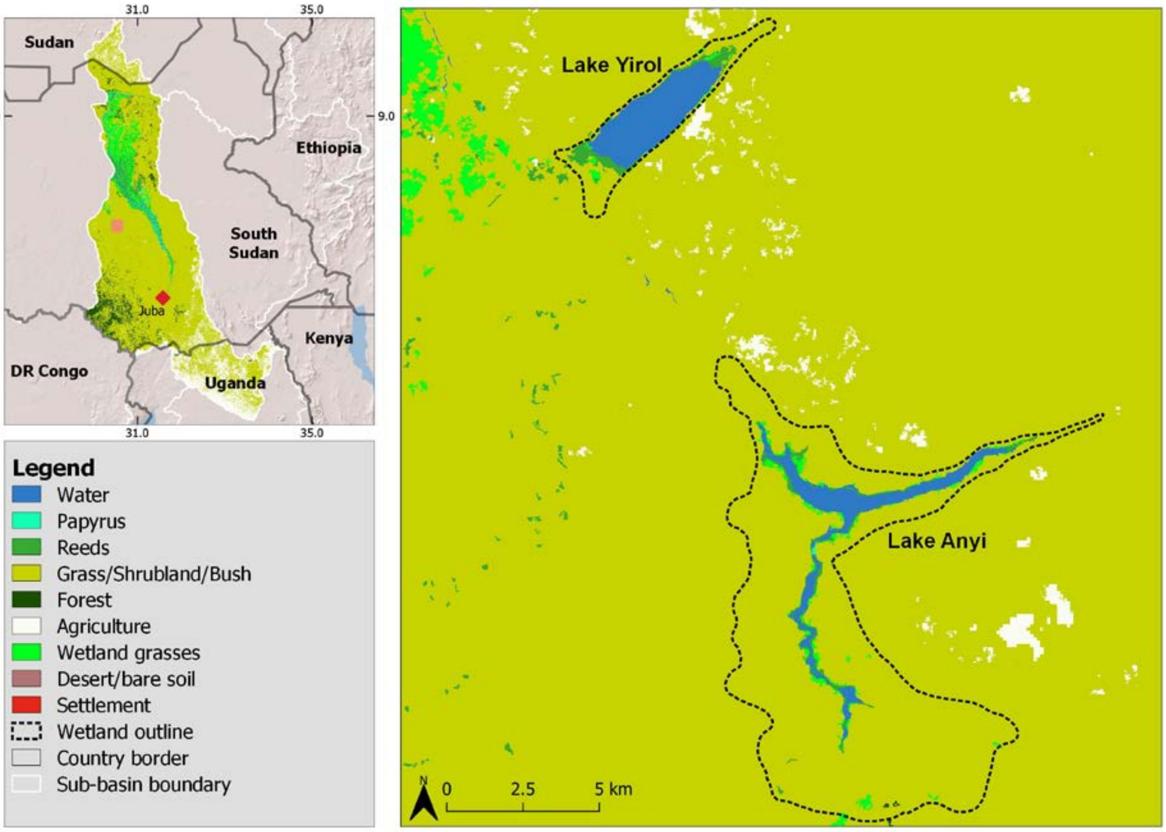

Figure 94 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Change Trajectories 1985-2015

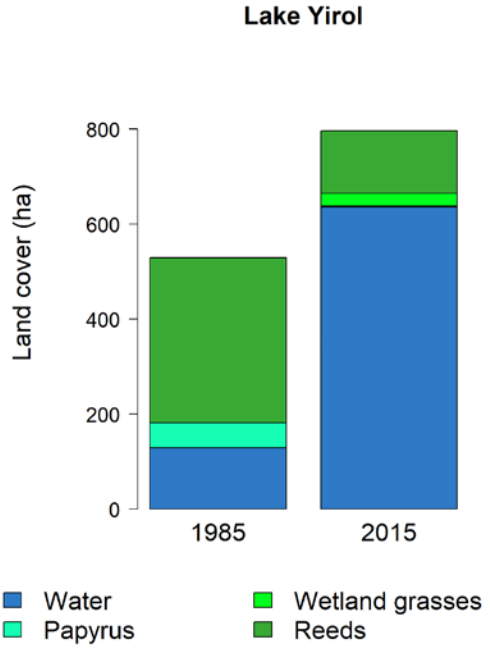

Figure 95 Land cover in 1985 and 2015

Table 70 Land cover in 1985 and 2015 and percentage of change

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

* Total area based on all 9 land cover classes

43. Lake Anyi

Wetland 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

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).

Classification

Inland Wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

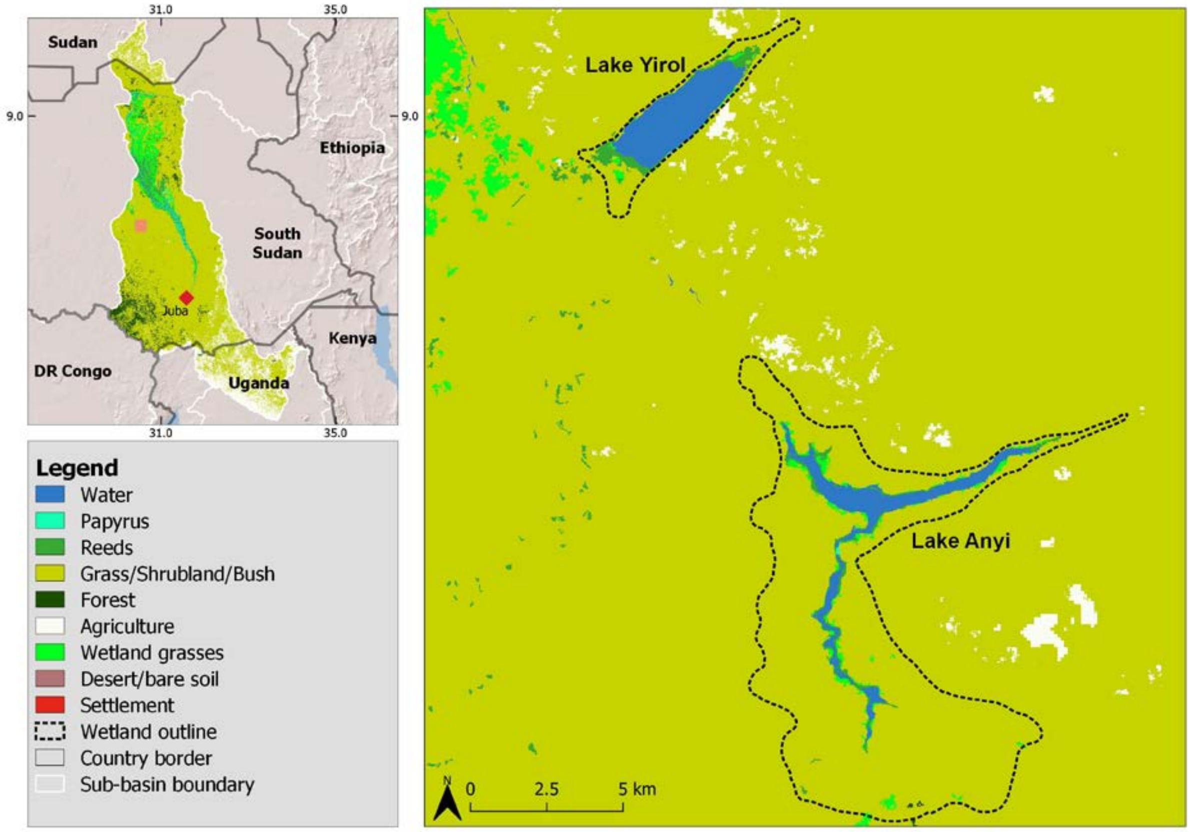

Figure 96 Location of the wetland in the sub-basin, top left corner (red square) and land cover map on the right in 2015

Change Trajectories 1985-2015

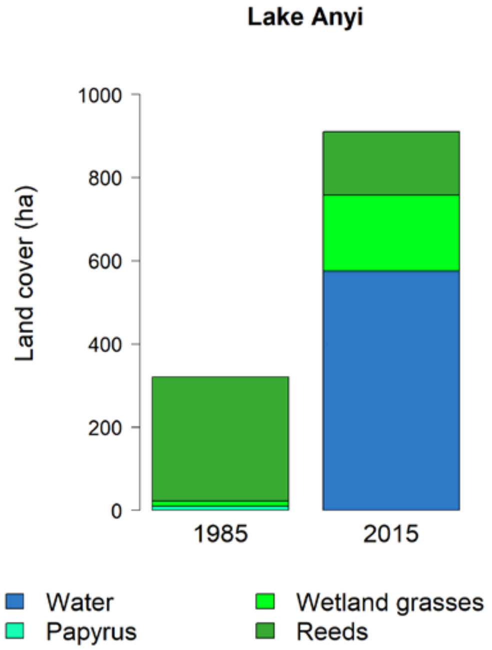

Figure 97 Land cover in 1985 and 2015

Table 71 Land cover in 1985 and 2015 and percentage of change

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

* Total area based on all 9 land cover classes

44. Lake Nyiropo

Wetland 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

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).

Classification

<u>Inland Wetland</u>

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

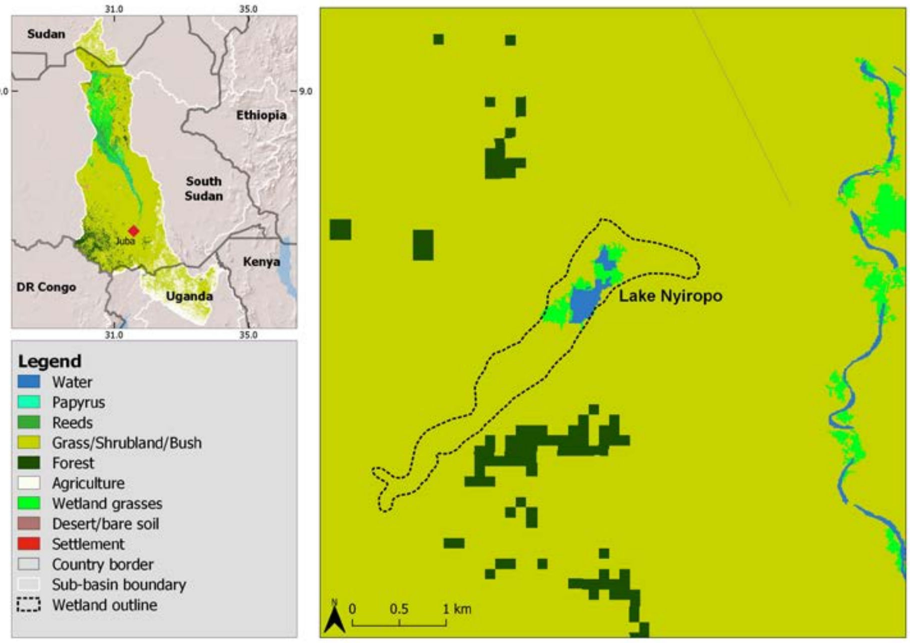

Figure 98 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

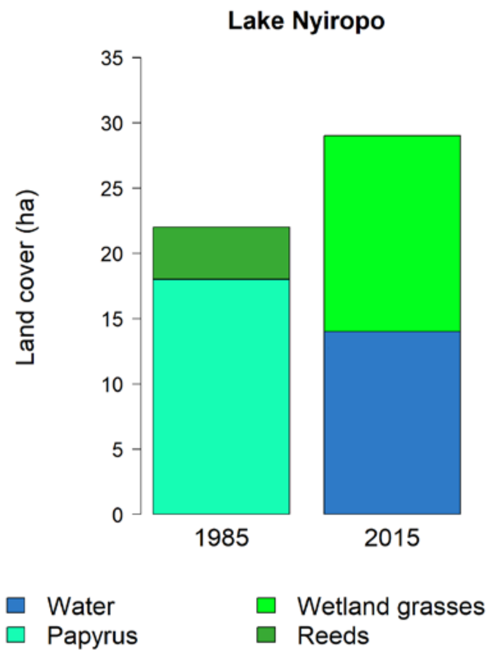

Figure 99 Land cover in 1985 and 2015

Table 72 Land cover in 1985 and 2015 and percentage of change

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

* Total area based on all 9 land cover classes

3.1.5 Bahr el Ghazal

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 Baro Akobo Sobat Basin is scarce however, a report by Ibnaof et al. (2013) studies the economic value of ecosystems and biodiversity within North Kordofan State, a State of 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.

Land Cover

Table 73 Land cover change in the Bahr el Ghazal Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	56	145	160.5
Papyrus	1387	726	-47.7
Wetland grasses	4426	3911	-11.6
Reeds	3918	404	-89.7
Total area*	609723	609723	0.00

* Total area based on all 9 land cover classes

BG. Bahr el Ghazal Wetlands

45. 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

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 Gm^2 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 km^2 (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 Gm^3/ 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).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
P Seasonal/intermittent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil
U Non-forested peatlands

Land Use and Land Cover

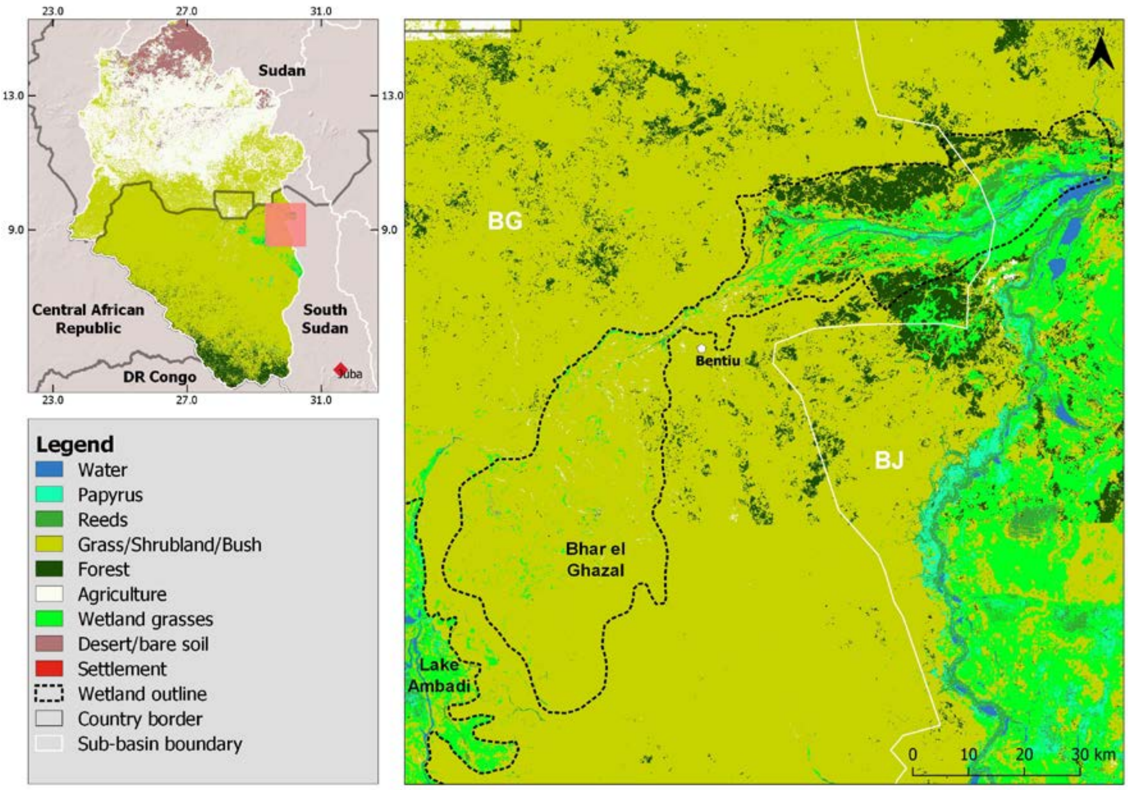

Figure 100 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

Change Trajectories 1985-2015

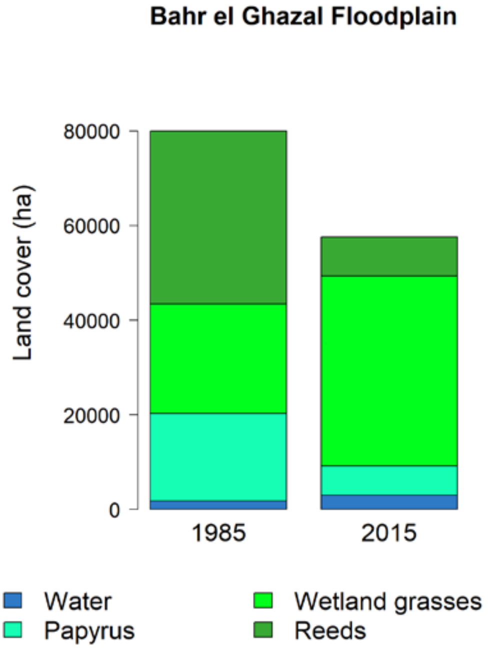

Figure 101 Land cover in 1985 and 2015

Table 74 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1783	3013	69.0
Papyrus	18521	6157	-66.8
Wetland grasses	23137	40176	73.6
Reeds	36469	8269	-77.3
Total area*	312456	312456	0.0

* Total area based on all 9 land cover classes

46. Lake Ambadi

Wetland Name: Lake Ambadi
Country: South Sudan
Coordinates: 8°42'16'' N / 29°19'16'' E
Altitude: 392 m
Area: 2,228 km²
Nearest Towns: Gogrial, Bentiu

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 m^3/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.

