



# Wetland Monograph for the Sio Siteko (Kenya - Uganda) Wetland Landscape

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Wetlands are among the most biodiverse ecosystems on Earth. Up to 40% of the world's species live and breed in wetlands. More than one billion people depend on them for a living and directly or indirectly, wetlands provide almost all of the world's consumption of freshwater. In addition, wetlands represent just three percent of total land area, but sequester 30 percent of all soil carbon. Maintaining and restoring damaged wetlands is necessary to ensure soil carbon is not released into the atmosphere. On equal areas, wetlands store between 10 and 50 times more carbon than tropical forests.

Yet these wetlands are disappearing three times faster than forests according to the Global Outlook Report, 2018 by RAMSAR and UNFCCC. In addition, more than 25% of all wetlands plants and animals are at risk of extinction. Approximately 35% of the world's wetlands were lost between 1970-2015 and the loss rate is accelerating, driven by population increase, urbanization, and changes to land and water use and to agriculture while the ones left are under threat from water drainage, pollution, unsustainable use, invasive species, disrupted flows from dams and sediment dumping from deforestation and soil erosion.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) comprised of over 550 scientists from more than 100 countries in its latest report warns that human destruction of nature is rapidly eroding the world's capacity to provide food, water and security to billions of people with the risks posed by biodiversity loss on the same scale as those of climate change. Although the focus of media and society and is on poaching particularly of rhinos, elephants and other exotic animals, far larger threats to nature are from habitat loss, invasive species, chemicals and climate change. The report adds that "Biodiversity and the ecosystem services it supports are not only the foundation for our life on Earth, but critical to the livelihoods and well-being of people everywhere." Exploitation including conversion of forests and wetlands to agriculture and urban development has devastated ecosystem services on which climate, economy and well-being depend.

The Nile Basin Initiative (NBI), created by member states of the Nile Basin 'to promote sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources' in 2013 established a Wetland Management Strategy to reverse degradation and sustain critical ecosystem services, including biodiversity.

In this connection, the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) has initiated an action research project to increase the knowledge base and strengthen capacity to integrate green infrastructure in river basin planning in three transboundary wetlands: *Semliki Delta* (DRC-Uganda), *Sango Bay-Minziro* (Tanzania-Uganda) and *Sio Siteko* (Kenya-Uganda). The project, implemented by Wetlands International in partnership with Acacia Water and Nature Uganda, is expected to strengthen national policies and institutional capacities for the effective management of wetlands with basin-wide importance; while contributing to biodiversity conservation as well as to ecosystem-based adaptation to climate change and to regional co-operation in the Nile region.

The project consists of three integrated components that build on each other: Wetland Monographs, Wetland Management Plans (WMPs) and Conservation Investment Plans (CIPs). These are complemented by Early Investment Projects to put the plans into practice as quickly as possible. The Wetland Monograph presents a detailed study of the physical context, biodiversity and ecosystems, policies and institutions, socio-economics and livelihoods, and social dimensions of the landscape. In the final chapters it identifies the main challenges the wetland landscape face, and the main conclusions on which to develop successful management plans and investment portfolios.

The Sio Siteko wetland landscape, one of the three focus areas of the project, lies on one of the busiest borders in Eastern Africa, between Kenya and Uganda as the gateway to South Sudan, DRC, Rwanda and Burundi. For Kenya, the region has the highest rainfall for the water scarce country, but awkwardly imports more than 70% of its food from Uganda and the neighbouring counties, in part due to high acidification of the soil from agricultural mining of the soil for decades without replenishment of soil organic matter. The rain is also a hazard- during the wet season from March to May the lower reaches of River Sio are inundated by floods, causing displacement, human misery and destruction of property and crop.

Untreated urban sewerage and solid waste from the fast-growing urban areas on the Kenyan side is destroying water sources in the downstream side of Busia-Uganda. On the other hand, some of the towns in Uganda

have excess potable water that could be piped to Kenya's thirsty communities but there not yet an enabling mechanism to allow bulk sale of water, unlike electricity or shared road infrastructure. Thus, a region with enormous economic potential instead suffers from surfeit of water during certain seasons and shortage of usable water most times.

On a positive note, after drawn out negotiations facilitated by respective local authorities, farmers from both sides of the border agreed on a calendar for irrigation because there is not enough common water during the dry seasons when it is needed most. Secondly, the Kenyan Water Resources Authority and the Ugandan Ministry of Water and Environment with the District Local Government officers have provided highly valuable technical assistance to the riparian communities, both to reduce wetland degradation but also to identify and promote environment-friendly livelihoods.

This provides a home-grown and ready precedence for establishing additional cross-border platforms for collaboration; and sets the stage for the NELSAP-GIZ project that is reactivating the stalled Sio Siteko Transboundary Wetlands Management Plan developed in 2009.

This project has received unprecedented support and cooperation from national agencies, ministries and departments of all member states, as well as inputs from technical officers, local authorities, community leadership and other stakeholders.

Special thanks are due to the NELSAP Technical Advisory Committee, the Wetland Management Team, GIZ, the Busia County (Kenya) and Busia District (Uganda) Local Government officials who contributed with valuable information, data and support; and, finally, the Sio Siteko community leaders and stakeholder groups who adopted the project as their own.

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## IV. ACRONYMS

AGL	- African Great Lakes
amsl	- above mean sea level
ASARECA	- Association for Strengthening Agricultural Research in East and Central Africa
AU	- African Union
BMU	- Beach Management Units
BMUB	- Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit
BMUB-ICI	- BMUB- International Climate Initiative
CBD	- Convention on Biological Diversity
CFR	- Central Forest Reserve
CIP	- Conservation Investment Plan
CMP	- Catchment Management Plan
CMS	- Convention on the Conservation of Migratory Species of Wild Animals
CSO	- Civil Society Organization
CWMP	- Community Wetland Management Plan
DO	- Dissolved Oxygen
DRC	- Democratic Republic of Congo
EAC	- East African Community
EMCA	- Environmental Management and Coordination Act
ENSAP	- Eastern Nile Subsidiary Action Program
ENTRO	- Eastern Nile Technical Regional Office
FNR	- Forest Nature Reserve
GEF	- Global Environment Facility
GIZ	- The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GIZ-NEL	- GIZ Nile Equatorial Lakes region project
GoK	- Government of Kenya
GoU	- Government of Uganda
IBA	- Important Birding Area
IFMP	- Implementation of Fisheries Management Plan
ITCZ	- Inter-Tropical Convergence Zone
IUCN	- International Union for Conservation of Nature
IWRM	- Integrated Water Resources Management
KMFRI	- Kenya Marine Fisheries Research Institute
KWS	- Kenya Wildlife Service
LVB	- Lake Victoria Basin
LVBC	- Lake Victoria Basin Commission
LVEMP	- Lake Victoria Environmental Management Project
MEA	- Multilateral Environmental Agreements
MUIENR	- Makerere University Institute of Environment and Natural Resources
MWE	- Ministry of Water and Environment
NaFIRRI	- National Fisheries Resource Research Institute
NBI	- Nile Basin Initiative
NELSAP	- Nile Equatorial Lakes Subsidiary Action Program
NELSAP-CU	- NELSAP Coordination Unit
NEMA	- National Environment Management Authority
NFR	- Nature Forest Reserve
NILE COM	- The Nile Council of Ministers

Nile VWU	Eco-	- Nile Ecosystem Valuation for Wise Use
NILE-SEC		- Nile Basin Initiative Secretariat
NILE-TAC		- Nile Technical Advisory Committee
NLC		- National Lands Commission
NMK		- National Museums of Kenya
NRBC		- Nile River Basin Commission
NT		- Near Threatened
NVDI		- Normalized Difference Vegetation Index
PC		- Project Coordinator
RAMCEA		- Ramsar Centre for Eastern Africa
SSWUA		- Sio Siteko Wetland Users Association
TNC		- The Nature Conservancy
UGX		- Ugandan shilling
UWA		- Uganda Wildlife Authority
VWMZ		- Victoria Water Management Zone
VU		- Vulnerable
WB		- World Bank
WRA		- Water Resources Authority
μS/cm		- micro Siemens per centimetre

The Nile Equatorial Lakes Subsidiary Action Program (NELSAP) has initiated an action research project to increase the knowledge base and strengthen the capacity to integrate green infrastructure in river basin planning in three transboundary wetlands: Semliki Delta (DRC-Uganda), Sango Bay-Minziro (Tanzania-Uganda) and Sio Siteko (Kenya-Uganda). This project builds upon existing and previous plans and programs and aims to pave the way and create drivers to improve governance, promote conservation and sustainable livelihoods in the Sio Siteko wetland landscape which directly or indirectly involve the wetlands.

This Wetland Monograph presents a detailed study of the physical context, biodiversity and ecosystems, policies and institutions, socio-economics and livelihoods, and social dimensions of the Sio Siteko wetland landscape. In addition, it identifies the main challenges the wetland landscape faces and on which to develop successful management plans and investment portfolios, setting the stage for the NELSAP-GIZ project that is reactivating the stalled Sio Siteko Transboundary Wetlands Management Plan developed in 2009.

Sio Siteko is part of the Sio-Malaba-Malakisi wetland system and an Important Birding Area (IBA) with over reported 300 bird species, including the endangered Grey Crowned crane and the threatened Papyrus Gonolek. Notable mammals include vervet monkey, otter, sitatunga, hippopotamus and water mongoose. In addition, there are 206 plant, 29 fish, and eight reptile species, among others. The Sio Siteko wetland also plays an important role in regulating the hydrological system and supporting livelihoods through the provision of fish, grazing land and building and craft materials.

The main challenges the wetland faces include the massive encroachment of the wetland for cultivation, over-exploitation of wetland resources, and invasive species. The root causes of the challenges are the high population growth rate (2.8% per year), increasing pressure on the wetland resources. Other underlying causes include weak law enforcement and institutional capacity, especially regarding the transboundary aspects of wetland management, poor access to sanitation and waste disposal services and climate change.

Water resources are likely to be increasingly strained in the future climatic and socio-economic conditions of the wider Sio Siteko area. Wetlands are an effective sink for carbon, thereby buffering the drivers of climate change and supporting climate resiliency. Sio Siteko wetland landscape needs better protection from human disturbance and climatic changes to protect the ecosystem and local livelihoods.

In order to develop successful and sustainable management and investment plans, it is crucial to understand the environmental and socio-economic system of the wetland landscape and the main threats it faces. Therefore, the first step and cornerstone of this approach is this Wetland Monograph, which serves as the baseline and reference for the Sio Siteko Wetland Management and Conservation Investment plans.