Classification

P Seasonal/intermittent freshwater lakes
O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soil
U Non-forested peatlands

Land Use and Land Cover

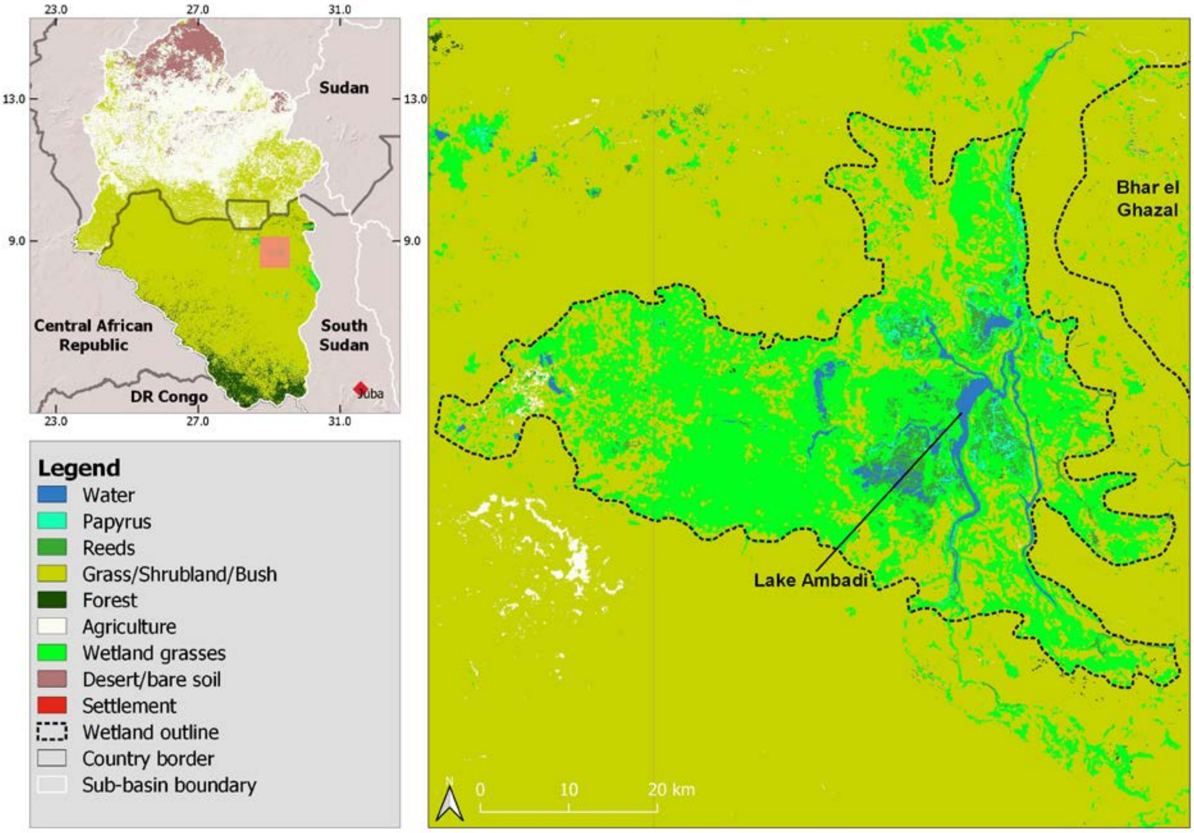

Figure 102 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

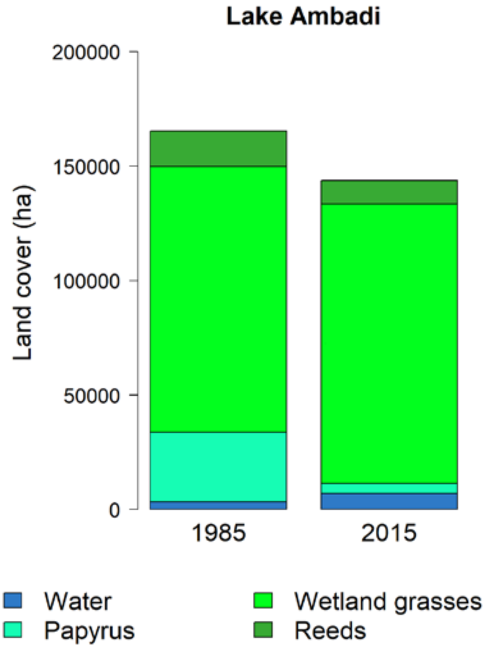

Figure 103 Land cover in 1985 and 2015

Table 75 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	3413	7019	105.7
Papyrus	30295	4403	-85.5
Wetland grasses	116072	121892	5.0
Reeds	15434	10350	-32.9
Total area*	225121	225120	0.0

* Total area based on all 9 land cover classes

3.1.6 Baro Akobo Sobat

Overview

The Baro-Akobo-Sobat (BAS) System is a vast and complex area containing numerous wetlands stretching over a wide expanse of plains. There is little is known about this system and data is missing to determine an accurate water balance.

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 are associated with the BAS sub-basin and are located in Gambela regional state in the grassland ecoregion. 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 other small tributaries. 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/year. 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 ^{o}C. The warmest months are March and April, actual evapotranspiration is highest in August and September (NBI, 2016).

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 km^2 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).

Land Cover

Table 76 Land cover change in the Baro Akobo Sobat Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	15	129	779.4
Papyrus	221	450	103.2
Wetland grasses	217	918	322.2
Reeds	826	57	-93.1
Total area*	206294	206294	0.00

* Total area based on all 9 land cover classes

BA. Baro Akobo Sobat Wetlands

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).

48. Kenamuke/ Kobowen Swamp

Wetland 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 Town: Bor
International Importance: Important Bird Area

Overview

There is little information on Kenamuke/Kobowen Swamp, one of the published descriptions available for the Ambadi 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 N-S 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.

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
U Non-forested peatland
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Management Status

Table 77 Protected area related to the wetland

Name	Type*	Designation Year
Loelle	National Park (VI)	Not reported
Boma	National Park (II)	1986

*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)*

Land Use and Land Cover

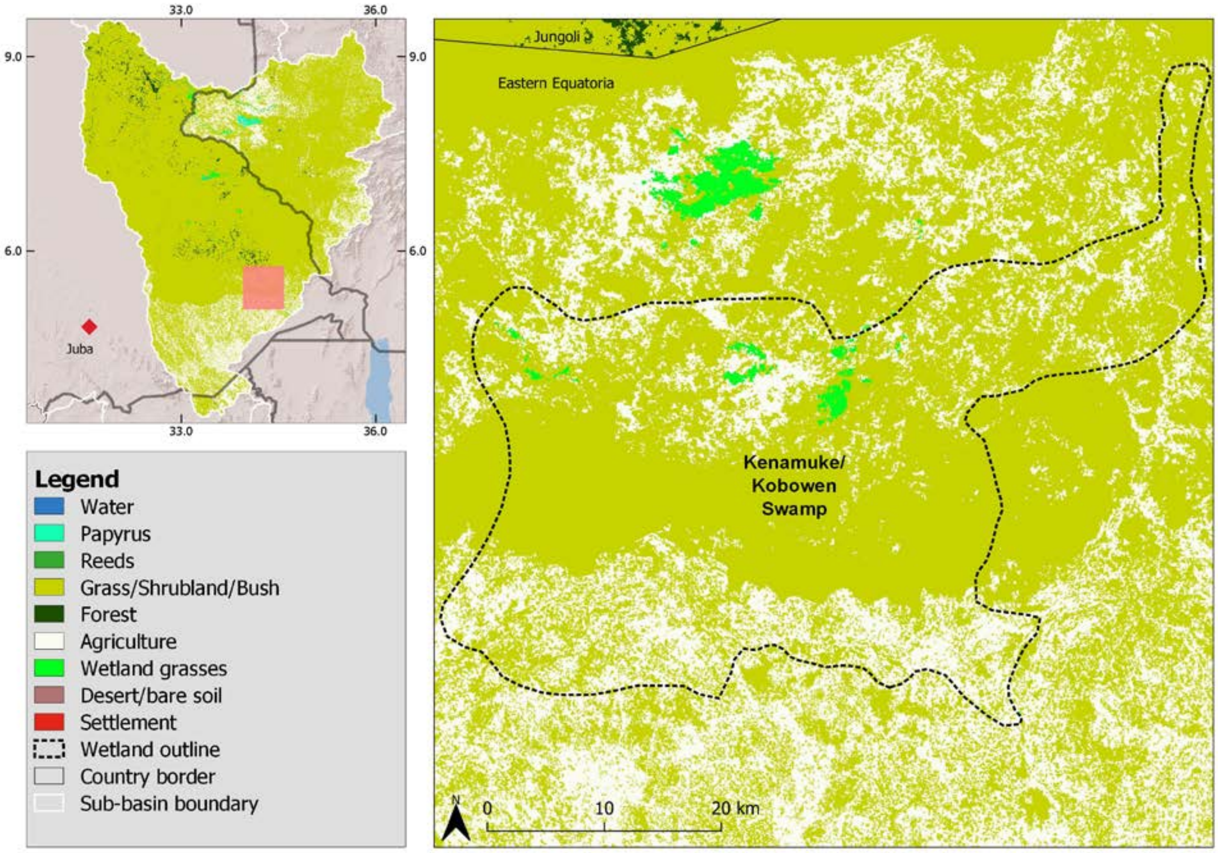

Figure 104 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

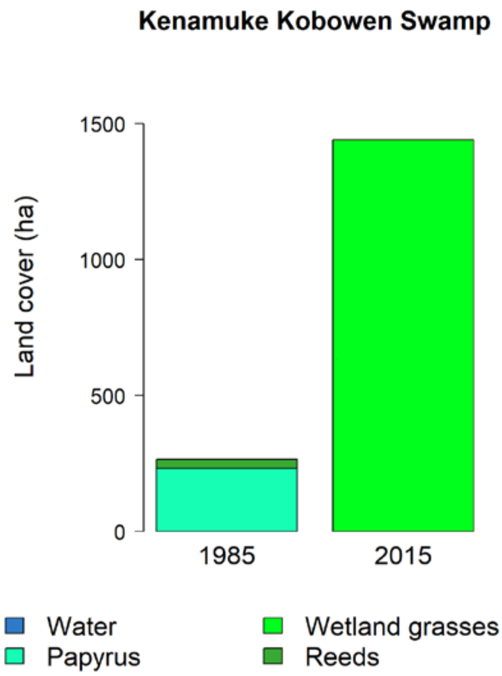

Figure 105 Land cover in 1985 and 2015

Table 78 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	0	0.0
Papyrus	233	0	-100.0
Wetland grasses	0	1440	N.A.
Reeds	33	0	-100.0
Total area*	165896	165897	0.0

* Total area based on all 9 land cover classes

47. Badigeru Swamp

Wetland Name: Badigeru Swamp
Country: South Sudan
Coordinates: 4°50'17'' N / 32°26'25'' E
Altitude: 480-700 m a.s.l.
Area: 345 km^2
Nearest Town: Juba
International Importance: Important Bird Area (Bandingilo)

Overview

There is little information on the Badigeru Swamp, one of the published descriptions available for the Ambadi 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 SSW-NNE. 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.

Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
U Non-forested peatland
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Land Use and Land Cover

Change Trajectories 1985-2015

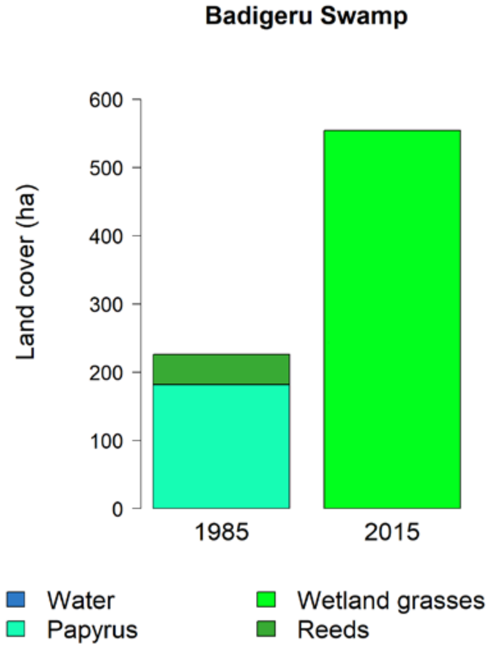

Figure 106 Land cover in 1985 and 2015

Table 79 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	0	0.0
Papyrus	182	0	-100.0
Wetland grasses	0	554	N.A.
Reeds	44	0	-100.0
Total area*	34705	34704	0.0

* Total area based on all 9 land cover classes

49. Lotilla River Swamps

Wetland Name: Lotilla Swamps
Country: South Sudan
Coordinates: 6°25'27'' N / 32°52'11'' E
Altitude: 415-620 m a.s.l.
Area: 22 km²
Nearest Towns: Bor

Overview

There is little information on Kenamuke/Kobowen Swamp, one of the published descriptions available for the Ambadi 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 km^2, 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.

Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
U Non-forested peatland
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Land Use and Land Cover

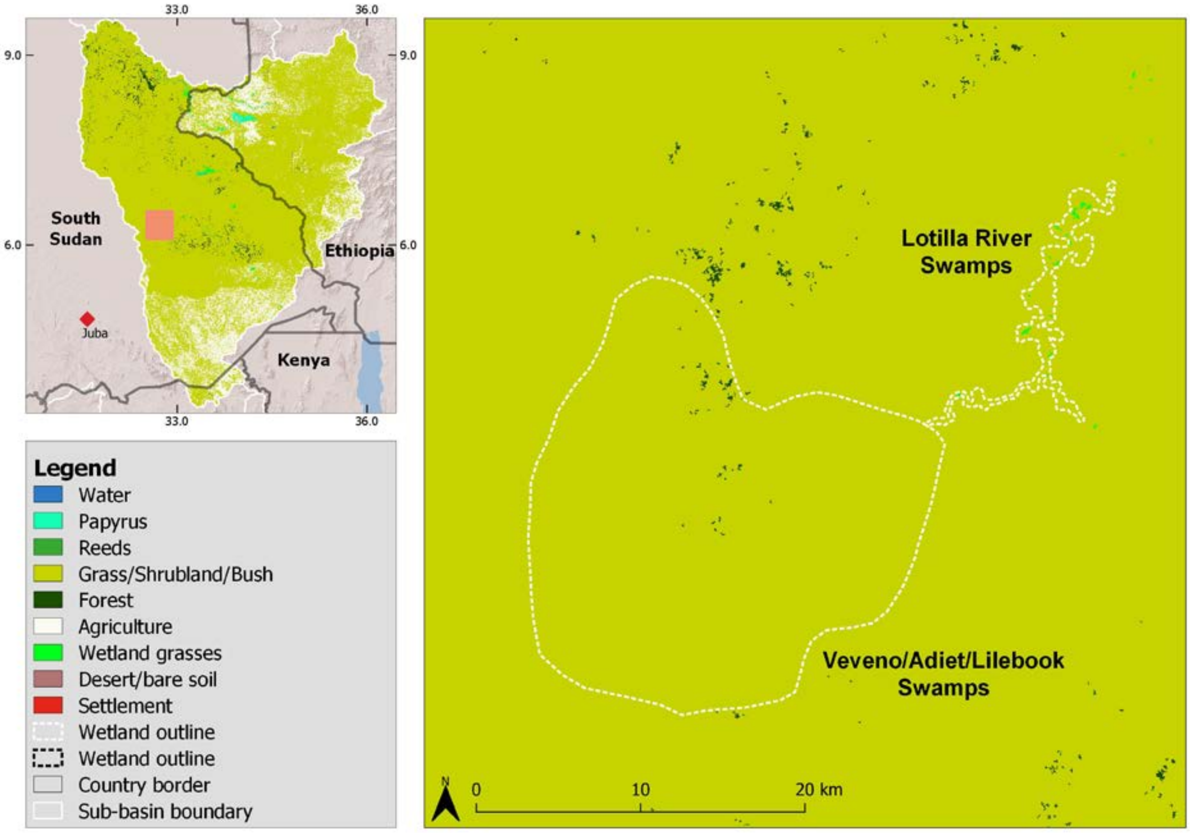

Figure 107 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

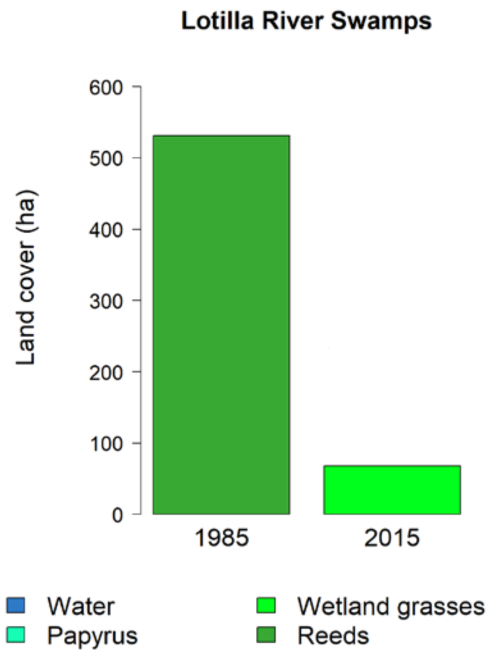

Figure 108 Land cover in 1985 and 2015

Table 80 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	0	0.0
Papyrus	0	0	0.0
Wetland grasses	0	68	N.A.
Reeds	531	0	-100.0
Total area*	2221	2221	0.0

* Total area based on all 9 land cover classes

50. Veveno/Adiet/Lilebook Swamps

Wetland 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

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).

Classification

Inland Wetland

- M Permanent rivers/streams/creeks
- N Seasonal/intermittent/irregular rivers
- Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
- U Non-forested peatland

Management Status

Table 81 Protected area related to the wetland

Name	Type*	Designation Year
Badingilo	National Park (II)	1986

*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)*

Land Use and Land Cover

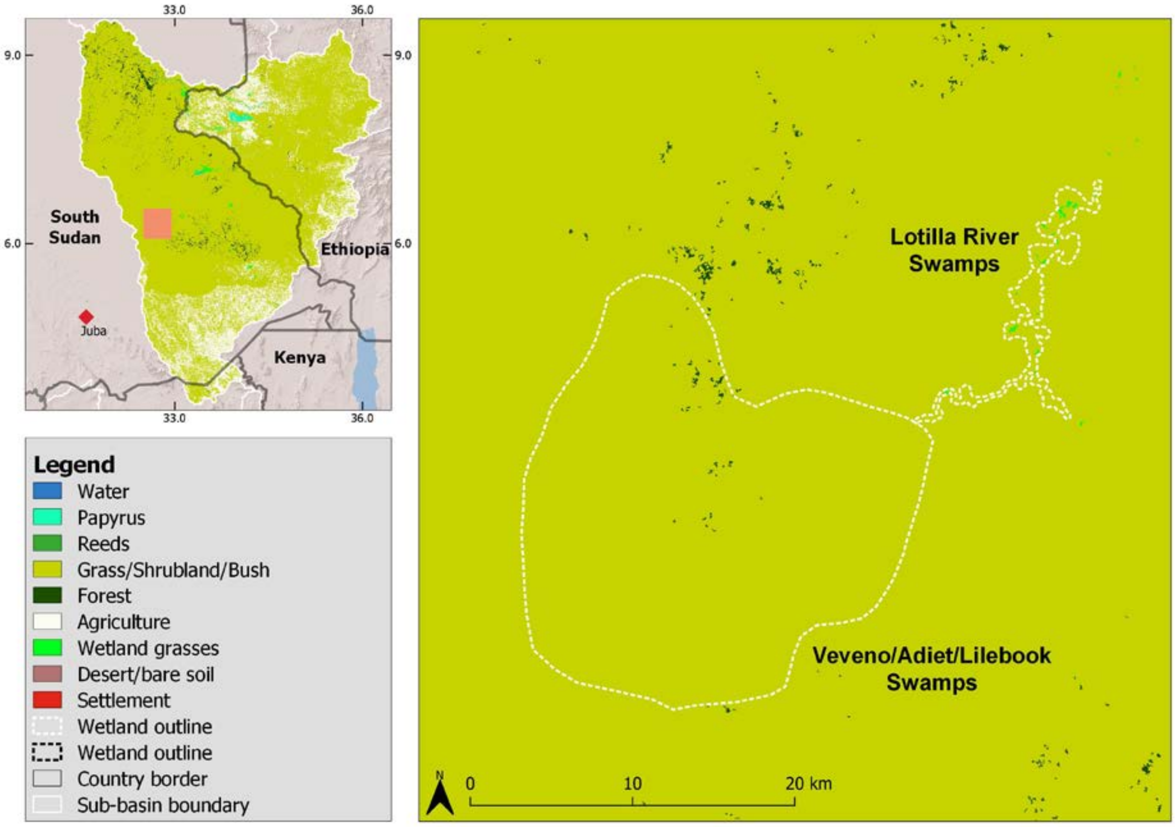

Figure 109 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

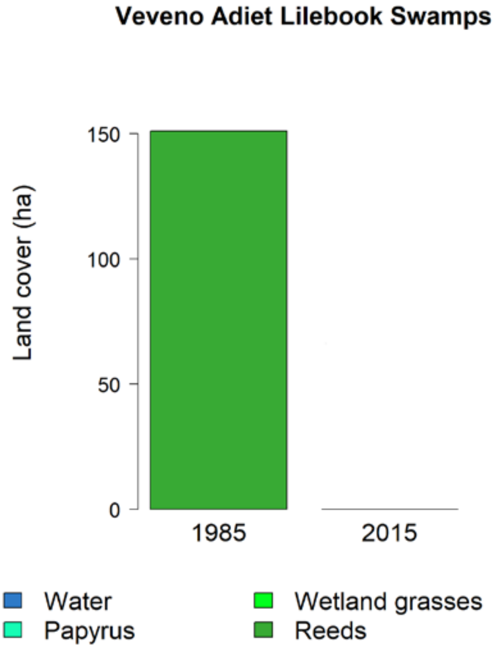

Figure 110 Land cover in 1985 and 2015

Table 82 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	0	0.0
Papyrus	0	0	0.0
Wetland grasses	0	0	0.0
Reeds	151	0	-100.0
Total area*	44624	44625	0.0

* Total area based on all 9 land cover classes

51. Baro Akobo Wetlands

Wetland 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.
Area: 516 km²
Nearest Town: Dembi Dolo, Nasir
International Importance: Important Bird Area

Overview

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 with 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 yield 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 forded some communities to relocate to higher altitudes, crating completion for resources. Reasons for a changing river regime are deforestation, expansion of cultivation and wetland degradation (Wood et al., 2018).

Classification

Inland Wetland

N Seasonal/intermittent/irregular rivers/streams/creeks
M Permanent rivers/streams/creeks
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
W Shrub-dominated wetlands

Management Status

Table 83 Protected area related to the wetland

Name	Type*	Designation Year
Gambella	National Park (II)	1974

*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)*

Land Use and Land Cover

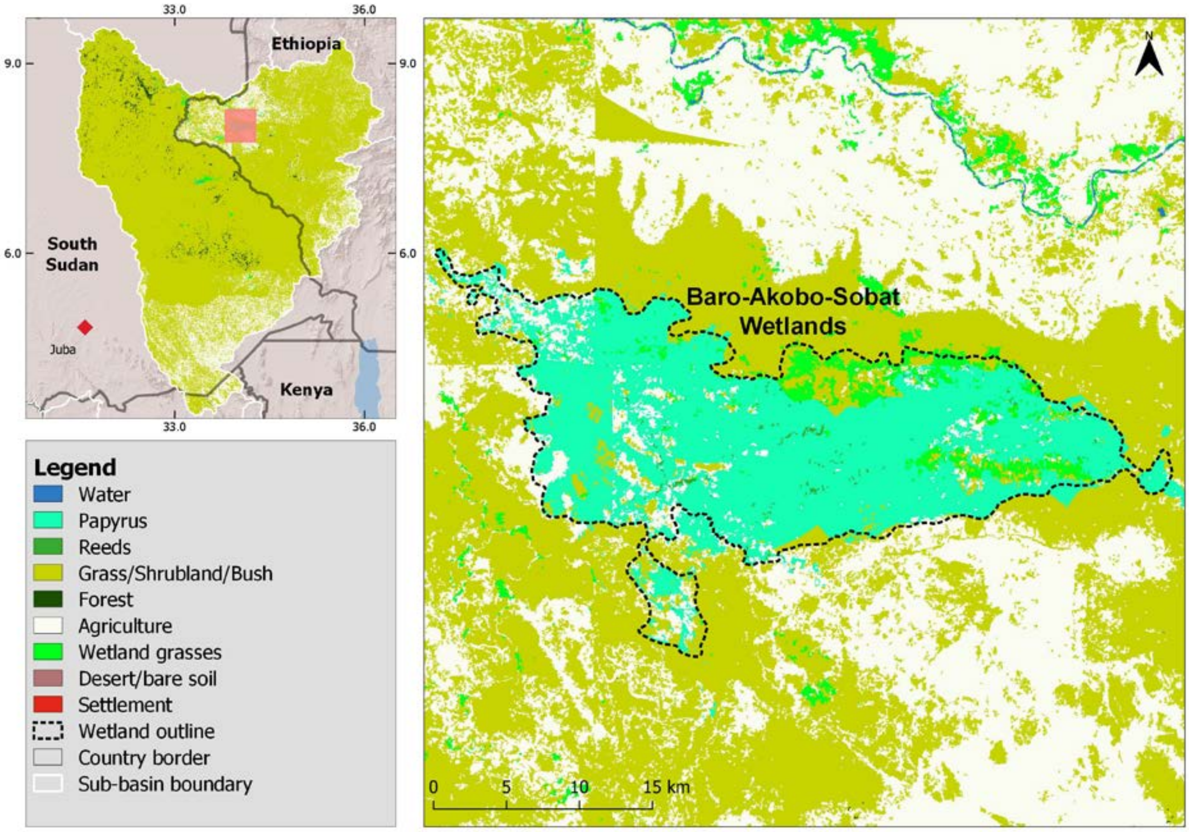

Figure 111 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

The Gambella Region is one of the world's land grabbing hot-spots. 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 km^2 (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).

Change Trajectories 1985-2015

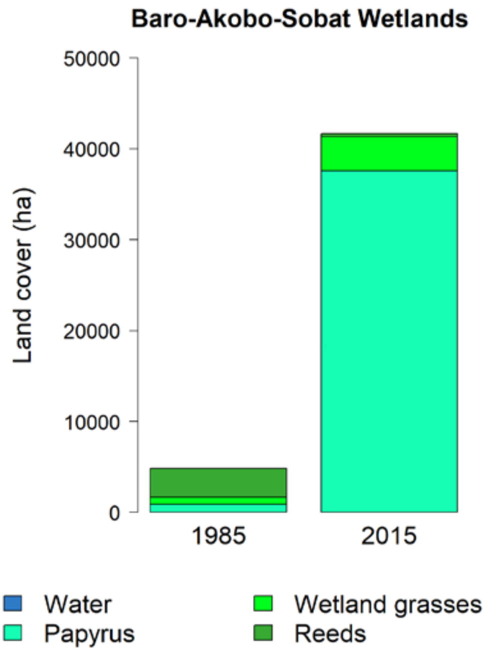

Figure 112 Land cover in 1985 and 2015

Table 84 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	1	N.A.
Papyrus	890	37566	4120.9
Wetland grasses	782	3763	381.2
Reeds	3194	323	-89.9
Total area*	522560	522560	0

* Total area based on all 9 land cover classes

52. The Machar Marshes

Wetland 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 Town: Malakal

Overview

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 Milotic tribes of South Sudan, it is one of the least monitored and understood wetlands (Y. A. Mohamed, 2018).

Physical Features

The Macha Marches lie are 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 Baro Akobo Sobat basin. In Hughes and Hughes (1992) the total wetland area is described 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 system.

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 distributary 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).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
P Seasonal/intermittent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland
Xf Freshwater, tree-dominated wetlands

Land Use and Land Cover

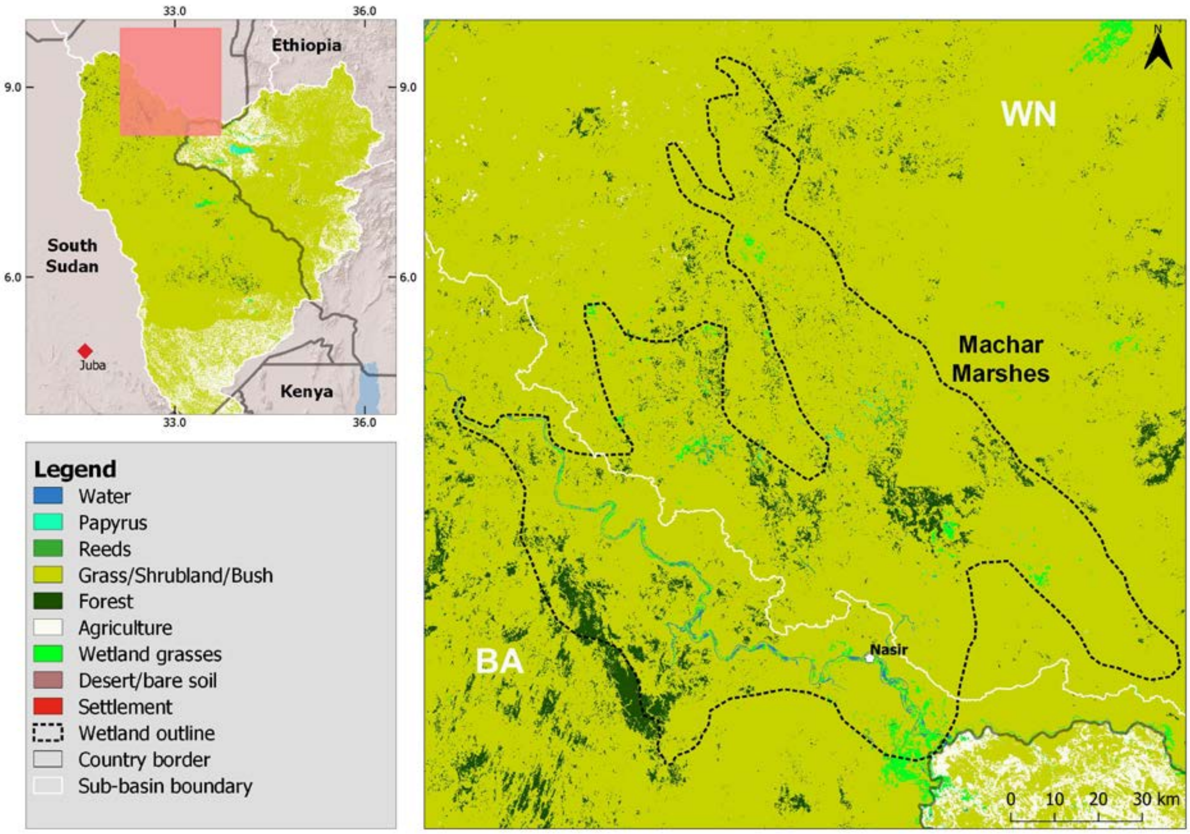

Figure 113 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

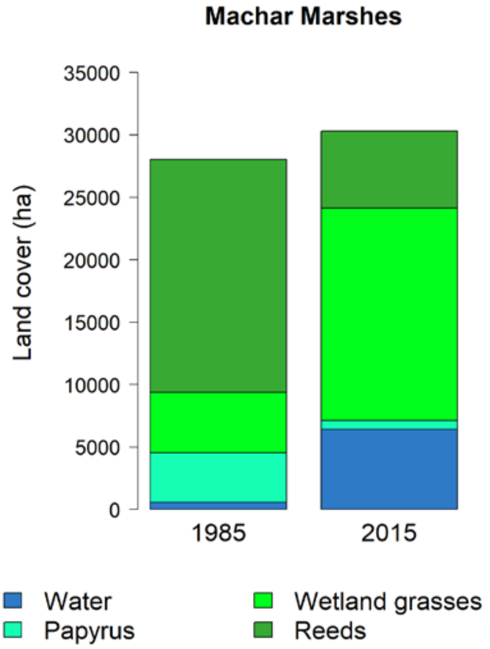

Figure 114 Land cover in 1985 and 2015

Table 85 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	588	6430	993.5
Papyrus	3949	717	-81.8
Wetland grasses	4846	17010	251.0
Reeds	18647	6140	-67.1
Total area*	1008516	1008517	0.0

* Total area based on all 9 land cover classes

3.1.7 White Nile

Overview

The White Nile 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 basin can be further divided into five major sub basins: 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 basin.

Climate

There is high spatioal variation of rainfall in the White Nile Basin. Semi-ari conditions increase from upstream to downstream. Rainfall in the southern part of the subbasin is gtreater than 1,000 mm/year but continuously decreases to less than 300 mm towards the north of the basin. Average annual precipitation is 700 mm/year at Malakal and drops to 170 mm/year at Jebel Aulia. Inter annual rainfall variation is high across the subbasin. The rainy period is from May to October. Precipitation in the whole 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^{o}C. Relative humidity ranges from 30 mm/month in January to almost 80 mm/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 Basin are further presented in WP 3: Ecosystem Service Assessment.

Land Cover

Table 86 Land cover change in the White Nile Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	1042	1299	24.7
Papyrus	157	84	-46.9
Wetland grasses	94	333	254.4
Reeds	595	223	-62.6
Total area*	265257	265257	0.00

* Total area based on all 9 land cover classes

53. White Nile Floodplain

Name: White Nile Floodplain (between Malakal and Khartoum)
Country: South Sudan, Sudan
Coordinates: 9°32'55"- 15°14'11'' N / 31°38'08" - 32°28'45'' E
Altitude: 400 m a.s.l.
Area: 672 km²
Nearest Towns: Malakal, Khartoum
International Importance: Transboundary Wetland

Overview

The White Nile between Malakal and Khartoum flows in a relatively confined bed that is fringed by papyrus and reed areas. This also includs islands, floodplains, Khors and the shores of the Gebel Auliya 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 White Nile receives the Atbara River on the right bank, its final major tributary, 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 m^3 and at Gebel Auliya it is 25 billion m^2. 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).

Classification

Inland Wetland

M	Permanent rivers/streams/creeks
N	Seasonal/intermittent/irregular rivers
P	Seasonal/intermittent freshwater lakes (over 8 ha)
Tp	Permanent freshwater marshes/pools
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils

Land Use and Land Cover

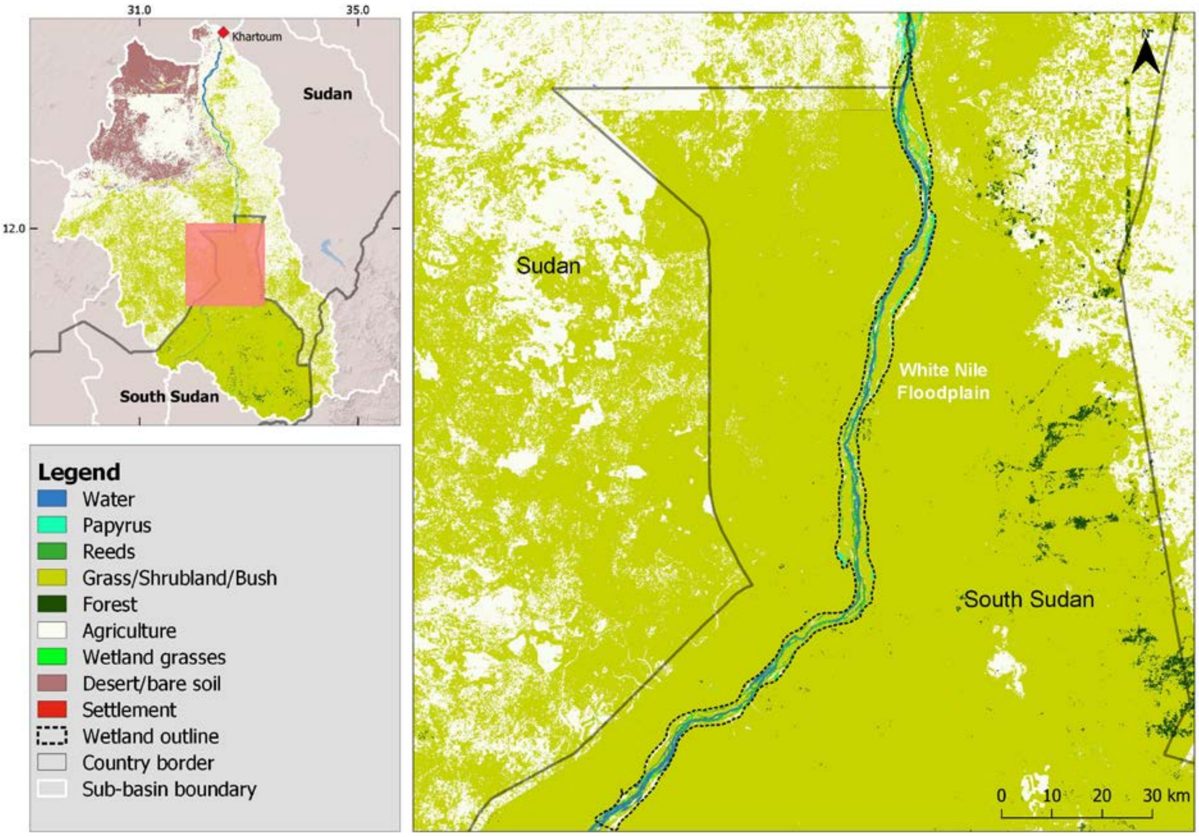

Figure 115 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

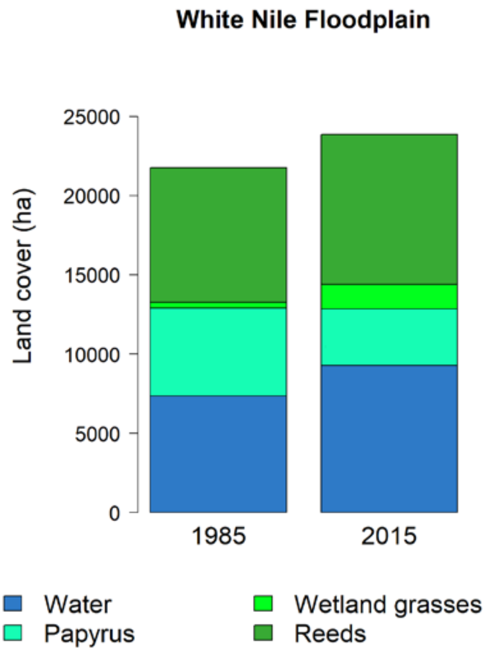

Figure 116 Land cover in 1985 and 2015

Table 87 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1756	2293	30.6
Papyrus	0	0	0.0
Wetland grasses	9	859	9444.4
Reeds	0	0	0.0
Total area*	71279	71279	0.0

* Total area based on all 9 land cover classes

54. Gebel Auliya

Wetland Name: Gebel Auliya (Jebel Awlia, Jebel Aulia)
Country: Sudan
Coordinates: 15°14'11'' N / 32°28'45'' E
Area: 894 km²
Altitude: 380 m a.s.l.
Nearest Town: Khartoum

Overview

The Gebel Auliya dam across the White Nile above 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 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).