***Eng. Elicad Elly Nyabeeya***

***Regional Coordinator NELSAP-CU***

# 1. INTRODUCTION

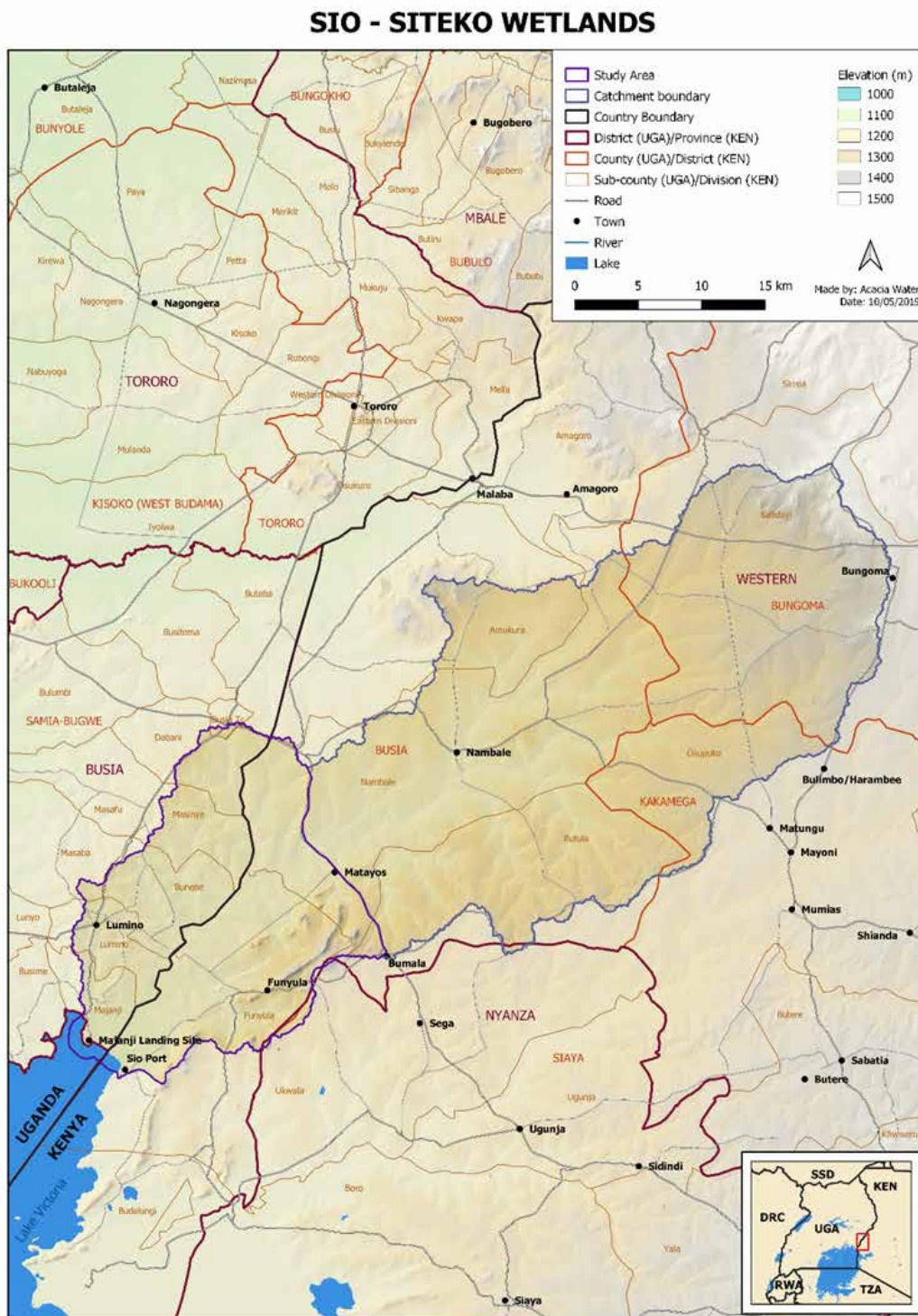
## 1.1 OVERVIEW OF THE WETLAND LANDSCAPE

### 1.1.1 Geographical location

The Sio Siteko wetland landscape is located northeast of Lake Victoria and encompasses the lower catchment of River Sio, crossing the boundary of the Kenya and Uganda (Figure 1). The Sio Siteko study

area lies between latitude 0.47 - 0.21 °N and longitude 33.98 - 34.20 °E and has an area of approximately 415 square kilometers. The project area is bounded by Lake Victoria to the southwest, the catchment boundaries to the south and west, and by the main road between Busia – Matayos – Bumala in the north and northeast.

FIGURE 1: GEOGRAPHIC LOCATION AND ADMINISTRATIVE BOUNDARIES OF THE SIO SITEKO WETLAND LANDSCAPE



### 1.1.2 Ecological potential

Wetlands have primary production often 10-50 times higher than rainforests per unit area, contributing to exceptional biodiversity and hosting enormous numbers of wild animals including fish, birds, and aquatic animals. They also produce vast quantities of fresh water, oxygen, store carbon, and process nitrogen, providing fertile soils for agriculture. Therefore, wetlands are of significant ecological and socio-economic value. The Sio Siteko wetland landscape consists of a number of interconnected

secondary and tertiary wetland systems that promote breeding and nursery ground for many species of fish (Figure 2). The wetland system is home to a large number of endemic species, including crocodiles, monitor lizards, sitatungas and hippos. The large number of bird species that call the wetlands home, including the globally threatened papyrus gonolek and pallid harrier, has resulted in the wetlands being recognized as an Important Bird Area.



FIGURE 2: THE SIO SITEKO WETLANDS ARE OF HIGH ECOLOGICAL IMPORTANCE, BEING RICH IN BIODIVERSITY AND PROVIDE A NUMBER OF ECOSYSTEM SERVICES FOR THE LOCAL POPULATION, INCLUDING THE PROVISION OF CLEAN WATER, FISH AND RAW MATERIALS.

### 1.1.3 Social economic potential

Besides the ecological value of wetlands, the Sio Siteko wetland landscape provides important socio-economic services to the 273,000 people (see paragraph 6.1) living within the wetland area itself, as well as the 1.38 million inhabitants of Busia District of Uganda and Busia County of Kenya. Sio Siteko's natural resources are harvested to provide food (mainly fish) and alluvial sand is being mined for construction. In addition, the fertile floodplains

are used for agriculture and grazing. Other important ecosystem services provided by the Sio Siteko wetlands include water filtration and purification, water buffering, protection against erosion, and cultural services (Figure 3).

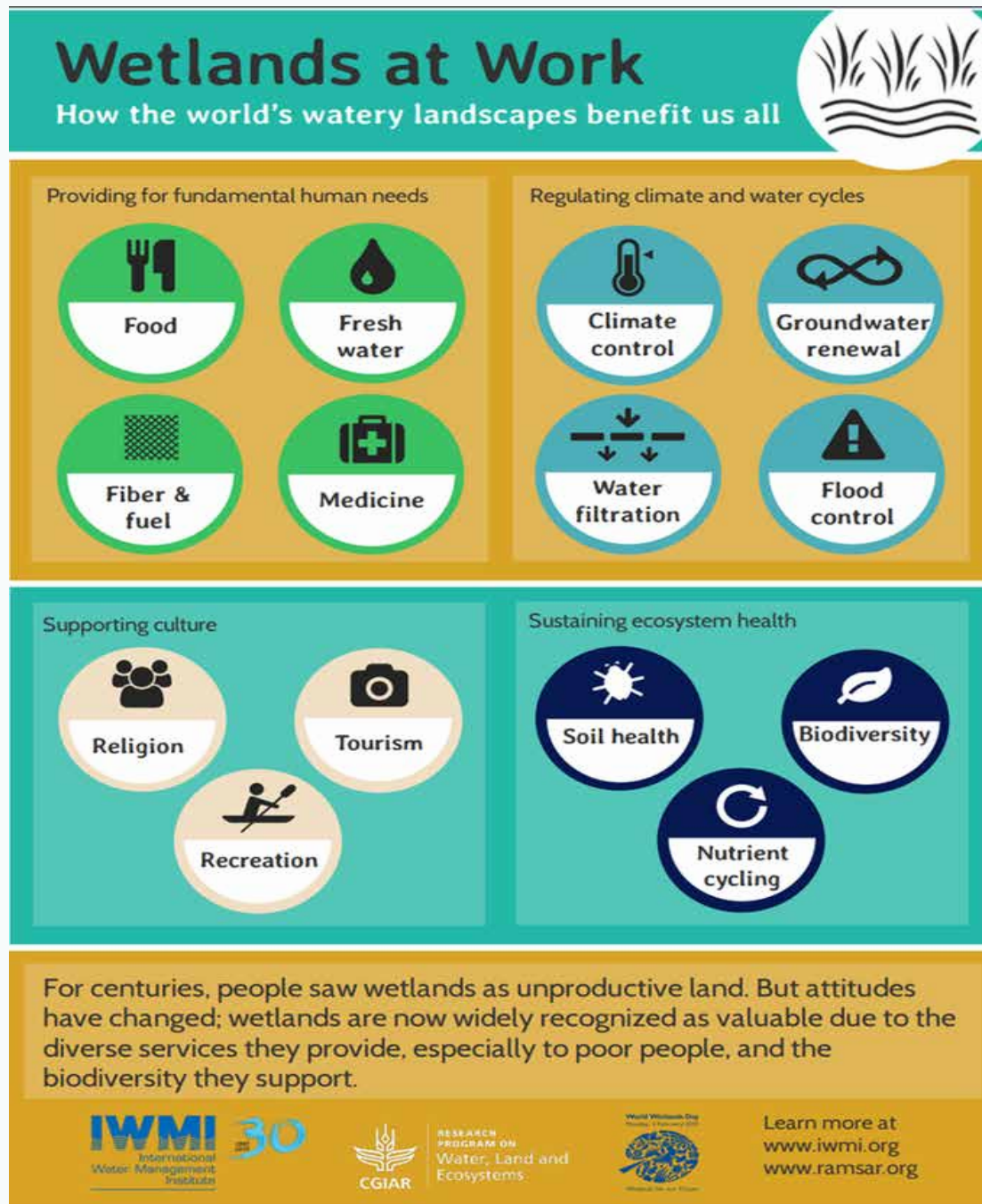


FIGURE 3: OVERVIEW OF ECOSYSTEM SERVICES OF WETLAND LANDSCAPES (SOURCE: IWMI).

In recent years, encroachment and unsustainable use of wetlands resources have become serious issues. The wetlands are being cleared to provide agricultural land to support the growing population. Deforestation, overfishing and other overuse of natural resources are also major threats to a landscape that is already vulnerable to climate change. Together, these threats not only have environmental consequences as habitats are destroyed and natural flooding regimes are disturbed but also put the continuation and sustainability of the ecosystem services the wetlands provide at risk. Due to the transboundary nature of

the wetlands, a transboundary approach is necessary to ensure the wetlands are sustainably managed, now and in the future.

## 1.2 DIGESTION OF PREVIOUS PLANS AND PROGRAMS

To understand the functioning of the wetland landscape and ultimately develop an effective wetland management plan, it is crucial to ensure that the plan is aligned with recent and ongoing plans and projects. These may be developed at levels from

global (i.e. United Nations) and regional (i.e. NBI) to national and local levels. Here we present the most relevant plans and projects in the Sio Siteko wetland.

### **Sio Siteko transboundary wetland community-based management plan 2010 - 2020**

The most pertinent plan for the Sio Siteko wetland is the transboundary wetland management plan from 2009, which was a part of NBI's Nile Transboundary Environment Action Project. The wetland management plan aimed to maintain the integrity of the wetland, promote economic benefits, and encourage the sustainable use of resources. Specific goals were to sustainably manage fisheries, improve livestock production, and mitigate adverse effects of wildlife pollution and reduce water-borne diseases in the Sio Siteko wetland while conserving wetland habitats and reduce human-wildlife conflicts. Various interventions and actions were proposed to meet those objectives. In addition, a set of relevant ecological and socio-economic indicators were proposed for monitoring. Implementation of these interventions and actions has been very limited up to date. Despite the comprehensive nature of the wetland management plan of 2009, it has now become outdated and will, therefore, be updated in the current project.

### **Sio-Malaba-Malakisi River (SMM) Basin Management Project**

The Sio-Malaba-Malakisi (SMM) River Basin Management Project seeks to reduce poverty in the region through the identification and preparation of a strategic portfolio of bankable water resources projects that demonstrate benefits of cooperation to partner states of Kenya and Uganda within a broader coordinated water-related investment strategy for the region. In the financial year 2018/2019, the project on behalf of both governments secured a grant to a tune of USD 1.5 Million from the NEPAD Infrastructure Project Preparation Facility Special Fund (NEPAD-IPPF Special Fund) managed by the African Development Bank, to finance the feasibility studies, detailed designs and preparation of tender documents in addition to the Environmental and Social Impact Assessment (ESIA) and Resettlement and Compensation Action Plan (RCAP) for the Angololo Water Resources Development Project. In addition, the government of Uganda committed to co-fund the project studies up to the tune of USD 75,000 (MWE 2019).

### **Crane conservation projects**

Several projects have been launched in and around the Sio Siteko wetland area to protect the Grey

Crowned Crane. Two examples are the Kenya Crane and Wetlands Conservation Project and Conserving Wetlands to save Grey Crowned Cranes and sustain community livelihoods in western Kenya. The former is a national-scale initiative focusing on four wetlands, one of which is the Sio Siteko wetland. The latter is a community-based initiative. These and other projects not only focus on protecting the crane but also on conserving and restoring their wetland habitat.

### **Water supply and sanitation project, Uganda**

The government of Uganda's Water supply and sanitation project is funded by the World Bank and will focus on the sub-counties of Majanji, Lumino, Buhehe, Masafu, Masaba, Dabani, Buteba, Masinya and Sikuda within Busia County. The project consists of three parts: delivering necessary water and sanitation infrastructure, supporting water-related institutions, and strengthening national and sub-national capacity to improve integrated water resources management. The initial year was 2016 and the horizon of the project is the year 2040. The water supply aims to reach more than 130,000 people by 2028.

### **USAID Kenya integrated water sanitation and hygiene project**

This US Agency for International Development (USAID) project is a 12 million USD project lasting five years. The project aims to develop and manage sustainable water, sanitation and hygiene services to improve the lives and health of Kenyans living in nine counties. Within Busia County, the project aims to benefit 12,000 households. The main interventions in Busia include water access and distribution, governance and policy interventions, sanitation and hygiene interventions and environmental sustainability interventions.

### **Kocholia-Amagoro-Amoni multipurpose water resources and food crop development project, Kenya**

The 57 million USD Multipurpose water resources and food crop development project is funded by the African Development Bank and the Korean Exim Bank. The project aims to improve food and water security in the region through the construction of a dam that will hold an estimated 67 million cubic metres of water, which can be used to irrigate approximately 2000 hectares.

### **Busia County integrated development plan, Kenya**

The counties of Kenya are obligated to develop a

county integrated development plan (CIDP). This plan outlines the coordination of multiple levels of government and other local institutions in order to meet development needs for local communities. The plan outlines economic, environmental, legal and spatial aspects of development. The plan is currently in the implementation phase, which covers the period 2018 – 2022.

### **TEEB study for Sio Siteko**

Currently, The Economics of Ecosystems and Biodiversity (TEEB) study is being undertaken for Sio Siteko (NBI 2019b). This TEEB study is coordinated by the Nile Basin Initiative (NBI) and has the goal of raising awareness about the importance of wetland ecosystem services to regional, national, sectoral and local-level development processes. It seeks to build the economic case for wetland conservation and wise use, with a specific focus on generating evidence on the economic value of wetlands as ‘green’ water infrastructure. By doing so, it intends to bring wetland ecosystem values to the attention of river basin planners and managers, and thereby promote better-informed, more effective, inclusive, equitable and sustainable conservation and development decision-making in the Nile River Basin. To this end, NBI seek to conduct a TEEB study for the Sio-Siteko wetland landscape which will help in supporting basin planning and investment agenda into the conservation and sustainable use of the wetland for sustainable provision of the ecosystem services for the local economies of Busia County in Kenya and Busia district in Uganda, and reduction in biodiversity loss. A presentation about the TEEB study in progress was attended during the NBI workshop in Nairobi on November 23<sup>rd</sup>, 2019, and a draft version of the TEEB study (NBI 2019b, November 2019) was consulted for harmonization with this Monograph; see chapter 3.2 on Ecosystem Services.

### **1.3 MONOGRAPH PURPOSE AND DEVELOPMENT APPROACH**

Recognizing the importance of wetlands locally as well as within the larger Nile Basin and the scale of the challenges the wetlands face, the Nile Basin Initiative launched a project to pave the way and create drivers to improve governance, promote conservation and sustainable livelihoods in the Sio Siteko landscape, as well as two other transboundary wetlands. This project builds upon other plans and programs that have been active in the area, which directly or indirectly involve the wetlands. Specifically, the project will update the Wetland Management Plan and Conservation Investment Plan of the Sio Siteko

wetland landscape.

This project comprises of four integrated components that build on each other:

1. **Wetland Monograph:** Establish the physical context, biodiversity and ecosystems, policies and institutions, socio-economics and livelihoods, and social dimensions where key development aspects that inform wetland management planning will also be addressed;
2. **Wetland Management Plan:** builds on the monograph and incorporates existing utilisation, social and cultural values; stakeholders involved and power mapping; existing and potential impacts or threats; to develop a strategy to reverse degradation, enhance conservation and promote livelihoods consistent with wetland protection and restoration;
3. **Conservation Investment Plans (CIPs):** Many environmental management plans often have excellent situation analysis including causes and threats to ecosystems from human, environmental or climate issues, but fail to clarify the economic value or propose sources of funding. CIPs expound on the economic benefits and detail the financial outlays economic benefits that can be derived from the implementation of management actions; presented as investment packages to attract public, finance and private institutions.
4. **Early Investment Projects:** In the last 30 years, many environmental studies have been taking place within the Nile Basin, mobilizing stakeholders and communities. To ensure there is sustained interest and demonstrate the potential of the CIP portfolios, this project with local stakeholders and communities is preparing readily implementable priority actions that promote ecosystem conservation through sustainable livelihoods.

In order to develop successful and sustainable management and investment plans, it is crucial to understand the environmental and socio-economic system of the wetland landscape and the main threats it faces. Therefore, the first step and cornerstone of this approach is the Wetland Monograph, which serves as the baseline and reference for the Sio Siteko Wetland Management and Conservation Investment plans.

This monograph presents an overview of the landscape within which the wetland system is located. The study was largely based on consultations with technical officers, community representatives, local administrative and political leadership and other social actors including civil society were held

in January, April and July 2019 with the aim of coming to a common and detailed understanding of the different dimensions of the wetlands system. The data collected during these consultations were supplemented with exhaustive studies of existing literature, openly available global datasets, and field visits.

#### **1.4 OUTLINE OF THE MONOGRAPH**

This monograph presents a comprehensive overview of the physical landscape, its ecology, the institutional setting and a socio-economic analysis of the Sio Siteko wetland landscape.

Chapter 1 gives an introduction and overview of the landscape within which the wetland system is located. A description of the physical landscape, including topography, geology and soils, the hydrology and water resources, as well as the current climate and expected climate change and how these influence the wetland, as well as the land use and land cover, is described in Chapter 2. Chapter 3 focuses on the

biological diversity and the ecosystem services the wetlands provide. The institutional context, main actors, policies and legislation are described in Chapter 4 at global, regional, national and local levels. This chapter also covers the protected areas and natural resources management. The socio-economic and livelihood system is presented in Chapter 5, describing the main livelihoods such as pastoralism and crop production, forestry, fisheries, trade and eco-tourism. Chapter 6 provides an overview of the social dimension of the wetland landscape, focusing on human demography, social organizations, WASH and public health. An overview of the main challenges the wetland landscape faces are presented in Chapter 7. Finally, the most important conclusions of the monograph are presented in Chapter 8.

The monograph is supplemented by maps, obtained from a variety of regional, NGO and government institutions, which were updated with more recent remote sensing data, and photos and observations taken on the ground during the field missions.

## 2. PHYSICAL CONTEXT

### 2.1 LOCATION AND DELINEATION OF THE WETLAND LANDSCAPE

The Sio Siteko wetland landscape is located northeast of Lake Victoria and is located along the border between Uganda and Kenya. This area lies within the Busia District of Uganda and mainly within the Busia County of Kenya. The city of Busia is located on the northwestern edge of the Sio Siteko wetlands. See Figure 1 and for more detail the [Administrative Boundary Map in Appendix A](#).

The boundaries of the wetland landscape are consistent with the boundaries of the study area of the previous wetland management plan and are based on a combination of topography and the road network. The north-eastern boundary follows the paved road between Busia and Bumala. The other boundaries are determined by the topography, following the water divide. In the southeast, the boundary extends one kilometre into the Lake Victoria to account for seasonal changes in the shoreline and more long-term effects of erosion and sedimentation.

The total study area, including the wetlands and their area of influence, covers approximately 415 square kilometres and is located between latitude 0.47 and 0.21 °N / longitude 33.98 and 34.20 °E.

### 2.2 TOPOGRAPHY, GEOLOGY AND SOILS

#### 2.2.1 Topography and geomorphology

The basin of the River Sio is located between 1,135 to 1,500 meters above mean sea level (m amsl), ranging from the Lake Victoria shores (1,135 m amsl) up to the hills (1,500 m amsl) located on the foot of Mt Elgon slope. The altitude of the Sio Siteko study area is located mainly between 1,135 and 1,200 m amsl, with the only exception being several elongated NW-SE orientated rocky outcrops ranging up to 1,450 m amsl in the most southern part of the study area. See Figure 1 and for more detail the [Elevation Map in Appendix A](#).

In its upper reaches the River Sio flows in narrow V-shaped valleys bordered by steep slopes. In its middle reaches the River Sio meanders in a narrow river bed within a much wider river valley that widens from tens to several hundreds of meters wide. The wide river valley indicates that conditions were much wetter in the past. The river bed is typically on the outer edge of one of the sides of the wide river valley (Figure 4). There are many contributing streams, which are then joined together into the

tributaries of the River Sio. This dendritic drainage pattern indicates that the underlying rocks are rather impervious. In its lower reaches, the river widens considerably in a wide floodplain, up to several kilometres wide, flooding an extensive area of flat land during the rainy season.

#### 2.2.2 Geology and soils

*The geology of the River Sio basin is mainly composed of Precambrian intrusive and metamorphic rocks, Tertiary volcanic and intrusive rocks, and Pleistocene unconsolidated sediments (see the Geological Map in Appendix A).*

The crystalline basement consists of intrusive granites, undifferentiated gneisses and metavolcanic rocks from the Neoproterozoic era. In the upstream part of Sio catchment, these granites and gneisses are known as the Kakamega-Syn-tectonic formation (beige colour in the Kenyan geological map), which is similar to the 'undifferentiated gneisses' (light orange colour in the Ugandan geological map). The 'Nyanzian formation' of the volcanosedimentary and volcanoplutonic rocks, with banded ironstones (BIF's), cherty quartzites and basaltic and gabbroic rocks occurs in the lower reaches of Sio catchment (light and dark green in Kenyan geological map; purple and dark orange in the Ugandan geological map). The gabbros and BIF's contains high concentrations of iron and manganese and give rise to the cementation of sediments and sedimentary rock (laterites and ferricretes) with iron and magnesium oxides. At the southern edge of Sio catchment on the Kenyan side, outcrops of basaltic and gabbroic rocks (Kakamega - Lower Nyanzian Formation) form elongated NE-SW oriented ridges.

The Tertiary volcanic and intrusive rocks consist of pyroclastic and lahar-type alkaline/sodic volcanic rocks and associated carbonatite plugs and fenites which are deposited by volcanic activity related to the continental rift tectonics, such as Mount Elgon, located 110 km northeast of the outlet of the River Sio. Carbonatites and fenites are a type of intrusive igneous rock defined by mineralogic composition consisting of greater than 50% carbonate minerals. They are relatively rare, and Mount Homa (located 90 km southeast of the outlet of the River Sio) is one of the very few carbonatite volcanoes in the world. The geological map (see [Appendix A3](#)) shows only a few round spots where carbonatites are found, but due to its intrusive occurrence as small volcanic plugs or dikes or sills, and due to the nearby presence of Elgon and Homa volcanoes, it is likely that carbonites are



FIGURE 4: TYPICAL MORPHOLOGICAL PATTERN OF THE RIVER SIO IN ITS MIDDLE REACHES, HEAVILY MEANDERING ON THE EDGES OF THE WIDE RIVER VALLEY, JUMPING FROM ONE EDGE TO THE OTHER SEVERAL TIMES, AS SEEN HERE JUST DOWNSTREAM OF THE BRIDGE OF BUSIA - BUMALA ROAD. SOURCE: GOOGLE EARTH

locally present throughout the whole Sio Siteko study area. Due to the high concentration of carbonate minerals, these carbonatites might give rise to salt deposits and highly mineralized groundwater, as have been found in various places (see Chapter 2.3.4 for more information).