Classification

<u>Inland Wetland</u>

M Permanent rivers/streams/creeks
O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools

Land Use and Land Cover

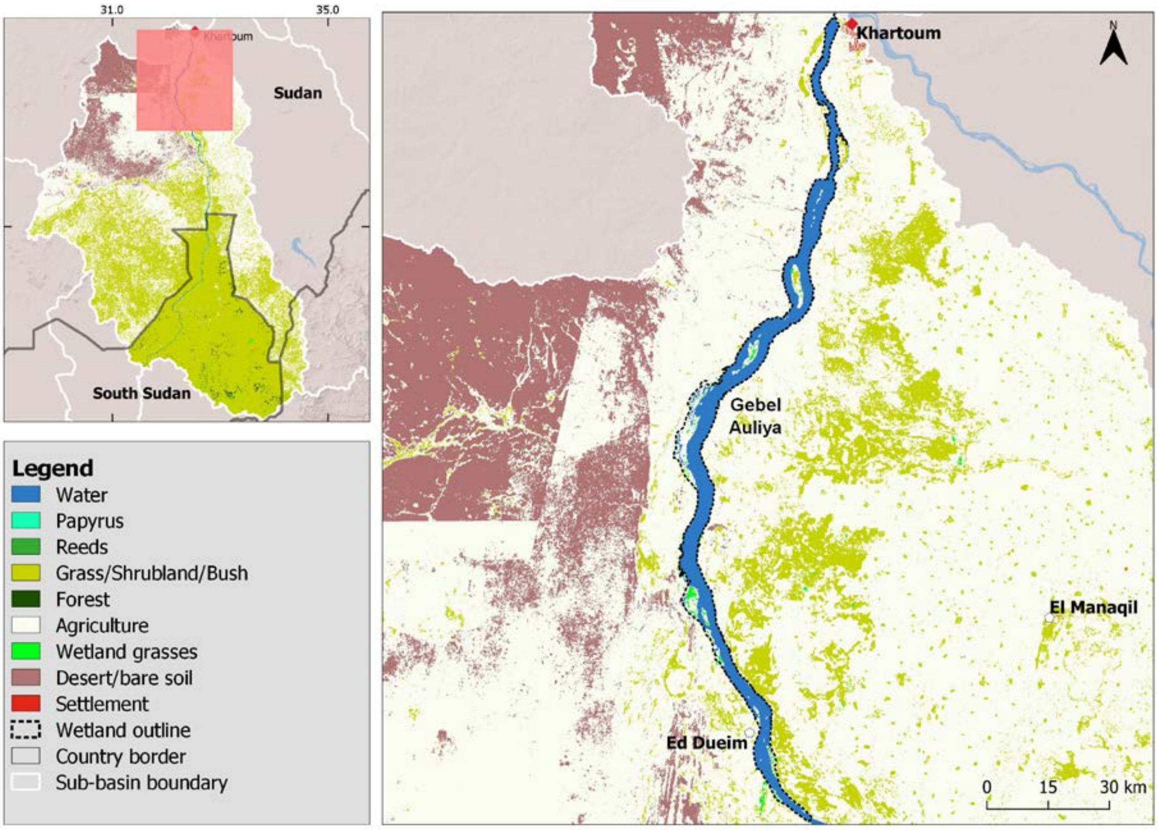

Figure 117 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

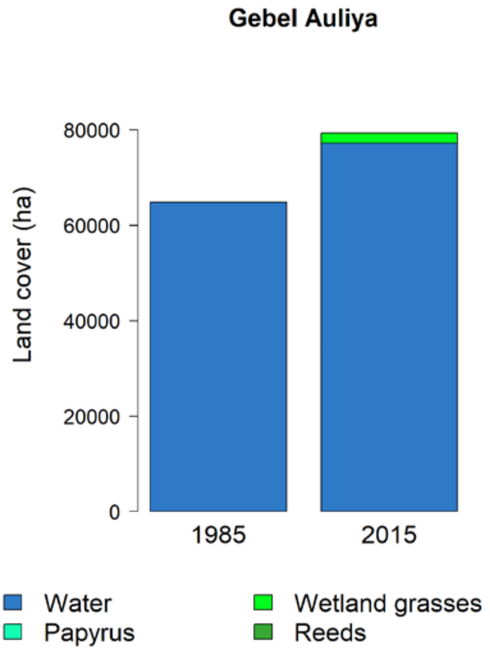

Figure 118 Land cover in 1985 and 2015

Table 88 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	64872	77256	19.1
Papyrus	5	0	-100.0
Wetland grasses	3	2051	68266.7
Reeds	0	0	0.0
Total area*	92605	92605	0.0

* Total area based on all 9 land cover classes

3.1.8 Blue Nile

Overview

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 m^3, 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 highlands with more than 1,200 mm/year. 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 (of provisioning and regulating services) in approximately 52 million US$ for 2011, concluding also that this could be way 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, collection of 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.

Land Cover

Table 89 Land cover change in the Blue Nile Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	3595	4128	14.8
Papyrus	1127	3	-99.7
Wetland grasses	19	188	891.9
Reeds	2864	1	-100.0
Total area*	313861	313861	0.00

* Total area based on all 9 land cover classes

BN. Dinder

55. Dinder Floodplain

Wetland 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 km^2
Nearest Towns: Sennar
International Importance: transboundary wetland, Important Bird Area

Overview
The floodplain occupies the land between the Dinder and Rahad Rivers which 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 km^2.The average flow of the Dinder is about 3×10^9 m^3/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^{O}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.

Bird flagship 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).

Mammal flagship species include *Aonyx capensis* (African clawless otter), Hippopotamus amphibious (hippopotamus), *Syncerus caffer* (African buffalo), *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), *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 as 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 from groundwater (Hassaballah et al., 2018).

Table 90 Protected area related to the wetland

Name	Type*	Designation Year
Dinder	National Park (II)	1935

*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)*

Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
U Non-forested peatland

Land Use and Land Cover

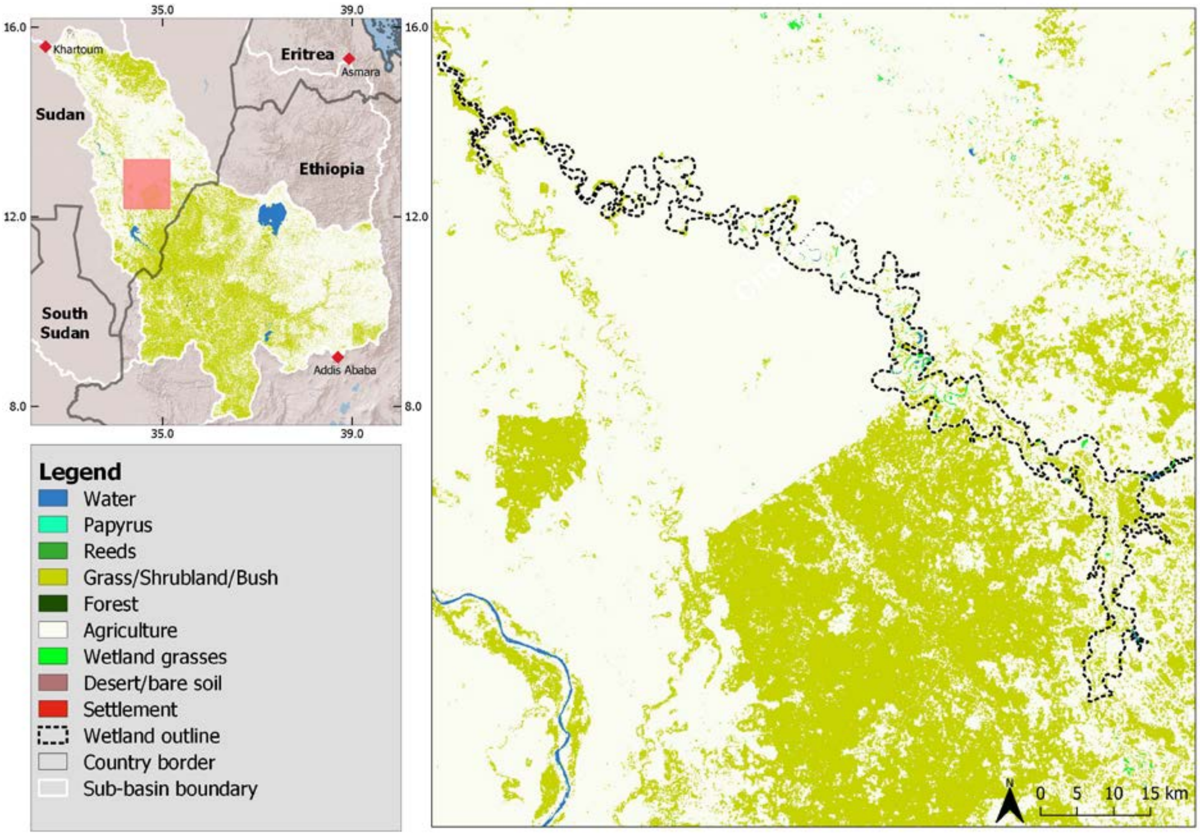

Figure 119 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

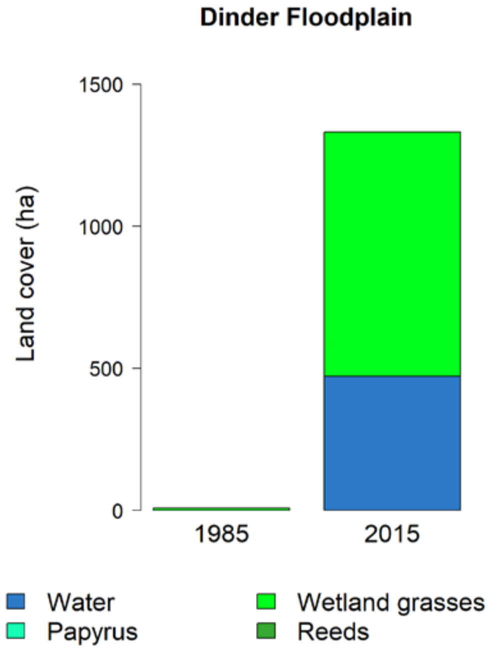

Figure 120 Land cover in 1985 and 2015

Table 91 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	0	472	N.A.
Papyrus	0	0	0.0
Wetland grasses	9	859	9444.4
Reeds	0	0	0.0
Total area*	53952	53952	0

* Total area based on all 9 land cover classes

BN. Lake Tana

56. Lake Tana

Wetland 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 Town: 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 north-west 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 km^2. 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 km^2 (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 km^2 during the dry season, to 3,600 km^2 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 km^3 (Mengistou et al., 2009).
The climate around Lake Tana is semi-arid with high diurnal temperature variation. The mean temperature is 18.5^{o}C with day-time extremes of 30^{o}C and night time lows of 6^{o}C. The surface water temperature ranges between 20 to 27^{o}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 south-west. 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 situates 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, Labeobarbus intermiduis* (Shkil et al., 2017). The main commercial fish species are *Lates niloticus*, *Oreochromis niloticus*, *Labeo hori*, *Clarias gariepinus*, *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. 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 weland group. Some of the 17 endemic fish species of Lake Tana include *Garra regressus, G. tana, Barbus tanapelagius, Afronemacheilus abyssinicus, 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.

Classification

Inland Wetland

M Permanent rivers/streams/creeks
N Seasonal/intermittent/irregular rivers/streams/creeks
O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils

Land Use and Land Cover

The major habitats around Lake Tana are farmland, grassland, forest, rocky areas, marsh, reed beds and the lake itself. Water retention is high, making the area prone to inundation. The Bahir Dar area is particularly well known for oil crops and *Carthamus tinctorius*. The flat land, particularly where water lies in the rainy season, is grassland with a mixture of palatable indigenous grasses and legumes (Mengistou et al., 2009).

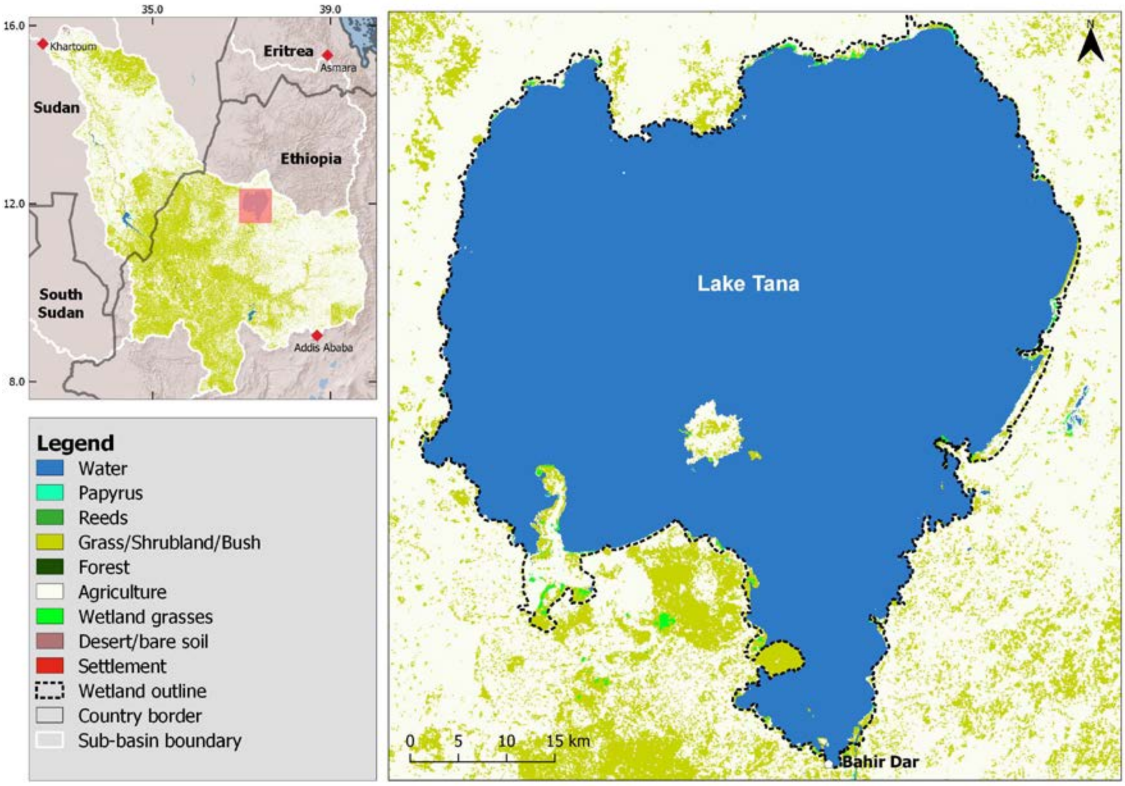

Figure 121 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Change Trajectories 1985-2015</u>

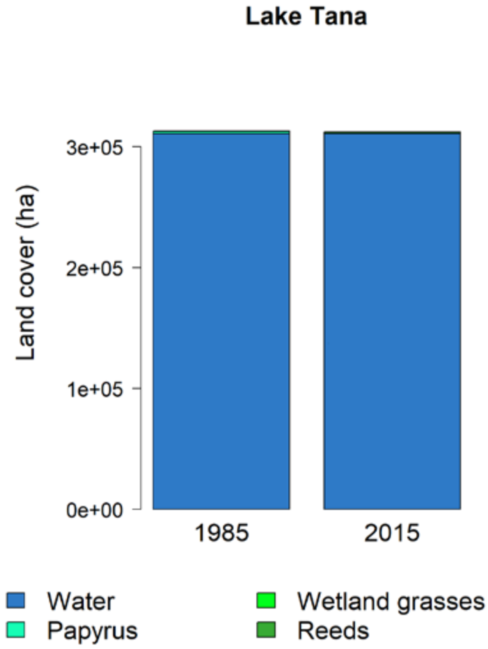

Figure 122 Land cover in 1985 and 2015

Table 92 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	310757	311084	0.1
Papyrus	1951	155	-92.1
Wetland grasses	163	1094	571.2
Reeds	25	67	168.0
Total area*	327833	327833	0.0

* Total area based on all 9 land cover classes

BN. Reservoirs in the Blue Nile Basin

57. Fincha'a-Chomen

Wetland 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, Sennar
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.