The Pleistocene and Quaternary sedimentary deposits consist of colluvium, alluvium and red (clayey or cemented) soils. The colluvial deposits

are typically composed of a variety of rock types and unconsolidated sediments ranging from silt to rock fragments of different sizes that have been deposited at the base of hillslopes. The alluvial deposits are generally homogeneous and relatively well-sorted river sediments that can be found in or near the valleys of the River Sio and its tributaries. Especially during rainy season, sand is carried to and transported with the River Sio, and subsequently settles and accumulates at the river mouth where the



FIGURE 5: A SAND HARVESTER WITH HIS HEAVY LOADED SHIP ON LAKE VICTORIA, LEAVING THE MOUTH OF THE RIVER SIO, WHERE LARGE SCALE SAND MINING TAKES PLACE



FIGURE 6: SAND HARVESTERS BRING THEIR SAND TO SIO PORT WHERE IT IS BEING SOLD FOR ABOUT 3000 KENYAN SHILLINGS PER LORRY.



FIGURE 7: BLOCKS OF LATERITIC ROCK FORM AT THE SURFACE, FOUND IN THE AGRICULTURAL PLOTS NEAR LAT: 0.2469 / LON: 33.9916 / 1145 M



FIGURE 8: ONLY IN FEW PLACES LATERITE ROCKS OUTCROP IN THE BED OF THE RIVER SIO, SUCH AS HERE AT LAT: 0.3613 / LON: 34.1392 / 1161 M

River Sio enters Lake Victoria. These fine to coarse river sands are mined for use in construction (Figure 5 and Figure 6).

The red soils are predominantly clayey due to the weathering of the gneisses and gabbros resulting in a lot of clay minerals. The rusty-red coloration is a result of the high iron oxide content. Over time, very hard horizons of laterite and ferricrete can develop in these red soils, as was observed at various sites throughout the Sio Siteko study area. They develop by intensive and prolonged weathering of the underlying parent rock. The iron and aluminium oxide cements are derived from the oxidation of percolating solutions of iron/aluminium salts in the hot and wet tropical climate. The hard, red, erosion-resistant layers look like sedimentary rock and are widely used for construction, foundations (Figure 9), and road surfaces, known as murram. At a few places the lateritic rocks can be seen in the bed of the River Sio (Figure 8).

The cuttings that came up with drilling of a borehole (well id: DWD61406, depth unknown) indicate a mafic intrusive igneous rock (basaltic or gabbroic) that was likely encountered at the maximum depth of the drilling, corresponding with the geological map (see Appendix A3). Cuttings of quartzites or quartzitic veins were also found. The topsoil was very red and clayey, in which blocks of lateritic rocks were found (Figure 7).

The soils on the higher parts of the Sio catchment are predominantly Ferrasols, while the lower parts closer to the river are characterized by Planosols and Leptosols (see the [Soil Map in Appendix A](#)).

Ferrasols develop in highly weathered material, mainly from mafic rocks like gabbro, and have a

high content of iron oxides. These soils are generally associated with high rainfall and relatively old land surfaces, which means they are highly leached and low in nutrients. The low soil fertility and the low phosphate retention in ferrasols are the most important limitations for agriculture. Regular applications of lime and fertilizers are essential for sustainable agriculture. As a result, many ferrasols are used for shifting cultivation.

Planosols have a light-coloured silty or sandy surface horizon that overlies a more clayey subsoil with low permeability. These soils are typically found in seasonally waterlogged flatlands and develop in clayey alluvial and colluvial deposits. Planosols in their natural state support sparse grass vegetation, often with scattered shrubs and trees that have shallow root systems and can cope with temporary waterlogging (Figure 10). They are not very suitable for agriculture or wood production, but can be used for extensive grazing.

Leptosols are very shallow soils over hard rock and are unattractive soils for rainfed agriculture because of their inability to hold water. In Sio Siteko, leptosols can be found along the southern edge of the River Sio basin, on the Kenyan side where the basaltic and gabbroic rocks of the Kakamega - Lower Nyanzian Formation are very close to the surface or outcropping, forming elongated NE-SW oriented ridges.

### **Wetland soil fertility and agriculture**

The wetland soils found near the River Sio and its tributaries are characterized by high soil fertility and high soil moisture and therefore is used more and more for agriculture. This is in contrast to the overall low soil fertility and/or low suitability for agriculture

of the ferralsols, planosols and leptosols, as described above. The use of wetlands for agricultural purposes has been known for decades. This is because of their fertile soil, which comes as a result of the regular sediment deposition when flood events take place. Wetland soils also have a high water holding capacity due to high organic compounds and high moist conditions due to high groundwater table and/or nearby presence of surface water. Wetland soils support vegetation which are adapted to the wet conditions. Carbon is the major nutrient cycled within wetlands. Most nutrients, such as sulphur, phosphorus, carbon, and nitrogen are found within the soil of wetlands. Anaerobic and aerobic respiration in the soil influences the nutrient cycling of carbon,

hydrogen, oxygen, and nitrogen, and the solubility of phosphorus thus contributing to the chemical variations in its water. The use of wetland area for agricultural purposes is one of the main drivers of wetland encroachment taking place in Sio Siteko. Due to unsustainable land use management, farmers have to leave their plots on the hills/slopes and go down in the wetland valley for new land, further enhancing the encroachment. This destruction of wetlands is especially severe during dry season and periods of drought “because it is believed that the wetlands are more productive than the terrestrial land and so all farmers scramble for the most productive options” (TEEB study for Sio Siteko, NBI 2019b).



FIGURE 9: TYPICAL RED-COLOURED FERRASOL SOIL IN WHICH A VERY HARD HORIZON OF LATERITE / FERRICRETE HAS DEVELOPED. THESE SECONDARY ROCKS ARE LOCALLY MINED AND CUT INTO SUITABLE SIZES WITH SUITABLE SURFACES (STONE DRESSING) AND USED TO CONSTRUCT FOUNDATIONS OF HOUSES. PHOTO TAKEN AT LAT: 0.3163 / LON: 34.0632 / 1162 M



FIGURE 10: TYPICAL LIGHT-COLOURED PLANOSOL SOIL WITH SPARSE GRASS VEGETATION AND SCATTERED SHRUBS, AS OBSERVED ALONG THE 950M WIDE TEMPORARILY WATERLOGGED FLOODPLAIN OF THE RIVER SIO. PHOTO TAKEN AT LAT: 0.3068 / LON: 34.0485 / 1148 M

## 2.3 HYDROLOGY AND WATER RESOURCES

### 2.3.1 Meteorology

The catchment of the River Sio has a tropical climate. Annual precipitation according to the Climate Hazards group InfraRed Precipitation with Station data (CHIRPS) dataset varies between approximately 2000 mm per year in the upper reaches of the catchment and 1400 mm per year in the lower reaches near Lake Victoria (Funk et al. 2015). There are two rainy seasons, the long rains between March and May and the second rainy season between late September and November. Evaporation rates are around 850 mm per year according to the Moderate Resolution Imaging Spectroradiometer mission (Mu et al. 2011).

### 2.3.2 Surface water

The River Sio originates south of Mount Elgon near the town of Bungoma and flows in a southwesterly direction before draining into the northeastern corner of Lake Victoria, and ultimately joins the Nile. The river is approximately 85 km long and the catchment covers about 1400 square kilometers. In the upper part of the catchment, the river flows through steep v-shaped valleys. In the middle reaches, the topography is flatter and the river meanders through narrow floodplains and has a width of about eight meters. The river banks are still steep and three to four meters high. At the mouth of the river, the



FIGURE 11. THE RIVER SIO NEAR BULWENGE HAS STEEP BANKS SEVERAL METERS HIGH AND VEGETATION IS LIMITED TO THE EDGES OF THE RIVER EVEN IN THE DRY SEASON (LEFT). WHERE THE RIVER ENTERS LAKE VICTORIA, THE TOPOGRAPHY IS FLATTER, AND VEGETATION COVERS THE RIVER'S SURFACE DURING THE DRY SEASON (RIGHT).

floodplains are wider and the river banks lower (Figure 11). The river is 10-12 meters wide where it enters the lake. While River Sio itself is perennial, some of its tributaries no longer run year-round.

Streamflow data from the Mundika intake station measuring water levels near the bridge between Busia and Bumala are available twice daily for the years 1958 to 2018. The average discharge during this period is 15 m<sup>3</sup>/s, but the variability during the year is high (Figure 12). Discharge tends to be high during the wet seasons (March to May and October to November). In fact the month with the highest discharge on average is May, with an average discharge of about 35 m<sup>3</sup>/s (Figure 13) and peaks as high as 60 - 70 m<sup>3</sup>/s (Figure 12). In the wet season, the average discharge drops to around 5 m<sup>3</sup>/s in January to March (Figure 13), though low flows are

in the order of 2 m<sup>3</sup>/s (Figure 12). The lower flows in the dry season allow the delta of the River Sio to be completely covered by vegetation (Figure 11). When the flow increases at the start of the wet season, this vegetation is flushed into the lake.

The dramatically increased flow in the wet season frequently results in flooding of the areas near the river and its tributaries. Due to the wide floodplains surrounding the river channel, the flooding can extend hundreds of meters up to even a couple of kilometres wide. These floods can last two to three months, usually in the period March to May. However, according to the TEEB study of Sio Siteko (NBI 2019b) there are no records of past damages cost by flooding, except for the self-reported damage to crops by farmers.

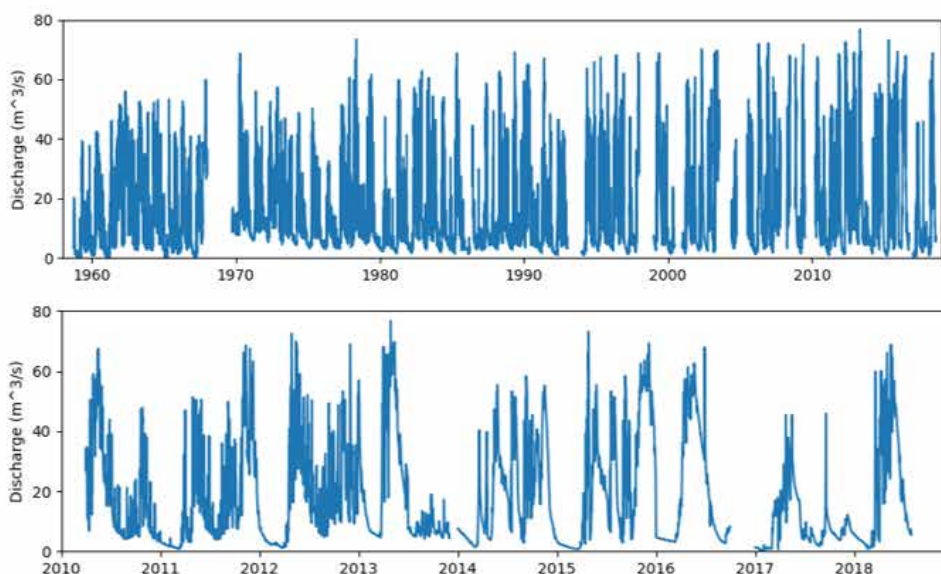
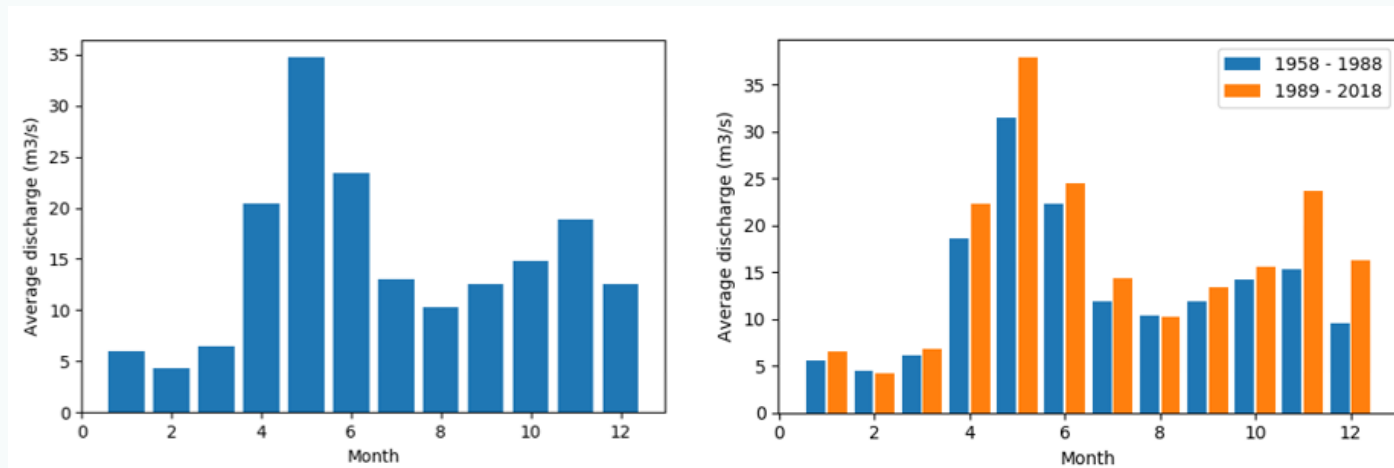