Classification

<u>Inland Wetland</u>

O Permanent freshwater lakes
Tp Permanent freshwater marshes/pools
Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

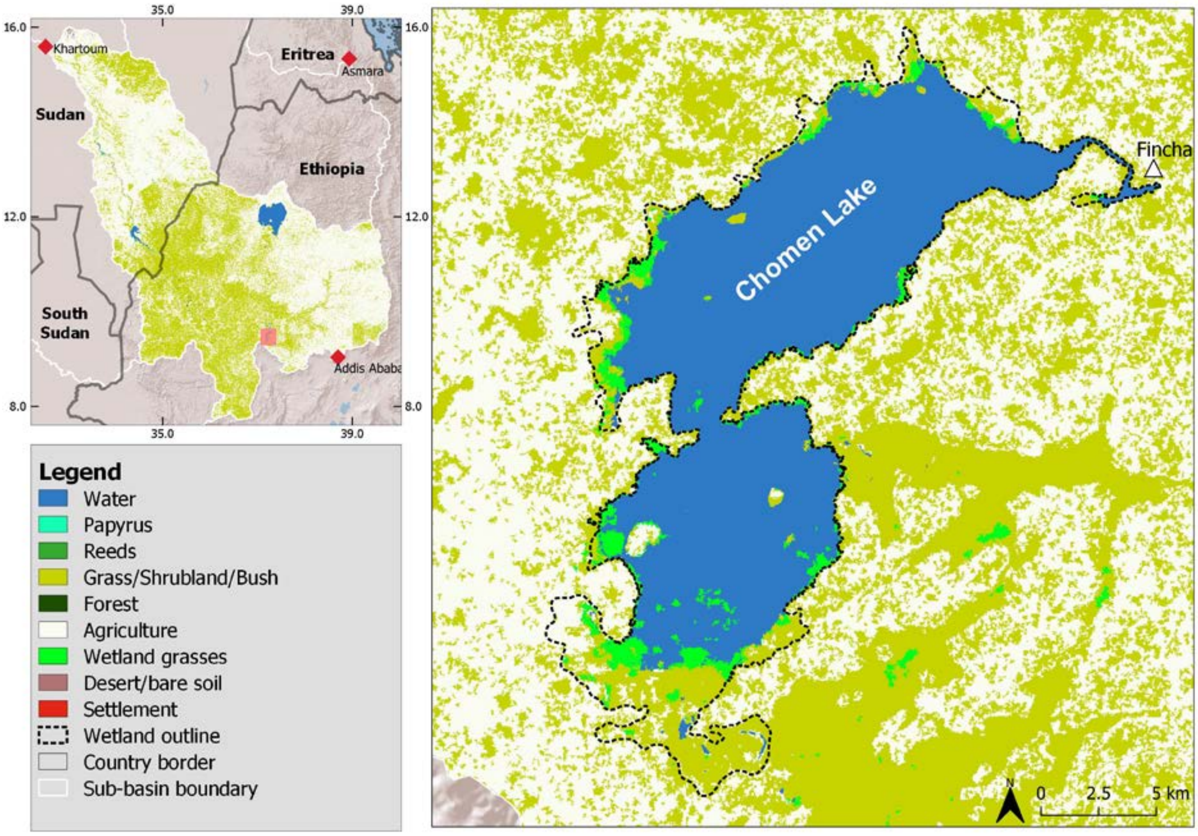

Figure 123 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

<u>Change Trajectories 1985-2015</u>

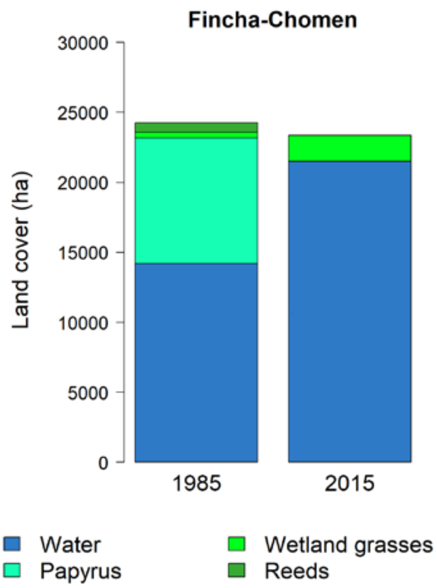

Figure 124 Land cover in 1985 and 2015

Table 93 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	14211	21494	51.2
Papyrus	8935	0	-100.0
Wetland grasses	427	1863	336.3
Reeds	666	0	-100.0
Total area*	28171	28171	0.0

* Total area based on all 9 land cover classes

58. El Roseires

Wetland Name: El Roseires artificial impoundment
Country: Sudan
Coordinates: 11°41'26'' N / 34°23'6'' E
Altitude: 480 m a.s.l.
Area: 535 km²
Nearest Towns: El Roseires (Khartoum 550 km SE)

Overview

The Roseires Reservoir is located just 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 km^3 (ENTRO, 2008b). Due to severe sedimentation in the last forty years, 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 ^{o}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 km^3/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 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 $*10^6$ m^3 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 km^2 in 2011 to 528 km^2 (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 km^3 (Muala et al., 2014). The bed of the reservoir is cut through by a 10 m deep channel (Omer et al., 2015).

Classification

Inland Wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

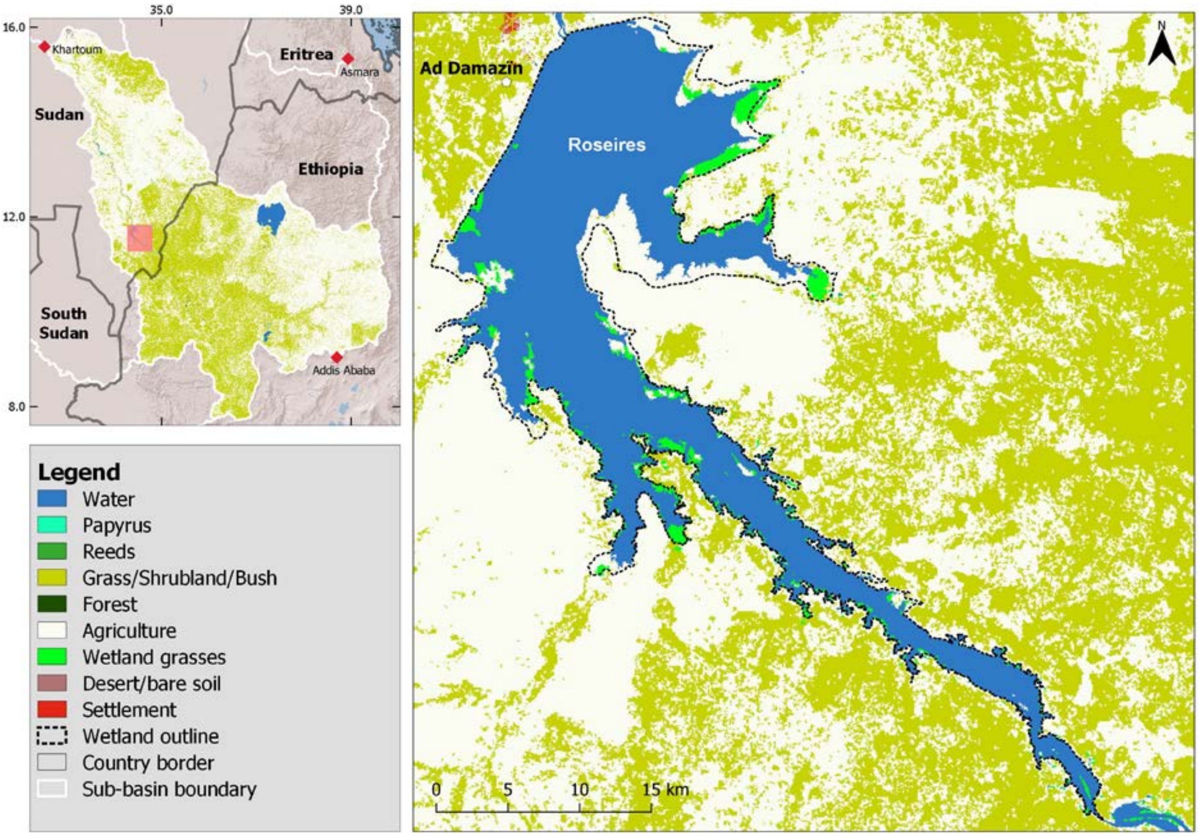

Figure 125 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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.

Change Trajectories 1985-2015

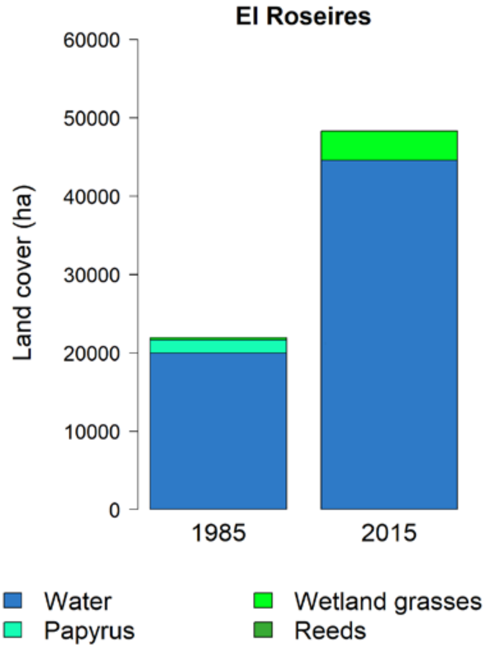

Figure 126 Land cover in 1985 and 2015

Table 94 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	20004	44558	122.7
Papyrus	1635	0	-100.0
Wetland grasses	321	3726	1060.7
Reeds	0	0	0.0
Total area*	54780	54779	0.0

* Total area based on all 9 land cover classes

59. Sennar

Wetland Name: Sennar artificial impoundment, Sinnar dam
Country: Sudan
Coordinates: 13°30'14''N / 33°40'3'' E
Altitude: 425 m a.s.l.
Area: 133 km²
Nearest Towns: Sennar

Overview

The Sennar Dam was completed in 1925 with a storage capacity of 0.93 km^3. 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 km^3/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 km^3.

Classification

Inland Wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

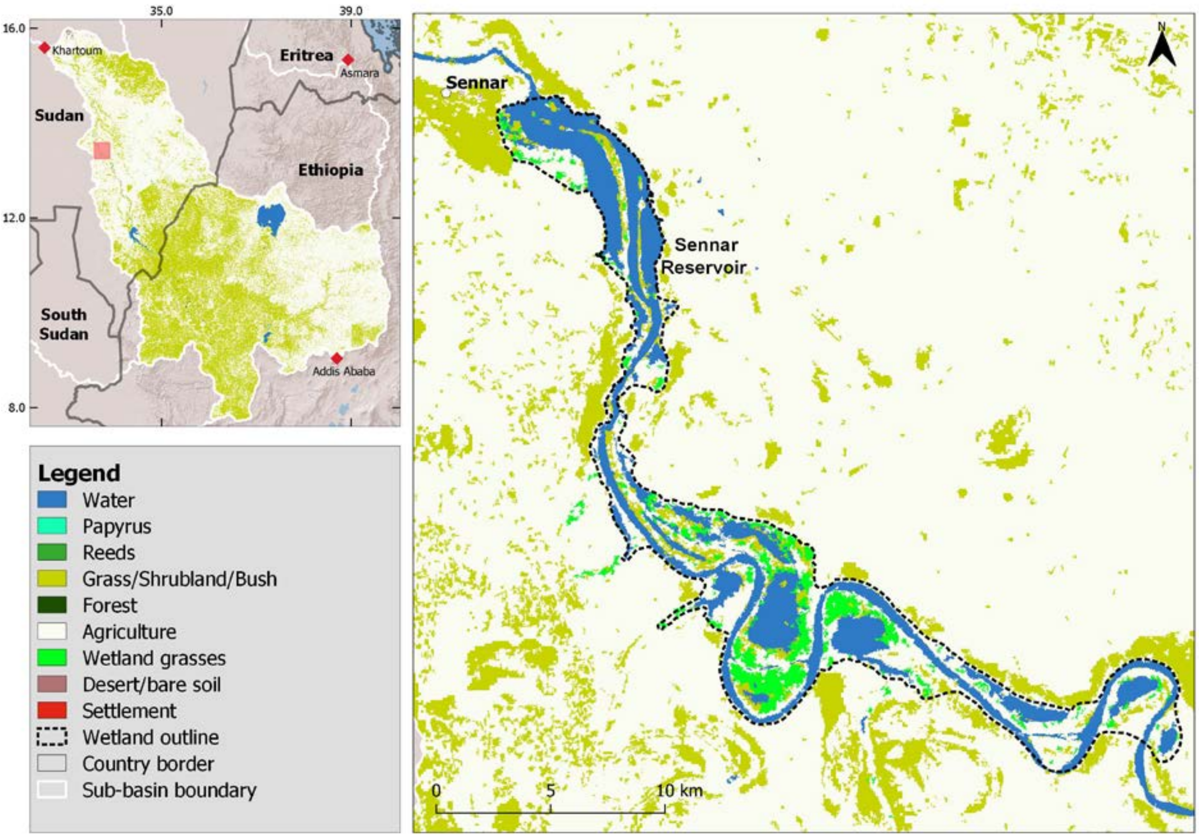

Figure 127 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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)

Change Trajectories 1985-2015

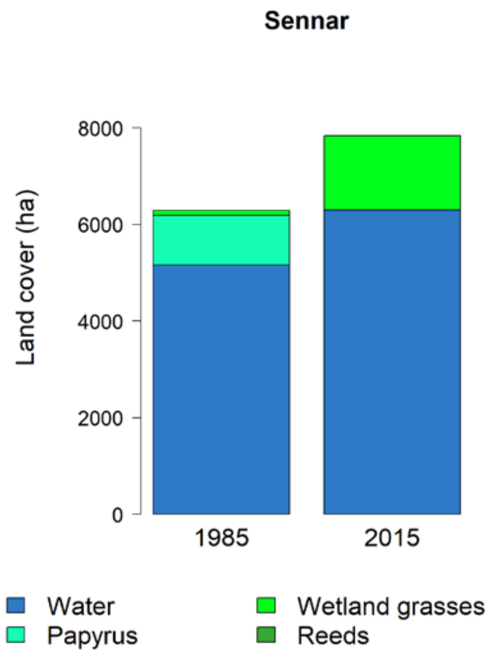

Figure 128 Land cover in 1985 and 2015

Table 95 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	5164	6301	22.0
Papyrus	1028	0	-100.0
Wetland grasses	101	1534	1418.8
Reeds	0	0	0.0
Total area*	13741	13742	0.0

* Total area based on all 9 land cover classes

3.1.9 Tekeze Atbara

Overview

The Tekeze-Atbara sub basin drains the highlands of central-north 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 sub-basin is approximately 12 x 10^9 m^3. 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). Sediments 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 uni-modal 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.

Land Cover

Table 96 Land cover change in theTekeze Atbara Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	91	324	257.4
Papyrus	11	0	-100.0
Wetland grasses	1	32	5022.6
Reeds	0	0	0.0
Total area*	240084	240084	0.00

* Total area based on all 9 land cover classes

60. Khashm el-Girba

Wetland Name: Khashm el-Girba
Country: Sudan
Coordinates: 14°54'1'' N / 35°53'40'' E
Altitude: c. 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 1,300 mcm (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 km^2 with mean annual inflow of 11.65 bm^3. The Girba reservoir is built for irrigation and hydropower purposes mean annual sediment inflow to the reservoir is in the order of 28.5 mm^3 (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).

Classification

Inland Wetland

O Permanent freshwater lakes

Tp Permanent freshwater marshes/pools

Ts Seasonal/ intermittent freshwater marshes/ pools on inorganic soils

Land Use and Land Cover

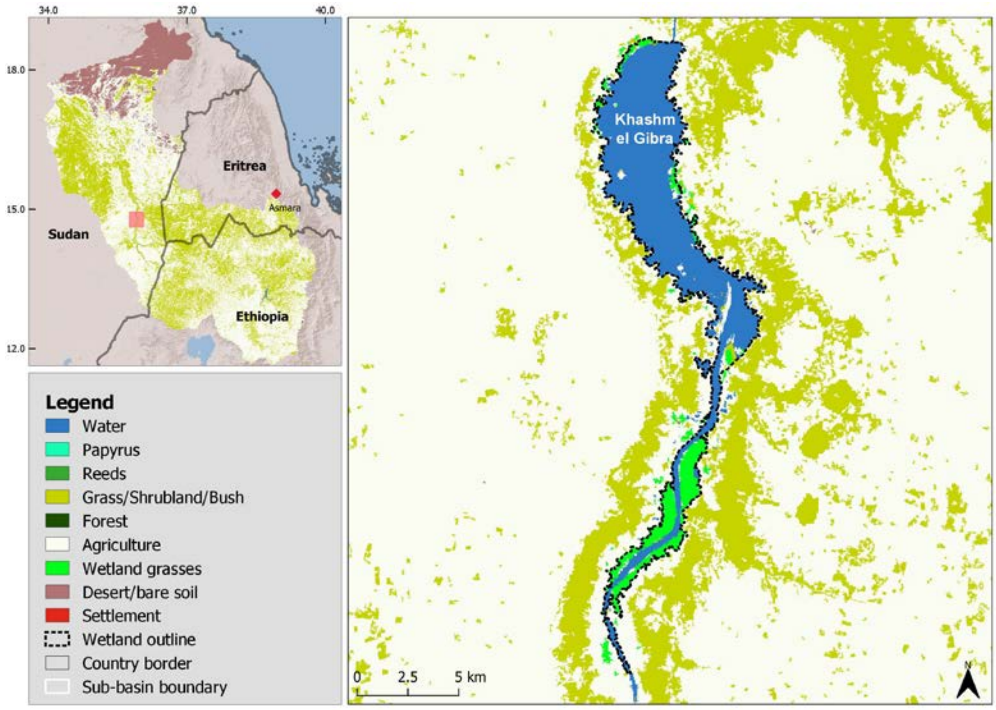

Figure 129 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Change Trajectories 1985-2015

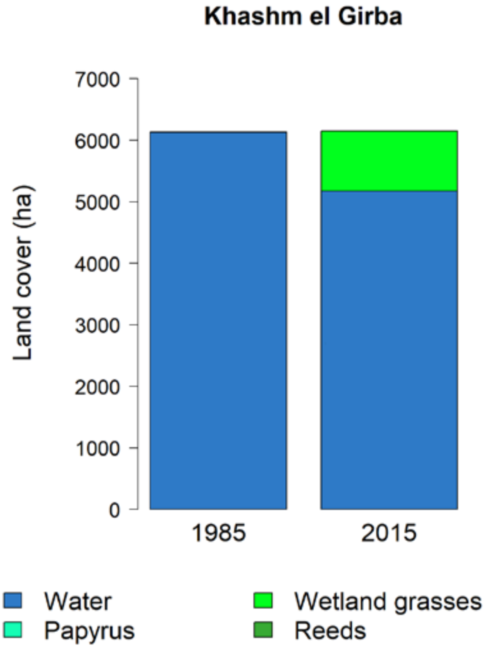

Figure 130 Land cover in 1985 and 2015

Table 97 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	6131	5177	-15.6
Papyrus	0	0	0.0
Wetland grasses	2	969	48350.0
Reeds	0	0	0.0
Total area*	6485	6484	0.0

* Total area based on all 9 land cover classes

3.1.10 Main Nile

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).

Land Cover

Table 98 Land cover change in the Main Nile Basin. Percentage of total area based on 2015 land cover.

Landcover Class	1985 (km^2)	2015 (km^2)	Change 1985-2015 (%)
Water	7629	9294	21.8
Papyrus	7	52	697.7
Wetland grasses	239	501	109.9
Reeds	1	21	1443.0
Total area*	1027806	1027813	0.00

* Total area based on all 9 land cover classes

MN. 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

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^{o}C and maximum temperatures go almost up to 40^{o}C. In January/December minimum temperature is 10 and the maximum temperature is 22^{o}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 for most of the year (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, 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. Bothe Ramsar sites, Wadi el Rayan and Lake Qarun are popular tourist destination, for birdwatching, safaris and visiting historical sites (Fouda & Fishar, 2012a, 2012b).

61. Lake Nubia/Nasser

Wetland Name: Lake Nasser/Nubia
Country: Egypt, Sudan
Coordinates: 23°8'17'' N / 32°47'11'' E
Altitude: 180 m a.s.l.
Area: 5,541 km²
Nearest Towns: Aswan
International Importance: Important Bird Area, transboundary wetland

Overview

In 1969 the construction of the High Dam at Aswan was completed, which lead to the formation of a 15 km wide and almost 500 km long lentic body of water. The impoundment is called Lake Nasser in Egypt and Lake Nubia in Sudan in Sudan. This reservoir is one of the world's largest man-made lakes. It is of vital importance for the country, representing Egypt's main reservoir of fresh water.

Physical Features

Lake Nubia makes up about one third, 150 km of the Aswan High Dam Reservoir, while the Egyptian part, Lake Nasser is about 350 km long. The total surface area of both lakes at a water level of 160 m is about 3,084 km² (Hamdan & Zaki, 2016)

The water volume in the lake fluctuates greatly, seasonally and from year to year, depending on the net annual volume of water it receives. The highest water-level of 181.3 m (above sea-level) was reached in November 1998 (NBI, 2016). At this level the reservoir is nearly full, has an area of 6,276 km² and a total volume of 162 × 10^9 m^3 (Hamdan & Zaki, 2016). Seasonal fluctuation in water-level ranges between 5 m and 10 m, with the level being highest in autumn then gradually receding to its lowest level in summer, depending on the amount of water released downstream from the dam, evaporation and the amount received from upstream (NBI, 2016).

The reservoir has an average depth of 25 m, maximum depth of 90 m, average width of 10 km, and maximum width of 60 km. The incoming Nile has an annual mean discharge of 2,900 m^3/s (Zaghloul et al., 2012). Water losses from the lake through evaporation are on average 13.62 × 10^9 m^3/year (Hamdan & Zaki, 2016). Percentage of evaporation relative to water storage in the lake vary from 3.55 % to 20.26 % (Hamdan & Zaki, 2016).

The reservoir itself has a riverine, a transitional and a lacustrine zone. These zones differ in physico-chemical and biological features. Multiple dendritic side extensions or flooded valleys called khors are characteristic for Lake Nasser. Some of these khors can be considered as semi-isolated lakes, as they sometimes differ greatly in morphology. Some are wide with a gentle slope and sandy bottom, others are steep and narrow with rocky bottom. The khors make up 79 % (ca. 4,900 km²) of the total lake surface. The shallow coastal area of the khors ecologically play an important role as they provide habitat for juvenile fish, especially tilapia (El-Shabrawy & Dumont, 2003). There are some 85 major khors, 48 on the eastern side of the lake and 37 on the western side. Allaqi, Kalabsha and Tushka are the three largest khors in Lake Nasser, making up a large part of its total area (BirdLife International, 2019).

Overall the reservoir can be considered oligo-mesotrophic and phosphorous limited, with pronounced seasonal variation linked to the arrival of the Nile floods from upstream (Zaghloul et al., 2012). The water temperature in the lake ranges from 17 to 32°C depending on the season and the khor (El-Shabrawy & Dumont, 2003).

Classification

Inland Wetland

O Permanent freshwater lakes (over 8 ha)
Tp Permanent freshwater marshes/pools
Ts Seasonal/intermittent freshwater marshes/pools on inorganic soils
W Shrub-dominated wetlands

Management

Currently, the management of Lake Nasser is under the main responsibility of High Aswan Dam Authority, under the Ministry of Water Resources and Irrigation. Presidential Decree n. 203 of 2002 provides general guidelines restricting human activities around the reservoir to avoid potential impacts. In 2002, Aswan Governorate issued a Lake Nasser Development Plan. A buffer zone of 2 km is established around the reservoir by Decree 203/2002, where no agricultural, tourist and industrial activities are allowed to take place. Under Law 102/1983, Wadi Alaqi is recognised as a Biosphere Reserve of international importance that should remain free of any development, disturbance and changes in land-use or activity that may degrade the natural site. (Zaghloul et al., 2012). In addition the lake is an Important Bird Area since 1999.

Table 99 Protected area related to the wetland

Name	Type*	Designation Year
Wadi Al Alaqi	Multiple Use Management Area (VI)	1996

*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)*

Land Use and Land Cover

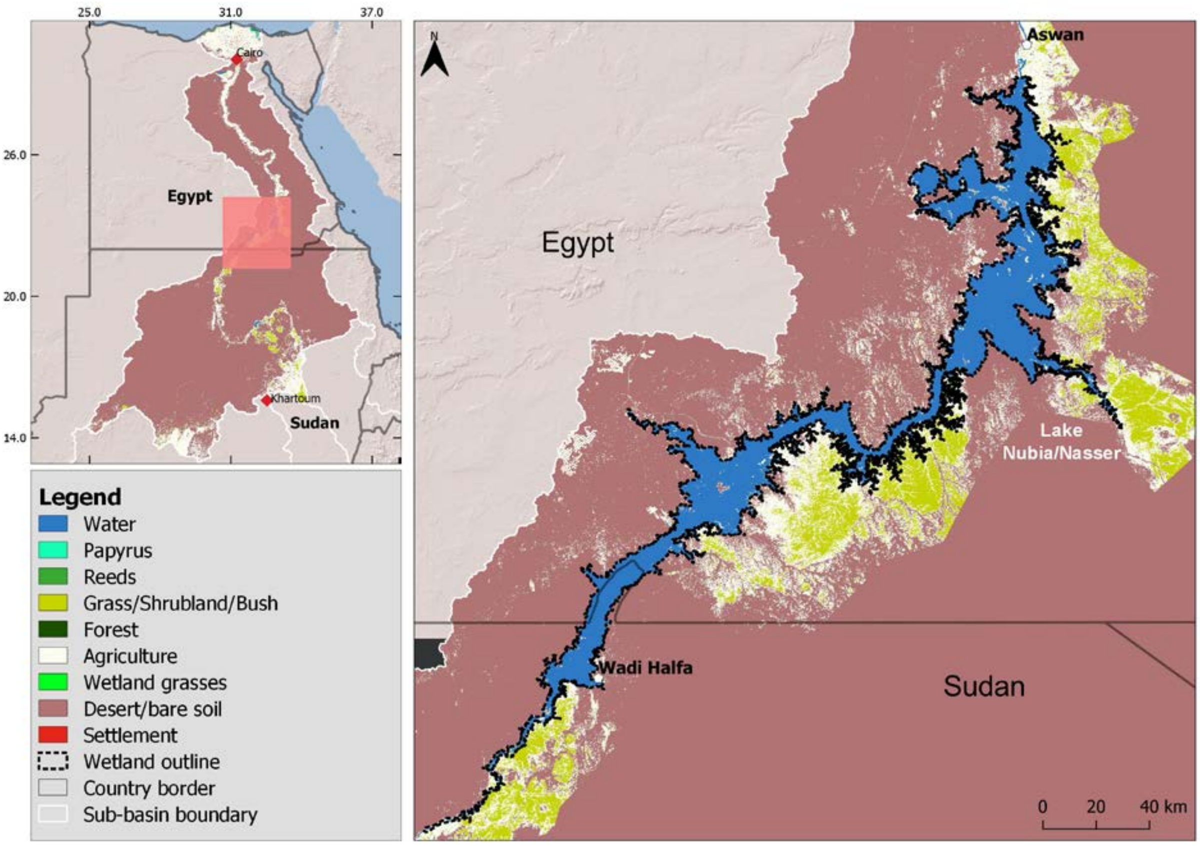

Figure 131 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

The irregular and huge fluctuations in water-level of the lake, poor soils, steep shoreline and inaccessibility are some of the factors that have led to the failure of many development efforts along the lake shores (BirdLife International, 2019).

Zaghloul et al. (2012) carried out a quantification of current pressures on Lake Nasser to estimate the total contribution of different pollution sources. Pressures identified were domestic wastewater input, agriculture, fisheries and navigation. The scenarios employed showed a large increase in agriculture between 2010 and 2022, which in turn would lead to increase of nitrogen load by 700 % and an increase in phosphorous load by 137 %. Most of the estimated nutrient load would come from upstream through the Nile. The study concludes that the current good water quality status of Lake Nasser and the low impact of local sources indicate that the future water quality status of the reservoir is dependent mainly on potential impacts that could come from the Nile inflow upstream.

Change Trajectories 1985-2015

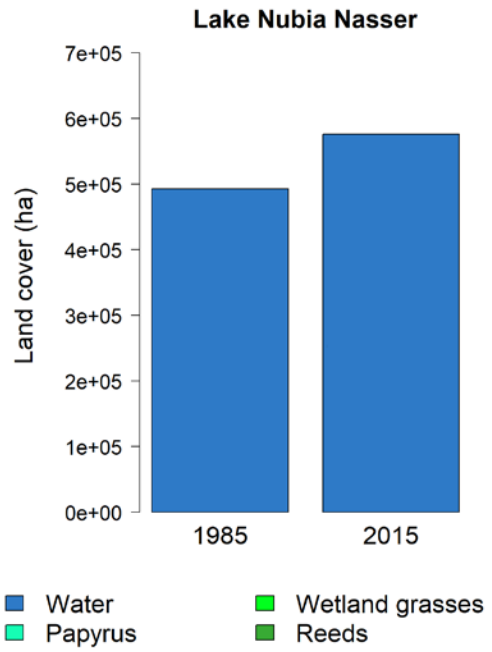

Figure 132 Land cover in 1985 and 2015

Table 100 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	492937	575726	16.8
Papyrus	0	0	0.0
Wetland grasses	0	0	0.0
Reeds	0	0	0.0
Total area*	611497	611498	0.0

* Total area based on all 9 land cover classes

62. Wadi El Rayan Protected Area

Name: Wadi El Rayan Protected Area
Country: Egypt
Coordinates: 29°12'35'' N / 30°26'37'' E
Altitude: 13 m b.s.l.
Area: 90 km²
Nearest Towns: El Faiyum
International Importance: Ramsar site, Important Bird Area

Overview

The two Wadi El Rayan lakes are depression located to the south-west of Faiyum, about 130 km southwest of Cairo. The northern lake has a surface area of 50 km^2 and a maximum depth of 14 m whereas the southern lake is 56 km^2 large and is maximum 36 m deep (Hereher, 2015). In 2017 their combined area was estimated to be 75.75 km^2 (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 m^3/year and hold approximately 2.13 and 2.9 bm^3, 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 both lakes suffer from a different degree of 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.

Classification

<u>Inland Wetland</u>

Q Permanent saline/brackish/alkaline lakes
Y Freshwater springs/oases
Sp Permanent saline/brackish/alkaline marshes/pools.

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 Rayan 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).

Table 101 Protected area related to the wetland

Name	Type*	Designation Year
Wadi El Rayan	Multiple Use Management Area (VI)	1989

*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)*

Land Use and Land Cover

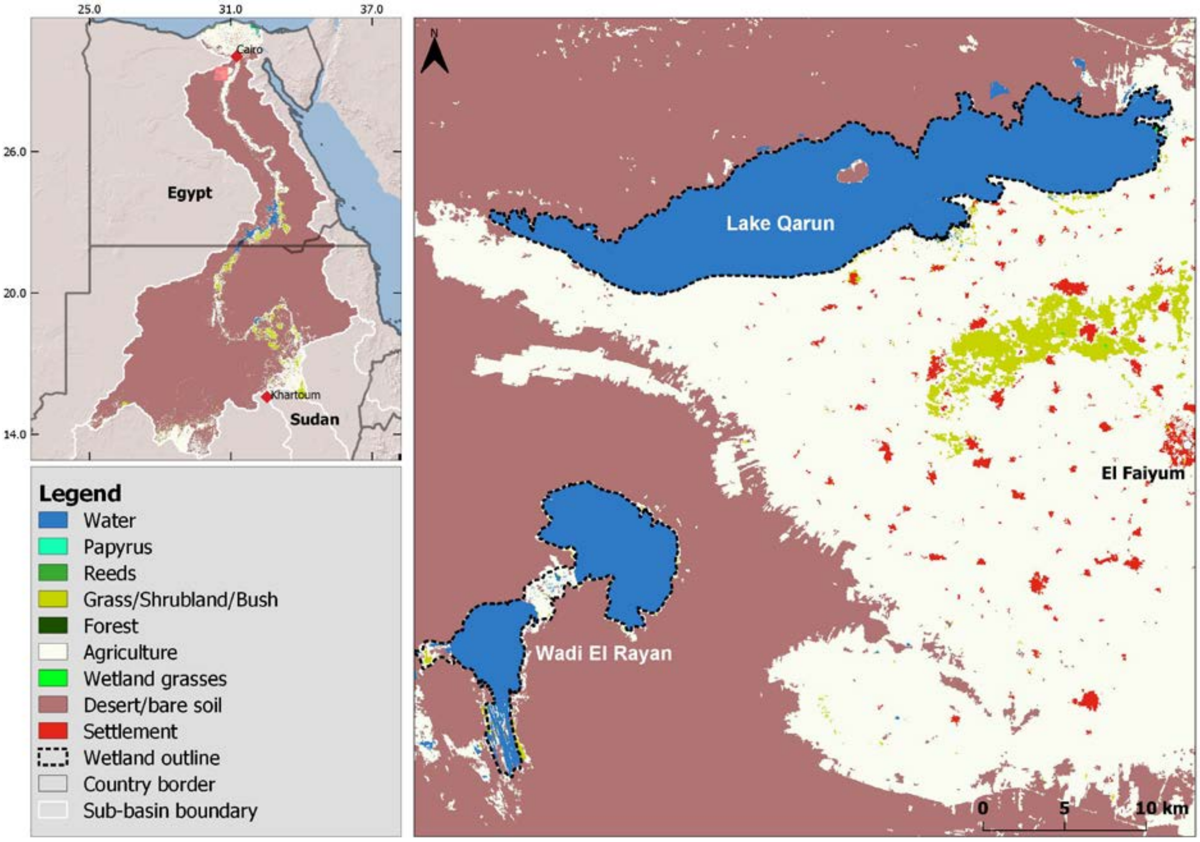

Figure 133 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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 km^2. Then the combined area of both lakes decreased to 86 km^2 (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 hyper-arid 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 km^2, respectively.

Change Trajectories 1985-2015

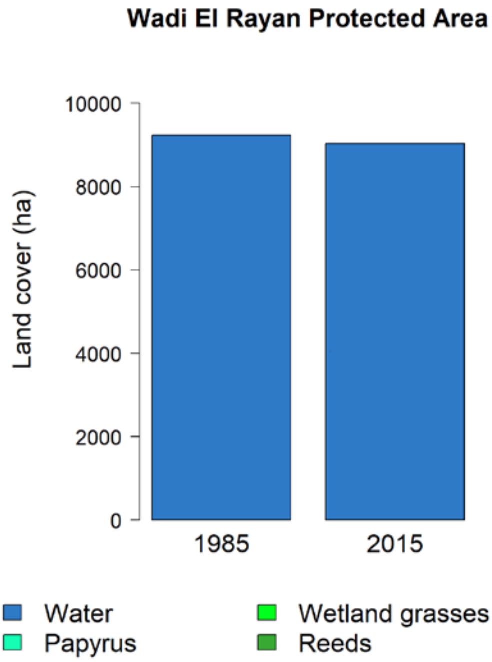

Figure 134 Land cover in 1985 and 2015

Table 102 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	9230	9029	-2.2
Papyrus	0	0	0.0
Wetland grasses	0	0	0.0
Reeds	0	0	0.0
Total area*	10333	10333	0.0

* Total area based on all 9 land cover classes\

63. Lake Qarun

Name: Lake Qarun
Country: Egypt
Coordinates: 29°27'36'' N / 30°38'27'' E
Altitude: 13 m b.s.l.
Area: 242 km^2
Nearest Towns: El Faiyum
International Importance: Ramsar site, Important Bird Area

Overview

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 km^2 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 km^2 (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

Lake Qarun occupies the deepest part of the Fayoum Depression and is 45 m below sea level. Its area has decreased form 249 km^2 in 1996 to 232 km^2 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 m^3 (Fouda & Fishar, 2012a).

About 370 million m^3 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 10^6 m^3 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 10^6 m^3 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 10^6 m^3 (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).

Classification

Inland Wetland

Q Permanent saline/brackish/alkaline lakes

G Flats (mud, sand or salt) Saline water

Sp Permanent saline/brackish/alkaline marshes/pools.

Management

The Lake Qarun Area is a protected site in the El-Fayoum 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 Qarun 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.