FIGURE 12: DISCHARGE TIME SERIES OF THE RIVER SIO MEASURED NEAR THE BRIDGE BETWEEN BUSIA AND BUMALA (RIGHT) JUST DOWNSTREAM OF THE MUNDIKA INTAKE, FOR THE ENTIRE AVAILABLE PERIOD (UPPER LEFT), AND THE PAST NINE YEARS (LOWER LEFT).

the end of the dry season, water retreats to the stream channel. In some locations, the stream may even run dry or contain only standing water.

FIGURE 13. AVERAGE MONTHLY DISCHARGE OVER THE ENTIRE AVAILABLE PERIOD 1958 - 2018 (LEFT) AND DIVIDED INTO ROUGHLY EQUAL PARTS (RIGHT).



A comparison between the periods 1958-1988 and 1989-2018 indicates that the characteristics of the river discharge are changing. The average discharge of the River Sio was more than 20% higher during the latter period than during the earlier period (16.7 m³/s compared to 14.5 m³/s, respectively). However, this increase is not universal (Figure 13). While (extreme) high flows and average discharge in the rainy months May and November were around 25% higher in the period 1990-2018, extreme low flows were 5-10% lower than in the earlier period. This means that despite higher overall flows, surface water availability in the dry season is lower than in the past. The observed changes to flow patterns could be attributed to land use change and related effects on the buffering capacity of the wetland areas, or climate change, but is likely a combination of both.

Currently the TEEB study for Sio Siteko is working on “Records of monthly river discharge are being analysed for flood frequency and time trend, and the effects of land conversion on flooding were will be quantified” (NBI 2019b), of which the final results have not been published yet. The results are expected to show “the impacts of increased flooding on crop production; here flood damage to crops is estimated taking into account a range of parameters such as: area of inundation, flood depth, duration, seasonality and frequency”.

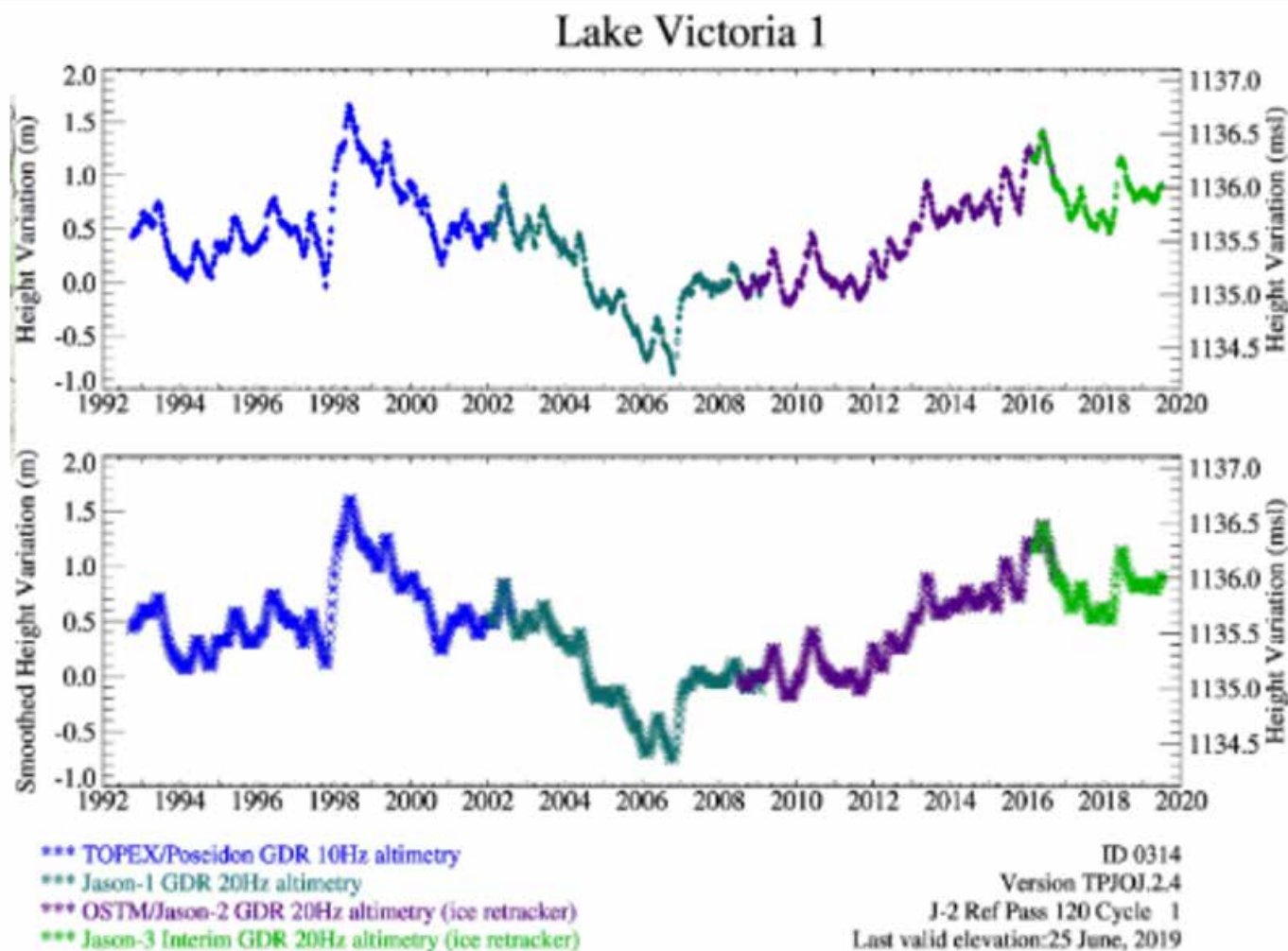
Besides the River Sio, the main source of surface water is Lake Victoria. The River Sio is only one of the many rivers and streams from Kenya, Tanzania, Uganda, Burundi, and Rwanda that feed the lake. Lake Victoria is the largest tropical lake, with an area of nearly 70,000 km², with an average depth of about 40 m (NEMA, 2009). However, water levels have varied considerably in the past due to sedimentation and changes in climate, with a sharp increase in the 60s, followed by steadily decreasing water level elevations.

Up to date measurements of lake water levels in Figure 15 show height variations of up more than two metres over the period 1992 - 2019 (USDA 2019). The water levels follow a seasonal pattern superimposed with interannual variability following a generally decreasing trend from 1992 - 2007 and an increasing trend between 2007 - 2019. This means that the water level in the wetlands of the lower reaches of the River Sio have similarly increased by about 2.5 meters since 2006. The changes in lake levels are primarily caused by changes in rainfall rather than changes in river flows.



FIGURE 14. THIS TRIBUTARY OF THE RIVER SIO HAS NO RUNNING WATER AT THE END OF THE DRY SEASON OF EARLY 2019. HOWEVER, THE NUMBER AND SIZE OF THE CULVERTS UNDER THE ROAD SUGGEST MUCH HIGHER FLOWS DURING THE WET SEASON.

FIGURE 15: RELATIVE LAKE HEIGHT VARIATIONS IN LAKE VICTORIA OVER THE PERIOD 1992 - 2019 (USDA, 2019).



### 2.3.3 Groundwater

Groundwater resources can be found in the Precambrian crystalline basement rocks when weathered and/or fractured. These aquifers generally have low permeability and low storage. Their physical aquifer properties are largely a function of tectonic history and long-term cycles of weathering and erosion. Most boreholes in the region tap groundwater from these basement aquifers. Very few boreholes have been drilled in volcanic rocks and little is therefore known about their aquifer properties.

There is anecdotal evidence that groundwater levels are decreasing. Local experts indicate that springs that used to provide water year-round tend to run dry in the dry season in recent years. This has also been reported for a handful of boreholes. Unfortunately, no groundwater measurements are available to confirm these observations.

### 2.3.4 Water quality

*The quality of surface water and groundwater can be affected by natural conditions such as geology as well as human activity. In summary, surface water is generally of better quality in terms of measured EC and nitrate levels. However, the sediment load in surface water is high, and surface water is more vulnerable to contamination than groundwater. The groundwater resources in the catchment have high EC and nitrate values, though these rarely exceed guideline values. In addition, this source is less vulnerable to contamination than surface water.*

During the field visit in April 2019, field measurements of water quality were performed at various rivers, streams, lakes, springs and boreholes throughout the Sio Siteko wetland landscape (Table 1). These measurements represent the hydrochemical characteristics at a specific site and moment in time, but give insight in spatial variations as well as the variation between different water types. The main water quality issues are discussed in more detail in the paragraphs below.

TABLE 1: FIELD MEASUREMENTS OF WATER QUALITY MEASURED AT VARIOUS TYPES OF SURFACE WATER AND GROUNDWATER IN SIO SITEKO

Type	Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Date	EC (µS/cm)	T (°C)	NO <sub>3</sub> (mg/l)	Turbidity (NTU)
Lake	Lake Victoria, Majarija Landing Site	0,24132	33,99199	11/04/2019	108	28,0	<5	60
Lake	Lake Victoria	0,23909	33,99734	11/04/2019	107	27,9	<5	36
River (perennial)	River Sio outlet	0,23419	34,00766	11/04/2019	133	27,3	<5	50
River (perennial)	River Zoa (Sio)	0,24255	33,99857	11/04/2019	150	27,6	<5	95
Borehole (handpump)	Maduwa village	0,24876	33,99117	11/04/2019	893	27,0	30	<5
Borehole (not in use)	Maduwa village	0,24694	33,99164	11/04/2019	6700	30,9	45	<5
River (perennial)	River Sio	0,30505	34,05103	11/04/2019	169	30,0	5	60
Stagnant water		0,33646	34,01648	11/04/2019	886		<5	<5
Borehole (handpump)	Kateruhana West	0,33946	34,03178	11/04/2019	726	27,3	25	<5
Borehole (not used)	Kateruhana East	0,33470	34,03306	11/04/2019	1986	26,3	15	<5
Stagnant water in valley	Lugudu wetland	0,35982	34,09190	11/04/2019	578		<5	<5
River (perennial)	River Sio	0,35161	34,09813	11/04/2019	154	27,8	<5	225
Lake	Lake Victoria, Sio Port beach	0,22366	34,01570	12/04/2019	145		<5	<5
Stream (perennial)	Wahunga Stream	0,28489	34,06409	12/04/2019	567	25,7	<5	48
Borehole (electric pump)	Nyakwaka girls' secondary	0,29733	34,06622	12/04/2019	1416	26,8	40	<5
River (perennial)	River Sio	0,30418	34,05232	12/04/2019	148	27,8	<5	85
Open well in wide valley	Sugarcane plantation	0,31800	34,06142	12/04/2019	353	24,6	<5	<5
Borehole (handpump)		0,31365	34,06418	12/04/2019	407	26,2	30	<5
River (perennial)	River Sio	0,36036	34,13184	12/04/2019	139	28,0	<5	85
River (perennial)	River Sio bridge at Mundika intake	0,38339	34,14599	12/04/2019	138	27,4	<5	75
River (seasonal)	River Buyosi	0,40099	34,10249	12/04/2019	358	27,9	<5	190
Stream (perennial)	Mabale Stream	0,42538	34,12023	12/04/2019	342	28,8	5-10	140

EC = Electrical Conductivity; T = Temperature; NO<sub>3</sub> = nitrate; NTU = Nephelometric Turbidity Units

One of the most important threats to water quality is faecal contamination. Busia County sewerage within the urban area of Busia town Kenya discharges its waste water into Lukonyi stream, which discharges its water into the Sio-Siteko wetland. Some premises in Busia County, Kenya are not connected to the existing sewerage system, which results in untreated discharges into natural water courses leading into River Sio. On the Ugandan side, the Busia Municipality does not have a sewage system thus raw waste water is discharged into the River Sio. Though Busia has water treatment in the form of sewage ponds, most residents of the study area use open pit latrines. The TEEB study of Sio Siteko reports that plans are underway for field sampling (at least for the main pollutant nitrates, phosphates, and biological oxygen demand) at the mouth of River Sio and at the point where the sewerage discharges its effluent into the Lukonyi stream, under guidance of Lake Victoria

North Basin Regional Office in Kakamega (NBI 2019b).

A second threat is domestic waste and animal waste. Solid waste generated in the urban areas is not well managed as well as waste water from the residential houses. This is especially important at the landing sites, or in other settlements close to surface water. The last important threat to water quality is the use of fertilizers and pesticides. This makes water resources in the Sio Siteko area vulnerable to contamination.

The electrical conductivity (EC) is an indicator of water quality. In practice, high values suggest water is saline and/or contains high levels of other ions such as nitrate. The Ugandan standard for drinking water is 2500 µS/cm. However, values above 1500 µS/cm are considered to be unpalatable (WHO 2017). In the Sio Siteko area, the EC of surface water

is considerably lower than these guidelines, generally ranging between 100-200  $\mu\text{S}/\text{cm}$  in the River Sio and in Lake Victoria. Some tributaries of the River Sio, such as the Wahunga Stream and River Buyosi, have slightly higher values up to 600  $\mu\text{S}/\text{cm}$ . EC levels in groundwater are typically higher in the Sio catchment, and the variability between different locations large. In shallow groundwater sources, the EC is around 350  $\mu\text{S}/\text{cm}$ . Boreholes extracting groundwater from deeper layers have higher EC levels, sometimes exceeding the WHO guideline for palatable water. The highest EC concentrations in the Sio catchment can be more than twice the Ugandan standard for drinking water, measuring more than 6000  $\mu\text{S}/\text{cm}$ . The locally high EC's are likely due to the accumulation of salts and carbonate minerals from the volcanosedimentary rocks and carbonatites present in the area.

Elevated nitrate concentrations in drinking water can cause methemoglobinemia, or blue-baby syndrome, in bottle-fed infants. The main sources of nitrate in surface and groundwater are agricultural activity, specifically overuse of fertilizer, and wastewater leaching into groundwater and surface water. The guideline for nitrate in drinking water is 50 mg/litre (WHO, 2017). In the Sio Siteko study area, nitrate levels in surface water were generally very low (smaller than 1 mg/litre). Nitrate concentrations in groundwater were higher, up to 45 mg/litre and just under the guideline for drinking water. Where these elevated concentrations are a result of wastewater leaching, this could be an indicator for biological contamination including faecal contamination. Elevated nitrate concentrations are also found in deep boreholes, f.e. in Nyakwaka girls' secondary school (Table 1). Deeper wells don't automatically mean safer wells; depends on geology and nearby

sources of pollution (f.e. Figure 40 showing faecal contamination from nearby pit latrines) if contaminated water percolates into deeper aquifers.

### **High sediment load (with turbidity as indicative proxy) in surface water**

Increased agricultural land use leads to accelerated erosion and deposition of fine sediment in surface water. Monitoring of suspended sediment yields has proven challenging due to the spatial and temporal variability of sediment loading. The simplest way of taking a sample of suspended sediment is to dip a bucket or other container into the stream, preferably at a point where it will be well mixed, such as downstream from a weir or rock bar. The sediment contained in a measured volume of water is filtered, dried and weighed. This gives a measure of the concentration of sediment (only at one moment in time) and when combined with the rate of flow gives the rate of sediment discharge. However, these measurements need to be repeated multiple times, as reliable sediment yield calculations depend on accurate monitoring of these highly episodic sediment loading events. Also, estimating soil loss from measurements of sediment movement in streams and rivers faces several problems.

Taking the measurements is time consuming and expensive; the accuracy of the measurements is likely to be poor; and even if there are good data on the movement in a stream it is not known where the soil came from and when (FAO, 1993). Turbidity measurements are often used to assess the amount of suspended solids in water (Alberto et al., 2016), and turbidity is considered to be a reasonably accurate proxy for suspended sediment data (Ruegner et al., 2013). Turbidity is a measure of the cloudiness of water and is related to the presence of suspended



FIGURE 16: WATER QUALITY ISSUES INCLUDE BOREHOLES WITH EC LEVELS ABOVE THE DRINKING WATER STANDARD (LEFT) AND A VISIBLE HIGH SEDIMENT LOAD IN THE RIVER SIO (RIGHT).

particles and organisms in water. For this monograph study it was used as indicative proxy for sediment load. Groundwater resources in the Sio Siteko study area have very low turbidity. However, the turbidity is high in the River Sio (Figure 16) and at the edges of Lake Victoria where lake sediments are regularly disturbed. This can be related to sand mining activities upstream in the river. Local stakeholders indicated during the community and district level meeting that the river carries more sand now than was the case 10 - 20 years ago (Wetlands International 2019b). This could be related to an increase in sand mining activities and other erosive activities over the same period.

According to the Sector Performance Report 2019, of the Ministry of Water and Environment of Uganda, artisanal mining is common in Busia District (MWE 2019). However, it does not become clear what precious metals or stones are extracted and where in the District this takes place. In the artisanal mining of gold, mercury is used to extract the gold from the soil or rock particles. This practice introduces mercury in the environment and subsequently into surface and ground water, which could cause pollution and adverse effects on the aquatic ecosystem including loss of biodiversity. Mercury kills fish and causes cancer in humans.

### 2.3.5 Hydrologic functions of the wetland system

The Sio Siteko wetland landscape plays an important role in the hydrology of the catchment and in the ecosystem. Here, we focus on the hydrological aspects of wetlands. The importance of wetlands as nurseries and habitat for a wide variety of wildlife, birds and aquatic organisms is discussed in Chapter 3.

In a wetland, water moves more slowly and is stored for a longer period of time. The large storage capacity allows peak flows, for example resulting from extreme precipitation events, to be stored, thereby reducing flooding. The stored water is then released slowly over a long period of time, making more water available in the dry season.

Water storage in wetland areas improves water quality, as well. Organisms have the opportunity to extract nutrients from the water. In addition, sediments in the surface water have the opportunity to settle, reducing the sediment load of water downstream from the wetland. This is especially vital as croplands such as in the Sio Siteko landscape tend to increase soil erosion and nutrients and agrochemicals are washed into the surface water. The water purification service of the wetlands is important for the survival

of fish and other aquatic organisms in downstream areas.

## 2.4 CLIMATE AND CLIMATE CHANGE

The current and expected effects of climate change differ locally, nationally and regionally. Similarly, the impacts of climate change on livelihoods, food and water security, ecosystems, infrastructure etc. differ per country and region, as well as community and individual, with gender a particularly important vulnerability factor.

Wetlands play a key role in buffering the effects of climate change, thereby supporting climate adaptation and resiliency. Indeed, vegetated and healthy wetlands are among the most effective carbon sinks on the planet, but when disturbed or warmed, they release the three most important heat-trapping greenhouse gases: carbon dioxide, methane, and nitrous oxide. Protecting wetlands from human disturbance therefore helps to limit the increase in greenhouse gases in the atmosphere. The role of wetlands in carbon sequestration in the Nile Equatorial Lake region, including the wetland system of Semliki Delta, has been studied by the Nile Basin Peatlands Carbon Sequestration Study (Elsehawi et al., 2019).

Wetlands are strongly dependent on the water cycle, so the current trends and future changes within the whole catchment area of the River Sio determine what the effects of climate change are on the water resources, food security and wetlands services in the Sio Siteko study area. Hence, this paragraph assesses the climate and climate change within the basin of the River Sio.

### 2.4.1 Current climate

The basin of the River Sio is located within a relatively humid equatorial climate zone, where the topography, prevailing winds and water bodies cause large differences in rainfall patterns. Average annual rainfall ranges from 1400 mm in the lower reaches to 1800 mm in the upper reaches of the basin of the River Sio, generally falling in two seasons (March to May and October to November). The high rainfall variability, both seasonal and spatial, makes the area vulnerable to both droughts and floods. Average daily temperature is around 28 °C, but varies with altitude, with lower temperatures in the upstream part of the catchment on the slopes of Mt Elgon, compared to low-lying Sio Siteko study area. Sea surface temperatures in the distant tropical Pacific, Indian and, to a lesser extent, Atlantic Oceans determine the movement

of the Inter-Tropical Convergence Zone (ITCZ) who strongly influences annual rainfall amounts and timing in the area. The effects of the ITCZ are considerably altered by the presence of Lake Victoria and local relief features like Mt. Elgon. Year to year variations in annual rainfall can be considerable, and the onset of seasons can shift by 15 to 30 days (earlier or later) and the length of the rainy season can also change by 20 to 40 days from year to year (Climate Change Profile Uganda 2018).

### 2.4.2 Observed trends

In comparison of records over two 30-year periods, from 1951 to 1980 and from 1981 to 2010 the data overall indicate no clear changes in annual rainfall in Uganda and direct surroundings. Analyses identified a statistically significant increase in temperature at a rate of 0.5 °C per decade over the past 30 years, with an increase in the average number of both hot days and hot nights per year (Climate Service Centre Germany 2015).

### 2.4.3 Climate change

Global projections of climate change focus on expected changes in precipitation and temperature. Projections are available for several scenarios of through the Coupled Model Intercomparison

Project (CMIP) version 5 (Taylor et al. 2012). These data provide an overview of the impacts of the different climate change scenarios. When the data is subsequently used in water resources planning or drought analysis, the data must be downscaled and bias-corrected (NBI 2019).

### Precipitation

Within the region, models predict potentially large changes in precipitation (Semazzi 2005). For example, in northern Uganda precipitation is expected to increase, while precipitation is expected to decrease in southern Kenya (Figure 17). However, the effect of climate change on annual precipitation along the northern shore of Lake Victoria and in the basin of the River Sio is expected to be limited (Figure 17). A closer look at climate projections from CMIP-5 (Taylor et al. 2012) for the River Sio study area shows that overall the distribution of precipitation during the year is not expected to change significantly by 2050, besides a slight increase in rainfall in the short rain season months of October and November (Figure 18). However, the uncertainty is high, as some models predict increases in precipitation and others predict decreases. The possibility of additional precipitation during the dry season between December and February (Climate Change Atlas of Uganda 2018), in particular, could have implications for livelihoods (see chapter 2.4.4).