Table 103 Protected area related to the wetland

Name	Type*	Designation Year
Qarun	Multiple Use Management Area (VI)	1989

*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)*

Land Use and Land Cover

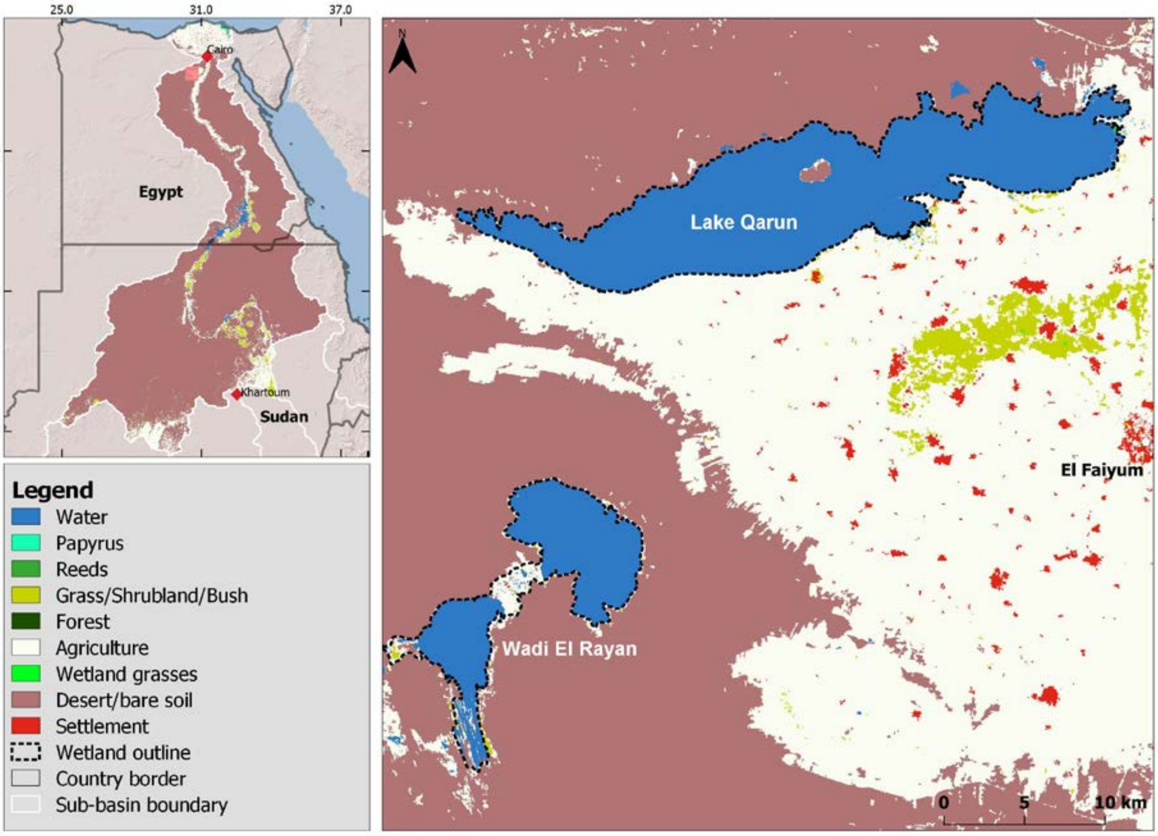

Figure 135 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

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).

Change Trajectories 1985-2015

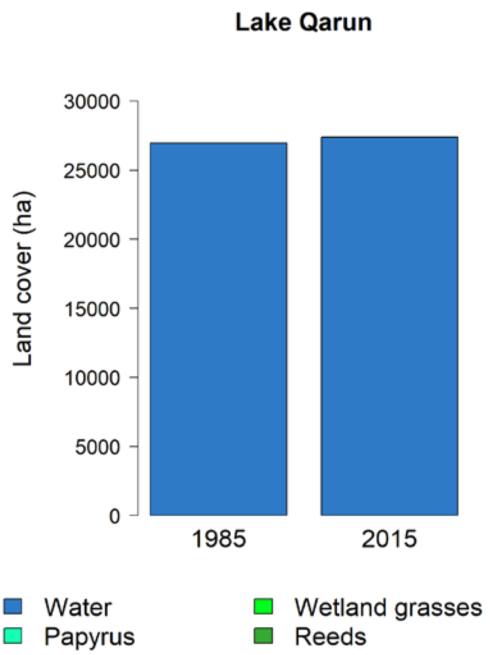

Figure 136 Land cover in 1985 and 2015

Table 104 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	26961	27374	1.5
Papyrus	0	0	0.0
Wetland grasses	4	11	175.0
Reeds	0	0	0.0
Total area*	27716	27716	0.0

* Total area based on all 9 land cover classes

MN. The Nile Delta

Overview

The Nile Delta is 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 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^{o}C in winter to 40^{o}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 mouse-tailed 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.

64. The Nile Delta Floodplain

Wetland 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

From north to south the Nile Delta is approximately 160 km in length. From west to east it covers some 240 kilometres of coastline. The delta is sometimes divided into west and east sections, with the Nile dividing into two main distributaries, the Damietta and the Rosetta, flowing into the Mediterranean at port cities with the same name. In the past, the delta had several distributaries, but these have been lost due to flood control, silting and changing relief. One such defunct distributary is Wadi Tumilat. To the north-west are three other coastal lakes or lagoons: Lake Burullus, Lake Idku and Lake Maryut. 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 remain. The best remaining habitat is found in the Lakes El Mannah, El Qatta, Faraontya, Sinnéra, Sanel Hagar and the coastal lagoons of Manzala and Miheishar (Hughes & Hughes, 1992).

Classification

<u>Inland Wetland</u>

L Permanent inland delta
J Coastal brackish/saline lagoons

M Permanent rivers/streams/creeks
Q Permanent saline/brackish/alkaline lakes
Tp Permanent freshwater marshes/pools

Human-made wetlands
3 Irrigated land

Land Use and Land Cover

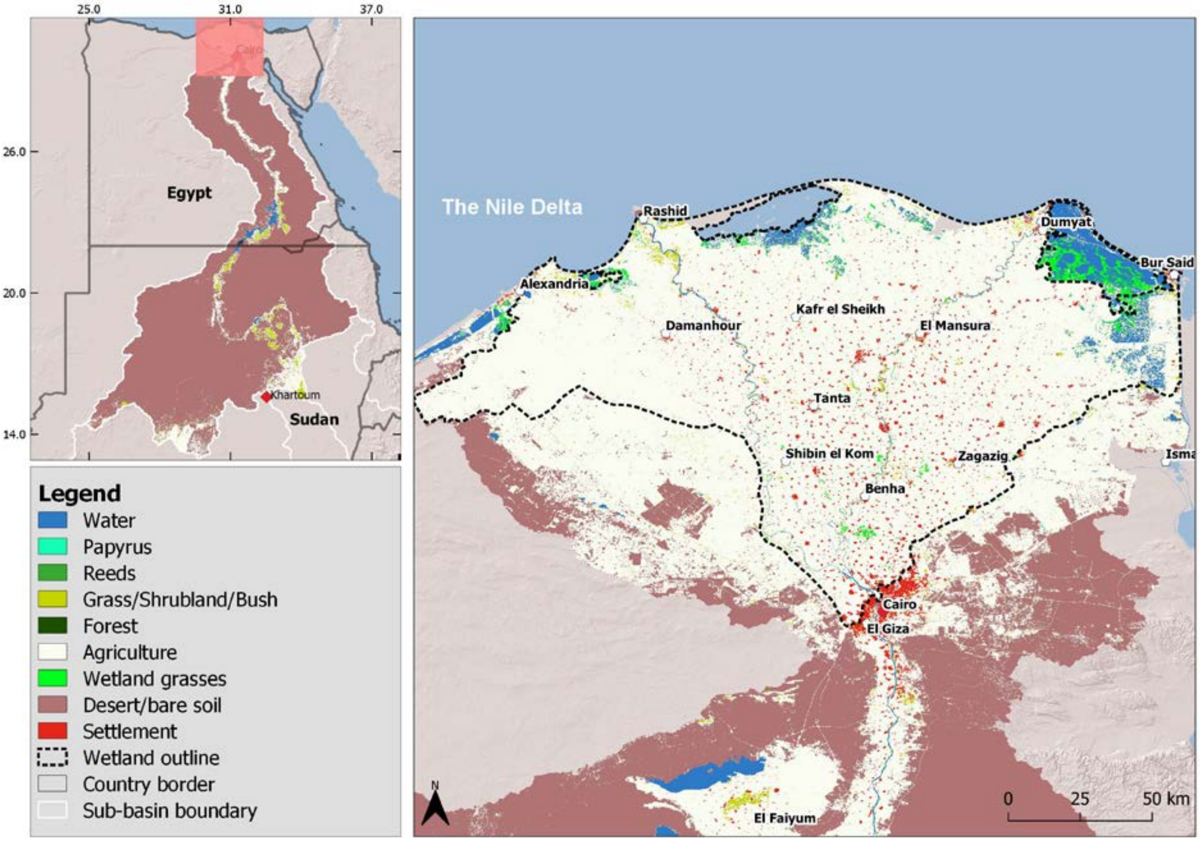

Figure 137 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

Drivers of Change

Considering agricultural expansion and population pressure, practically no areas of delta habitat remain undisturbed. The completion of the first Aswan Dam (between 1912 and 1934) dampened the annual flood pulse in the Nile Delta. The completion of the second Aswan (High) Dam totally stopped flooding and most of the former seasonally or permanently flooded habitats have subsequently been converted to settled agriculture. Before the dams were built, floodplain farming had occurred for over 5,000 years, although flooded areas were only farmed after the flood receded. However, since the closure of Aswan Dam floodplains are farmed year-round, causing the loss of much of the wetland habitats of the delta and lower Nile River floodplain. The hydrological impacts have also led to decreasing the papyrus habitats and increasing salinity levels, affecting agriculture as well as fishes composition (NBI, 2009; Hamza, 2009; Rebelo & McCartney 2012).

Change Trajectories 1985-2015

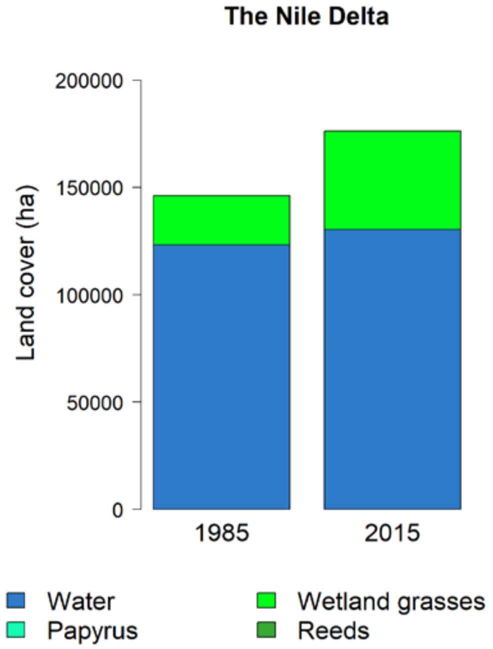

Figure 138 Land cover in 1985 and 2015

Table 105 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	123266	130313	5.7
Papyrus	0	0	0.0
Wetland grasses	22766	45870	101.5
Reeds	0	0	0.0
Total area*	2576047	2576047	0.0

* Total area based on all 9 land cover classes

65. Lake Maryut

Wetland 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 Town: Alexandria (2 km SW)
International Importance: Important Bird Area

Overview

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 km^2 (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, 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 12^{th} 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 19^{th} 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 m^3/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 South-western 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).

Classification

Inland Wetland

Q Permanent saline/brackish/alkaline lakes

J Coastal brackish/saline lagoons

Human-made wetlands

1 Aquaculture

Land Use and Land Cover

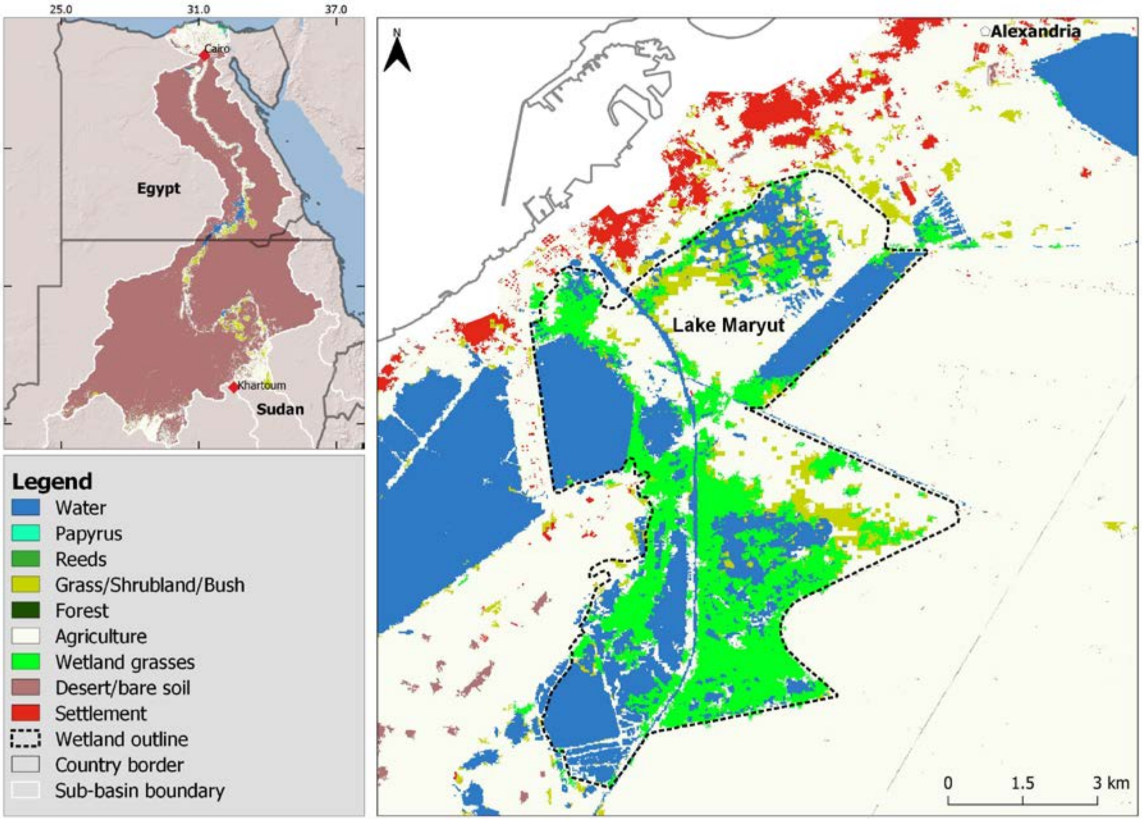

Figure 139 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

<u>Change Trajectories 1985-2015</u>

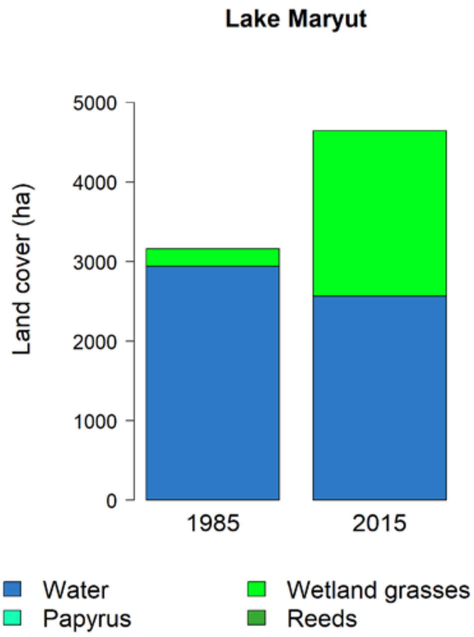

Figure 140 Land cover in 1985 and 2015

Table 106 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	2940	2565	-12.8
Papyrus	0	0	0.0
Wetland grasses	222	2077	835.6
Reeds	0	0	0.0
Total area*	7660	7660	0.0

* Total area based on all 9 land cover classes

66. Lake Idku

Wetland Name: Lake Idku, Lake Edku
Country: Egypt
Coordinates: 31°14'43''N / 30°12'40''E
Altitude: sea level
Area: 55 km^2
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 km^2 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 10^6 m^3 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 10^3 m^3 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).

Classification

<u>Inland Wetland</u>

Q Permanent saline/brackish/alkaline lakes
J Coastal brackish/saline lagoons

<u>Human-made wetlands</u>

1 Aquaculture

Land Use and Land Cover

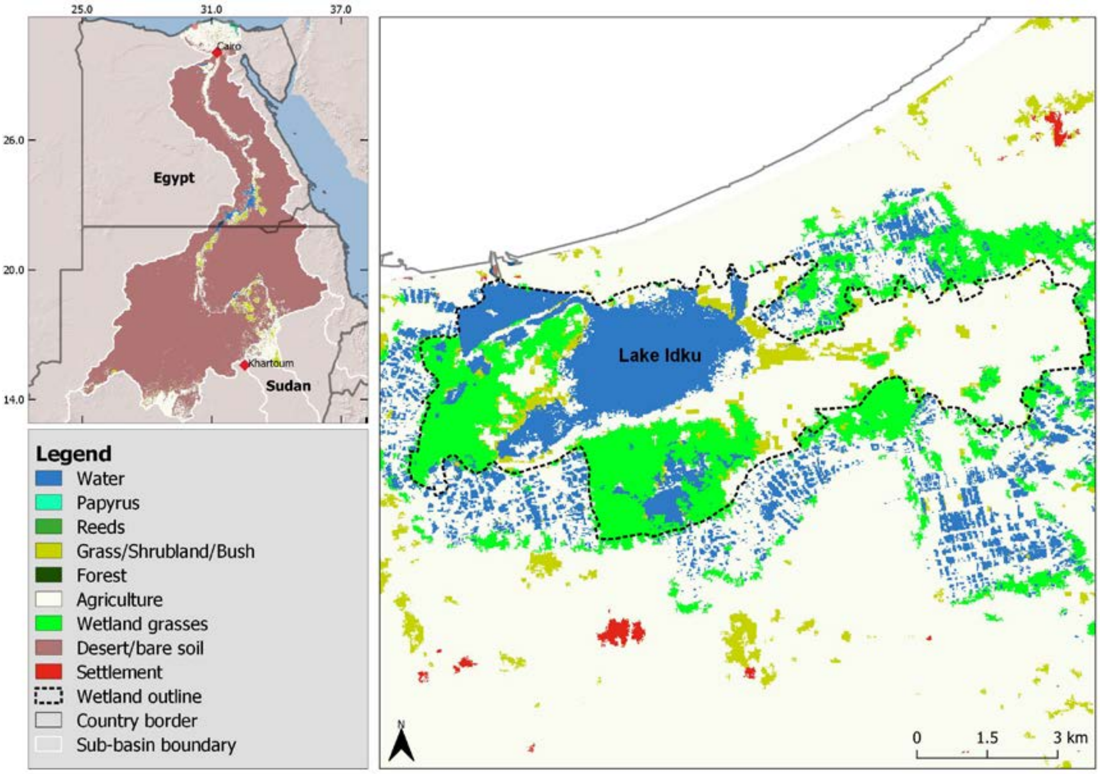

Figure 141 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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).