FIGURE 17: PROJECTED CHANGES IN ANNUAL RAINFALL (BLUE IS DECREASE, RED IS INCREASE) DUE TO CLIMATE CHANGE ACROSS UGANDA, WITH THE LOCATION OF SIO SITEKO INDICATED WITH A BLACK STAR (SOURCE: SEMAZZI 2005).

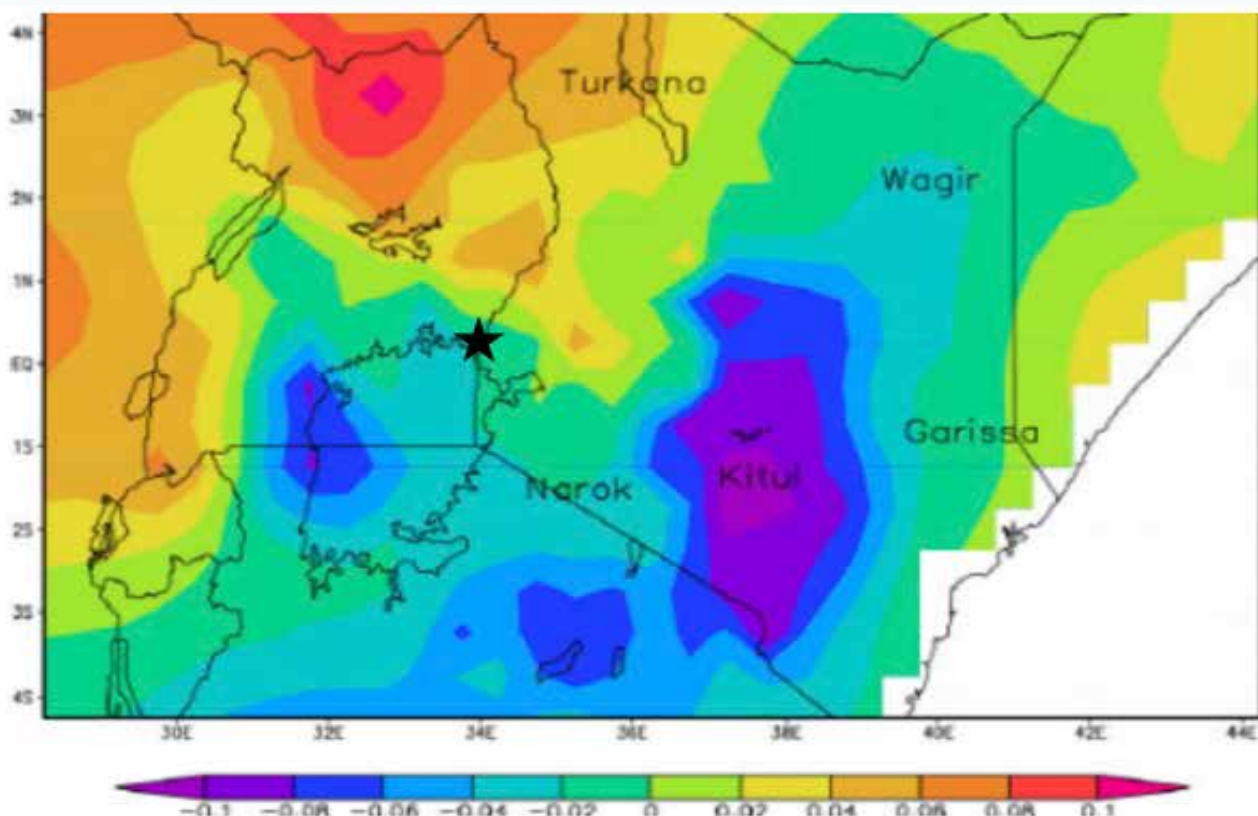
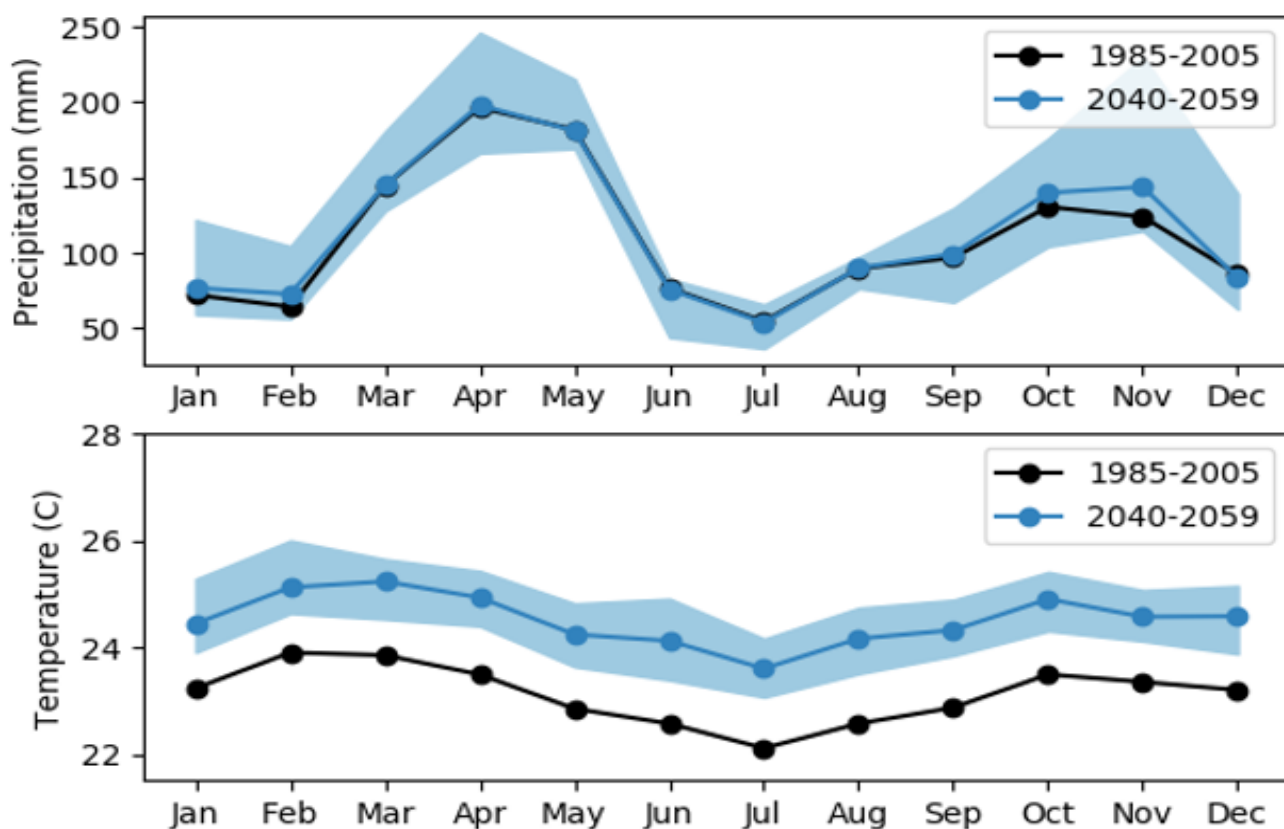


FIGURE 18. HISTORICAL MONTHLY PRECIPITATION AND MONTHLY AVERAGE TEMPERATURE FOR THE PERIOD 1985 - 2005 AND FOR THE RCP4.5 CLIMATE SCENARIO CONSIDERING THE PERIOD 2040-2059. THE BLUE LINE SHOWS THE MODEL ENSEMBLE MEDIAN, THE SHADED AREA SHOWS THE 10<sup>TH</sup> TO 90<sup>TH</sup> PERCENTILES OF THE MODEL ENSEMBLE (N=35).



### Warming and extreme events

The temperature is projected to increase by about 1.2 °C by 2050 (Figure 18) based on the results of the CMIP-5 experiment (Taylor et al. 2012), though some models predict temperature increases of more than 2 °C. These projections are in line with the observed warming trend. The projected warming is slightly higher in the slightly cooler period June and August and relatively low in the months January and February (Figure 18). Due to this warming, there is a potential for an increase in the frequency and intensity of extreme events (e.g. heavy rainstorms, flooding, droughts). The percentage of rainfall coming in the form of heavy precipitation events is anticipated to further increase, due to continued warming, which would escalate the risk of disasters such as floods and landslides. An increase in the frequency and intensity of droughts and floods in recent years was reported by local community members of Sio Siteko (see community meeting report in Wetlands International 2019b and 2019c).

#### 2.4.4 Impacts of climate change

The projected effects of climate change on precipitation and temperature will have impacts on

the wetlands, water resources, and food security in the Sio Siteko landscape.

### Wetlands

Climate change may affect the health of the wetland ecosystems of Sio Siteko, which provide critical ecosystem (and economic) services for the surrounding communities. Wetlands strongly dependent on the water cycle and for this reason are extremely vulnerable to the effects of climate change. Some of the main consequences that can be predicted from climate change for wetlands are modifications in hydrological regimes, in particular decreased surface water and ground water levels, which can cause intense droughts. Therefore, climate change will likely cause the loss of, or reduction in, the total wetland area of Sio Siteko and will challenge the adaptability, composition and distribution of species, as wetland networks are key corridors and stepping stones allowing species to move to cooler areas and thus adapt to rising temperatures. This loss of biodiversity will probably have consequences for the human population that depend on them. In addition, droughts impair the ability of freshwater wetlands to deliver other ecosystem services, including improving water quality, water supply, flood control,

and storm protection, with severe negative ecological and socioeconomic impacts.

### Water resources

Water resources are likely to be increasingly strained in the future climate of the basin of the River Sio. While it is projected that the total rainfall will increase, warmer temperatures will accelerate evapotranspiration, reducing the benefits of increased rainfall. With more frequent and severe droughts, the river basin will likely experience negative impacts on water supply, biodiversity and hydropower generation. A shift in rainfall patterns will decrease the recharge of rainwater into the soil, which will have a negative impact on groundwater resources and water tables in wells. Recent years have shown that climate change has disrupted rainfall patterns, resulting in more intense rains and then drier spells.

### Food security

If temperatures rise and the frequency and intensity of extreme droughts and floods increase, it can reduce crop yields and cause a loss in livestock, which will have important implications for food security in Sio Siteko. The expected increase in rain during the dry season (December - February) could have a significant impact on both livestock and agriculture. An overall decrease in the predictability of rainfall intensity and of the onset of the rainy season increases the chance of crop failure, especially on perennial crops and post-harvest activities such as drying and storage. The potential increase in the frequency of extreme events like droughts and flooding can have a devastating effect on the pasture lands available for livestock in Sio Siteko.

### 2.4.5 Climate vulnerability

The magnitude of the impacts of climate change is determined by the extent of climatic changes on the one hand, and the ability to mitigate the effects of those changes on the other. The GAIN index summarises a country's vulnerability to climate change and other global challenges, combined with their readiness to improve resilience to these challenges. Uganda ranks 155<sup>th</sup> out of 181 countries in the ND-GAIN index for climate vulnerability and Kenya ranks 150<sup>th</sup> of 181 countries (Gain Index, 2016).

Uganda is the 14<sup>th</sup> most vulnerable country and the 48<sup>th</sup> least ready country - meaning that it is very vulnerable to, yet unready to address climate change effects. Vulnerability measures the country's exposure, sensitivity, and ability to cope with the negative effects of climate change by considering

vulnerability in six life-supporting sectors: food, water, ecosystem service, health, human habitat and infrastructure. Readiness measures a country's ability to leverage investments and convert them to adaptation actions by considering the country's economic, governance and social readiness.