<u>Change Trajectories 1985-2015</u>

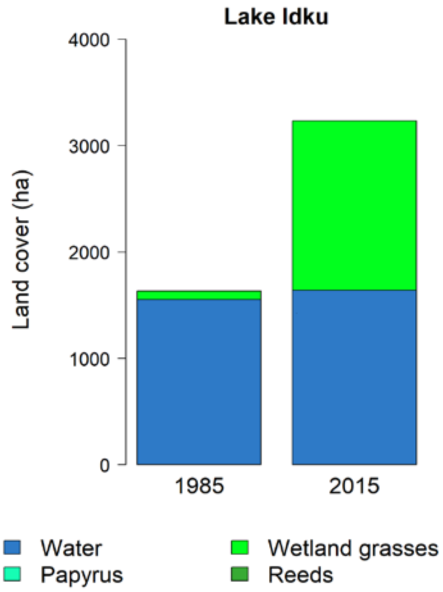

Figure 142 Land cover in 1985 and 2015

Table 107 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	1553	1641	5.7
Papyrus	0	0	0.0
Wetland grasses	79	1589	1911.4
Reeds	0	0	0.0
Total area*	6451	6452	0.0

* Total area based on all 9 land cover classes

67. Lake Burullus

Wetland Name: Lake Burullus
Country: Egypt
Coordinates: 31°28'10''N / 30°52'22''E
Altitude: 17 m b.s.l.
Area: 450 km²
Nearest Town: Rashid
International Importance: Important Bird Area, Ramsar Site

Overview

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 km^2 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 m^3 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 an Phragmites (Egyptian Environment Affairs Agency, 1998).

Classification

<u>Inland Wetland</u>

Q Permanent saline/brackish/alkaline lakes

J Coastal brackish/saline lagoons

Human-made wetlands

1 Aquaculture

Management Status

In 1998 the lake and its surrounding wetlands have been declared a protected area and in it 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.

Table 108 Protected area related to the wetland

Name	Type*	Designation Year
El Bourollus	Multiple Use Management Area (VI)	1998

*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)*

Land Use and Land Cover

Land cover map not available

Drivers of Change

The lake surface area has decreased from an estimated 553 km^2 in 1952 to about 285 km^2 in 2012. One main reason for this is the drastic increase in fish farming from 30 km^2 of fish farms in 1987 to 272 km^2 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.

Change Trajectories 1985-2015

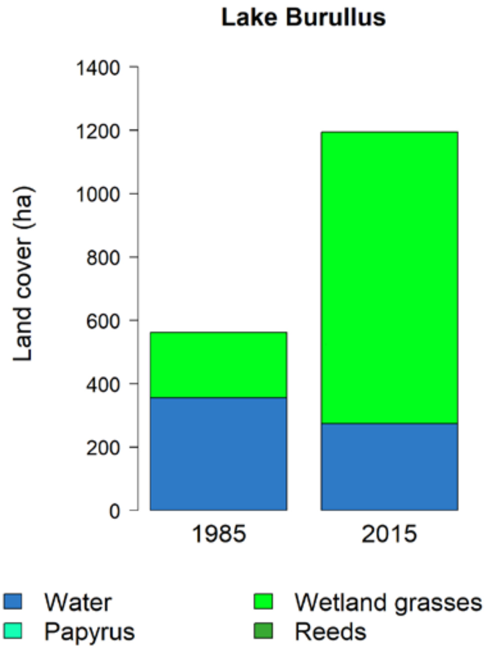

Figure 143 Land cover in 1985 and 2015

Table 109 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	356	275	-22.8
Papyrus	0	0	0.0
Wetland grasses	206	919	346.1
Reeds	0	0	0.0
Total area*	1624	1624	0.0

* Total area based on all 9 land cover classes

68. Lake Manzala

Wetland Name: Lake Manzala
Country: Egypt
Coordinates: 31°17'38''N / 32°1'37'' E
Altitude: sea level (saltmarsh partly below sea level)
Area: 847 km²
Nearest Towns: Bur Said, Dumyat
International Importance: Important Bird Area

Overview

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 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 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 is classified as very bad, 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) (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.

Classification

Inland Wetland

Q Permanent saline/brackish/alkaline lakes

J Coastal brackish/saline lagoons

Human-made wetlands

1 Aquaculture

Management

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.

Table 110 Protected area related to the wetland

Name	Type*	Designation Year
Ashtum El Gamel	Multiple Use Management Area (VI)	1998

*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)*

Land Use and Land Cover

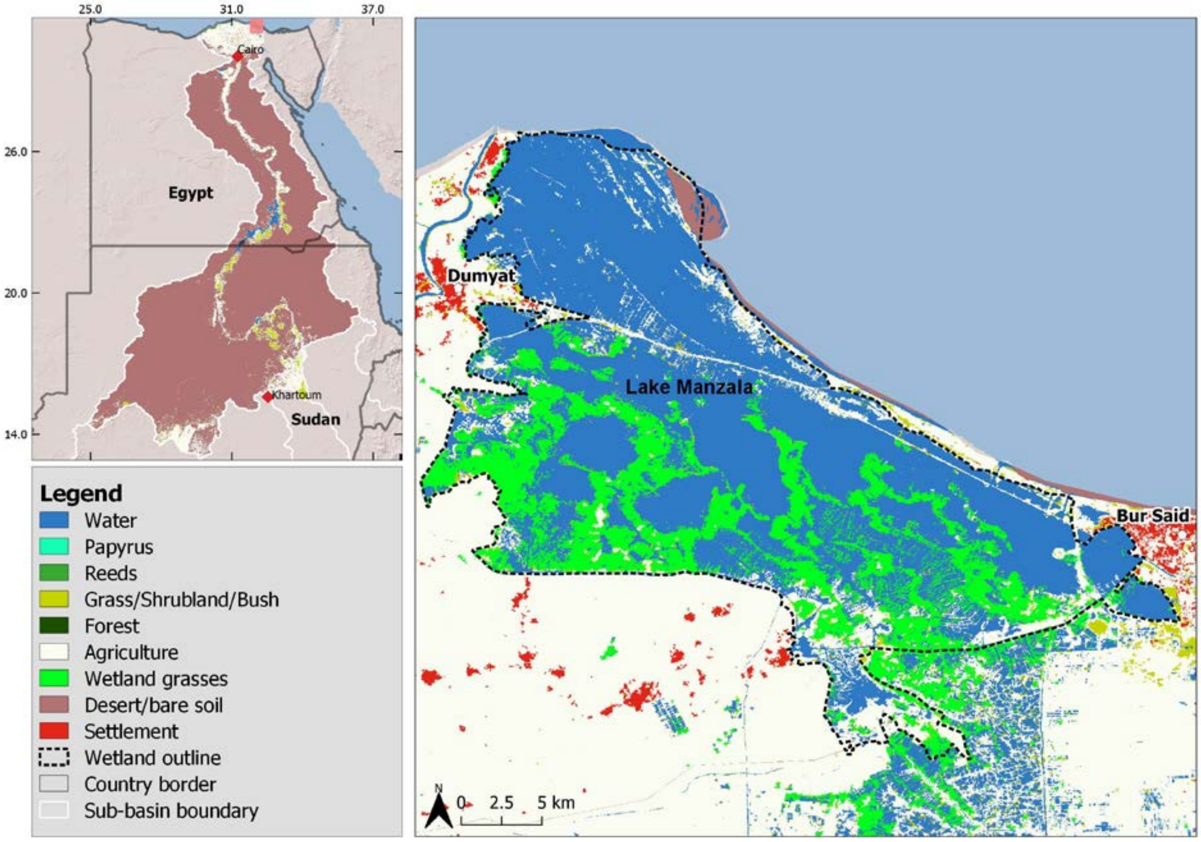

Figure 144 Location of the wetland in the sub-basin, top left corner (pink square) and land cover map on the right in 2015

<u>Drivers of Change</u>

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.

Change Trajectories 1985-2015

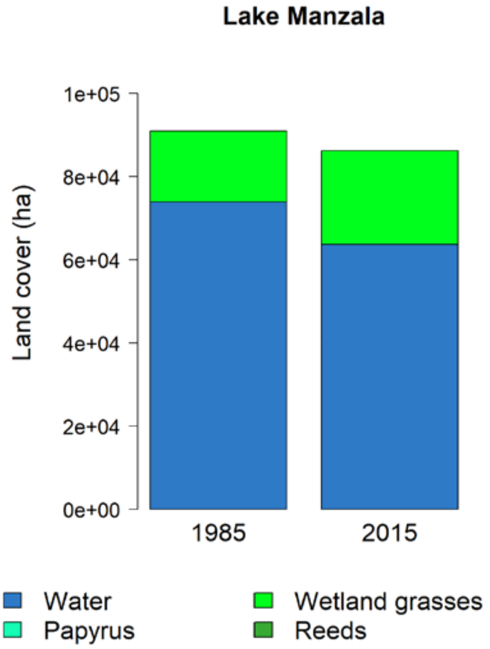

Figure 145 Land cover in 1985 and 2015

Table 111 Land cover in 1985 and 2015 and percentage of change

Landcover Class	1985 (ha)	2015 (ha)	Change 1985-2015 (%)
Water	73910	63686	-13.8
Papyrus	0	0	0.0
Wetland grasses	17029	22561	32.5
Reeds	0	0	0.0
Total area*	99102	99102	0.0

* Total area based on all 9 land cover classe

3.2 Literature Review

Judging from the literature review conducted during creation of the wetlands inventory, wetlands were classified into wetlands with a (i) good, (ii) fair, and (iii) poor level of information. Wetlands with a poor level of information availability are often mentioned in reports by NBI or others, however, there is no or hardly any information available which is published in scientific journals or elsewhere. Most literature about wetlands with a fair or poor level of information was published before 2005. Since wetlands are highly dynamic systems, information on these might not be accurate anymore. Reports, such as the previous wetland inventory (NBI, 2009) or the Baro Akobo Sobat Wetlands Knowledge Base (Busulwa, 2012) merely copied 'A directory of African Wetlands' by Hughes and Hughes (1992). Thereby this standard reference from 1992 is often the main or only source of information for many wetlands in the Nile Basin, such as the swamps in the Baro Akobo Sobat Basin or the Lake in the Bahr el Jebel Basin. Wetlands that are of high economic importance for hydropower production, fisheries or source of water for irrigation are generally studied better.

Table 112 Degree of information available for each wetland in the inventory

Nr	SBasin	Wetland Name	Degree of Information		
			Good	Fair	Poor
1	LV	Nyando	x		
2	LV	Yala Swamp	x		
3	LV	Nzoia River		x	
4	LV	Sio Siteko			x
5	LV	Mara Wetland	x		
6	LV	Ruvubu National Park		x	
7	LV	Ruvyironza River			x
8	LV	Paysage Aquatique Protégé du Nord		x	
9	LV	Lake Cohoha South			x
10	LV	Lake Rwihinda			x
11	LV	Lake Kanzigiri			x
12	LV	Lake Rweru			x
13	LV	Akanyaru Swamps		x	
14	LV	Akanyaru River Swamps		x	
15	LV	Lake Cohoha North			x
16	LV	Rugezi Marsh		x	
17	LV	Lake Burera		x	
18	LV	Lake Ruhondo			x

19	LV	Kamiranzovu Swamp			x
20	LV	Lake Muhazi		x	
21	LV	Nyabarongo Wetlands		x	
22	LV	Lake Mugesera			x
23	LV	Kagera Swamps		x	
24	LV	Lake Mburo Nakivali System		x	
25	LV	Sango Bay-Musambwa Islands -Kagera Wetland System		x	
26	LV	Lake Wamala	x		
27	LV	Nabajjuzi Wetland			x
28	LV	Lake Nabugabo		x	
29	LV	Mabamba Bay		x	
30	LV	Lutembe Bay		x	
31	LV	Winam Gulf	x		
32	VN	Lake Bisina		x	
33	VN	Lake Opeta		x	
34	VN	Kyoga Kwania Swamp Complex	x		
35	LA	Rwenzori Mountains Ramsar Site		x	
36	LA	Lake George	x		
37	LA	Lake Edward	x		
38	LA	Semliki Valley Wetlands		x	
39	LA	Murchison Falls Lake Albert Delta	x		
40	LA	Lake Bunyonyi		x	
41	BJ	The Sudd	x		
42	BJ	Lake Yirol			x
43	BJ	Lake Anyi			x
44	BJ	Lake Nyiropo			x
45	BG	Bahr el Ghazal Floodplain		x	
46	BG	Lake Ambadi			x
47	BA	Badigeru Swamp			x
48	BA	Kenamuke/ Kobowen Swamp			x
49	BA	Lotilla River Swamps			x
50	BA	Veveno/Adiet/Lilebook Swamps			x

51	BA	Baro-Akobo Wetlands			x
52	BA	Machar Marshes		x	
53	WN	White Nile Floodplain		x	
54	WN	Gebel Auliya		x	
55	BN	Dinder Floodplain	x		
56	BN	Lake Tana	x		
57	BN	Fincha-Chomen	x		
58	BN	El Roseires	x		
59	BN	Sennar	x		
60	TA	Khashm el Girba		x	
61	MN	Lake Nubia/Nasser	x		
62	MN	Wadi El Rayan Protected Area	x		
63	MN	Lake Qarun	x		
64	MN	The Nile Delta	x		
65	MN	Lake Maryut	x		
66	MN	Lake Idku	x		
67	MN	Lake Burullus	x		
68	MN	Lake Manzala	x		

4 Discussion, Conclusion and Recommendation

The Nile basin is a highly divers and dynamic system, which makes it challenging to identify general trends and draw strong conclusions. Nevertheless, based on the description of 68 wetlands in this inventory, that includes locations in all sub-basins and all Nile Basin countries, some observations are worth mentioning here.

There is an overall increase of agricultural land and grazing area at the expense of forested and other natural land cover throughout the Nile Basin, but most remarkable around Lake Victoria. If we zoom in on the wetland ecosystems there is an increase in wetland grasses and a decrease of papyrus, which could indicate less permanently saturated zones in the wetlands or simply less water in the wetlands. The reasons for these observed changes that come out of this inventory are the increasing population in the basin and through that the growing demand for food. This demand for food, but also energy could explain deforestation, peat harvesting (e.g. Akanyaru Swamps), reservoir construction and expansion (e.g. Grand Ethiopian Rennaissance Dam and El Roseires Dam), large scale irrigation schemes (e.g. Baro Akobo Wetlands) and water pollution (e.g. wetlands in the Nile Delta and Lake Victoria Shoreline Wetlands). Poverty and unemployment increases the dependency and unsustainable exploitation of wetland goods such as papyrus and fish.

Besides the general benefits of wetlands to regulate the local climate, store carbon, hold and purify water, prevent floods, mitigate and help adapt to climate change and act as biodiversity hotspots the wetlands provide direct benefits to the local, mostly vulnerable and poor, population. The wetlands in the Nile Basin are seen as important for fishing, directly, but also in their role as nurseries especially around the bigger lakes. In the same areas they are important for conserving native species and are refuges for vulnerable endemics (e.g. cichlid species).

In the Sudd traditionally the wetland grasses are valued for grazing and the wetland area is seen as important in providing freshwater for people, livestock and habitat for unique biodiversity such as the Nile lechwe and the shoebill which are of cultural importance to the local tribes. The Sudd area is thought to have expanded due to increased rainfall in the African Great Lakes region and subsequently increased flow of the While Nile, but remains vulnerable to climate change as well as large infrastructural projects (e.g. dams, roads, canals, irrigation schemes, oil mining) that alter the hydrology. In addition the civil war and subsequent migration into the Sudd also put pressure on the ecosystem. Due to its large size a change in the Sudd will affect the hydrology of the whole region, not only in changing the flow of the rivers, but also the rainfall patterns and through that impact food production.

While the inventory includes descriptions of all the wetlands of international importance, which are wetlands that are cross boundary and or influence cross boundary flow of rivers within the Nile Basin, data availability is still a major challenge. Table 112 summarizes the data availability for each wetland with a score. The database that is linked to this inventory contains details on data availability for each individual wetland. In general, wetlands that have a direct impact on peoples' livelihoods or health (waterborne diseases from polluted wetlands) are studied more and therefor there is more data available. The wetlands in the

Main Nile and the Blue Nile are best described as they are mostly reservoirs, which are important for hydropower production and fisheries. Data availability in the other sub-basins varies. As a consequence, the information that is used in the inventory is sometimes too old (decades) to describe trends reliably. Nevertheless we believe that the most recent information on all 68 systems is included in this inventory.

While remote sensing brought out new information for all wetlands in terms of land use and land cover as well as allowing for a delineation based on ecosystem characteristics, it still needs to be supplemented and verified through field data. For example in remote sensing the reflection (colour) of the different types of vegetation is used to identify land cover, however the colour of the same species of plant (e.g. *Cyperus papyrus)*, varies based on the environmental conditions, climate and level of disturbance. While smart technologies and self-learning software can do a lot to compensate for these variations, ground truthing remains essential to distil optimal and reliable results from the analysis of satellite imagery. Moreover field monitoring is essential to reveal drivers of change that are behind the observed trends identified by remote sensing. In this inventory state of the art technology and software was used to produce the maps for 1985 and 2015. While this is the best available, it is important to realize that the actual land cover may differ from the maps in this report.

In conclusion: 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, based on state of the art remote sensing data.

The main recommendation is to increase monitoring efforts, especially for those wetlands that were identified as data poor and to continuously update the database when new information comes available. This will allow for efficient updating of this inventory and bringing together monitoring initiatives at local and national level under the umbrella of the Nile Basin Initiative.

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