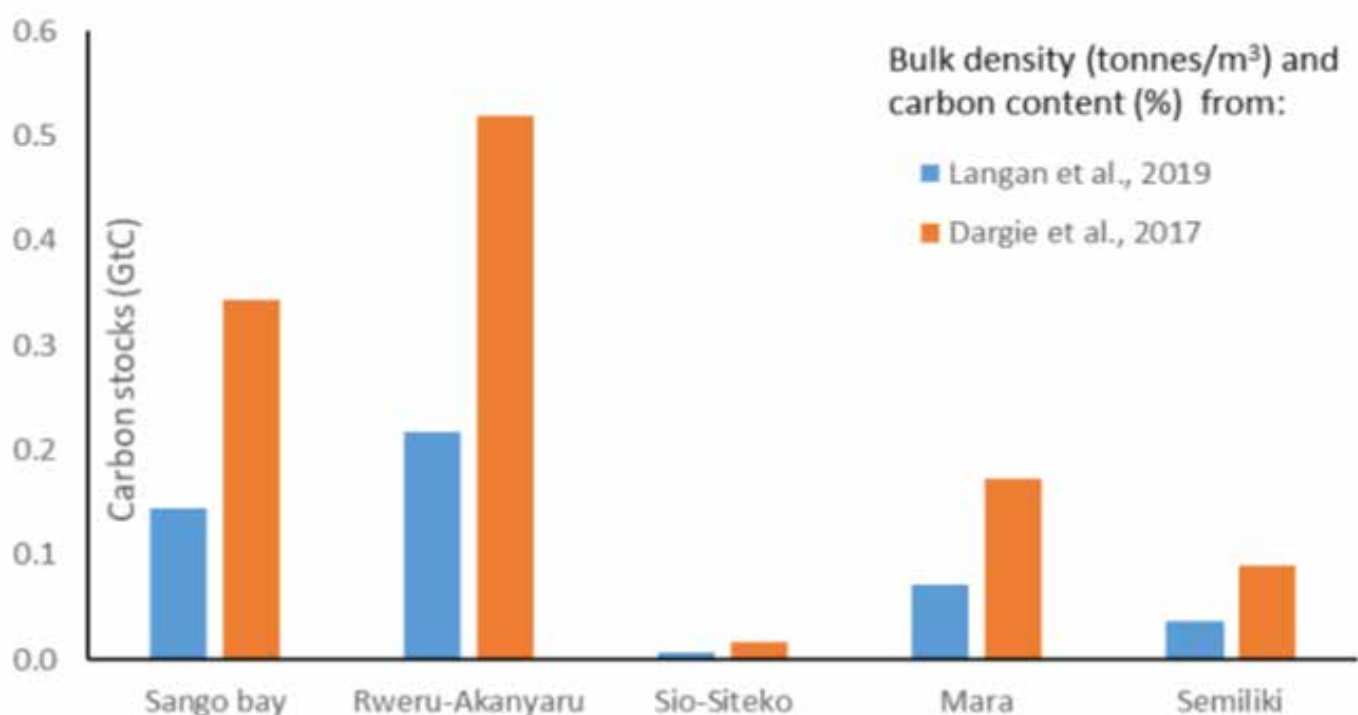
Due to a high Multidimensional Poverty Index (39% of the population in Kenya and 55% in Uganda is in multidimensional poverty; UNDP 2019b), low rural incomes, lack of income diversity and heavy dependence on rainfed-agriculture, the basin of the River Sio and its people are very vulnerable to climate change. High population growth rate (2.8% per year) and the expansion of farming and pastoralism under an unpredictable and warmer climate regime could decrease the resilience of the ecosystem and dramatically increase the number of at-risk people in the next 20 years.

### 2.4.6 Carbon storage in Semliki Delta peatlands

The oxygen-free environment in wetland ecosystems prevents the decay of vegetation and organic matter, causing the formation of peat which effectively traps carbon. Tropical peatlands are known to be the most space-efficient terrestrial carbon stock pool, with their carbon stock per hectare 10-15 times higher than a tropical rain forest on mineral soil. The Nile Equatorial Lakes region is estimated to contain over 12,000 km<sup>2</sup> of peatlands holding 2.5-6 billion tonnes of organic carbon. Figure 19 shows total carbon content of transboundary wetlands in the Nile Basin. Sio-Siteko is one of the smaller wetlands in this category, with relatively little carbon stored: about 10 million tonnes. However, 10 million tonnes is still a large volume of carbon stored for such a small area, while degradation is reported with increasing threats of peat burning due to prolonged dry seasons (Elsehawi et al. 2019).

Globally, the draining of peatlands emit about 2 giga tonnes of CO<sub>2</sub>, which amounts to ~5 % of the global CO<sub>2</sub> emissions. In DRC and Uganda, CO<sub>2</sub> emissions from drained peatlands equal more than 50 % of national fossil fuel and cement emissions, indicating the importance of peatlands for national climate policies in these countries. Preventing further drainage (i.e. keep peatlands wet) and rewetting already drained peatlands (i.e. make drained peatlands wet again) would lead to avoidance and reduction of further emissions. Unsustainable use of peatlands can turn peatlands from a carbon sink to a huge carbon source (Elsehawi et al. 2019).

FIGURE 19: CARBON STOCKS (IN GIGATONNES OF CARBON) OF SOME OF THE TRANSBOUNDARY WETLANDS IN THE NILE BASIN (ELSEHAWI ET AL. 2019).



## 2.5 LAND USE AND LAND COVER

The Sio Siteko wetland landscape largely consists of cropland, with wetland areas immediately surrounding the River Sio and its tributaries. Scattered within the catchment are patches of tree cover and built-up area. Funyula and Lumino are the most notable villages within the project area. The larger towns of Busia and Bungoma are located along the edge of the Sio catchment.

A land cover map developed by the Climate Change Initiative Land cover programme based on Sentinel satellite imagery (ESA CCI Land cover 2017) is shown in (see the Land cover map in Appendix A). The coverage of different land use types is summarized in Table 2. It should be noted that part of the area classified as ‘trees’ includes papyrus swamps & reeds

OVERVIEW OF RELATIVE COVERAGE OF DIFFERENT LAND COVER TYPES IN THE SIO SITEKO STUDY AREA, BASED ON THE 20-M RESOLUTION DATASET FOR AFRICA PRODUCED BY THE CCI LAND COVER PROGRAMME

Land cover	Coverage (%)
Trees*	11.1
Shrubs	1.1
Grassland	4.2
Cropland	80.9
Built up	1.2
Water	1.5

\*this might include also dense papyrus and reed vegetation; see Explainer 1

(with some tree cover), which is explained in more detail in Explainer 1

The wetlands are restricted to a relatively narrow band around the main drainage network in the lower half of the Sio catchment (see the Wetland type and wetland probability maps in Appendix A), though this band broadens as the River Sio approaches Lake Victoria. The wetlands have an area just under 60 km<sup>2</sup>, and thereby cover 15% of the study area, as is the wetland size used in the Sio Siteko TEEB study (NBI 2019b).

Generally, the wetlands are a combination of papyrus swamp and other herbaceous cover such as reeds. The wetlands are permanent, though the extent of the flooded area varies considerably during the year. An overview of the coverage of different wetland types based on the AFcover dataset is found in Table 3. The similarities and differences between the land cover and wetlands data sets are explained in Explainer 1.

The most important land use in the project area is farming interspersed with livestock grazing (see Figure 19). Rainfed subsistence farming is the dominant agricultural practice, with crops including cassava, beans, vegetables and rice. However, larger-scale commercial farming is on the rise. One of the most important commercial crops is sugarcane, of which the cultivated area is expected to increase dramatically in the near future.



FIGURE 19: TYPICAL LAND COVER IN THE VALLEYS OF THE SIO CATCHMENT IS AGRICULTURAL LAND INTERSPERSED WITH TREES AND NATURAL VEGETATION INCLUDING PAPYRUS AND REEDS. LAND USE IN THE WETLAND LANDSCAPE INCLUDE FARMING, STANDS OF EUCALYPT OR PINE TREES, AND GRAZING AREA.

TABLE 3: OVERVIEW OF THE AREAL COVERAGE OF DIFFERENT WETLAND TYPES IN SIO SITEKO STUDY AREA.

Wetland type	Area (km <sup>2</sup> )
Aquatic agriculture	2.7
Grass and papyrus swamps, permanently flooded	55.3
<b>Total</b>	<b>58</b>

Other land uses within the Sio Siteko project area include tree plantations, transportation, and industry. The tree plots mainly consist of eucalypt and pine species and are located close to the villages. The main transportation routes in the project area are the road between Busia and Bumala along the northeastern boundary of the project area, by foot and boat at the River Sio crossing between Lumino and Funyula, and by boat in Lake Victoria (Figure 20). Industry is limited to the outskirts of Busia in the north.

### Wetland encroachment and wetland degradation

The land cover and land use have changed in recent years. Encroachment of agricultural land into the wetlands has increased (Figure 21), especially for rice and sugarcane. Cultivation of crops on the river banks and the encroachment into the wetlands, on the Uganda side for example, in Bwalira, Bwaya, and in the eastern parts of Majanji (0.26 °N, 34.01 °E), Lumino (0.16 °N, 34.01 °E), and Buhehe (0.21 °N, 34.05 °E), and on the Kenya side at Nangoma (Buyende and Bulolo), Khadoda, and North of Sio Town (around Sigalame 0.15 °N, 34.01 °E). Agriculture on the slopes between the settlements on higher ground and the valley floors is also more common now than in previous decades. A possible explanation for increasing agricultural activity is increasing population pressure in and around the wetland areas. Increasing encroachment is also



FIGURE 20: TRANSPORTATION OF PEOPLE AND GOODS FOR TRADE IS COMMON ALONG THE RIVER SIO (LEFT), BUT ESPECIALLY SO SIO PORT (RIGHT).

attributed to poor agricultural practices, which have caused soil fertility to decline in fields on the higher ground near the settlements. Tree cover has decreased as trees are cleared for agricultural fields and to provide firewood. The deforestation and increasing agricultural area on the slopes also increase erosion and the risk of landslides. At the same time, eucalyptus and pine tree species have been planted in and around the wetland on a massive scale; predominantly in Busumba and Buyengo areas, and Mundulusia along Mavale River which is a tributary of River Sio. On the satellite imagery used it is not possible to differentiate between pine and eucalyptus species. The idea is that the local communities will use these trees for timber instead of the remaining natural vegetation in the wetlands. In general trees can be good for shade (cooling) and preventing soil erosion. However, if they are newly introduced in water logged areas the consequences can be overall negative due to drying out of wetland area, as well as creating a mono vegetation versus diverse vegetation.

Land cover and use changes related to encroachment and deforestation are not visible in the 300-m CCI land cover dataset looking at the period 1995 to 2015 (ESA CCI Land cover 2019). The land cover dataset does indicate that built up areas have increased significantly, increasing more than tenfold between 1995 and 2015. However, Google Earth imagery (as in Figure 21) suggests that encroachment has

doubled or even tripled between 2010 and 2019 in some branches of the wetland. Encroachment has increased more significantly near settlements and roads, and along the tributaries of the River Sio, than along the River Sio itself. Currently the TEEB study for Sio Siteko is working on determining the annual wetland degradation rate “*using remote sensing to construct a degradation history of the study area, and to ascertain an annual degradation rate*” (NBI 2019b), of which the final results have not been published yet.

### Quantifying land cover change

In the ESA CCI 300m dataset, observed land cover changes between 1995 and 2015 in the project area are negligible. In reality, land cover change including wetland encroachment and deforestation has taken place. The most likely reason this is not visible in the land cover dataset is that the land cover changes are scattered and (much) smaller than the 300m resolution of the dataset. The ESA CCI 20m dataset would be suitable to study land cover change because of its high resolution, but is only available for one year (2016) and hence would require a new classified ESA CCI 20m dataset to become available. Moreover, on satellite images it hard to distinguish between certain types of crop (like sugar cane) and natural wetland vegetation (papyrus and reeds). This might keep wetland encroachment underexposed on satellite images; see also the explanatory notes in Explainer 1.

#### Explainer 1 – Land cover and wetland datasets

An increasing number of global and regional datasets related to land cover and vegetation type are becoming available. The products are developed by different organizations, are based on different information (for example using different satellites), and have different spatial and temporal characteristics and accuracies. As a result, while datasets tend to agree on general patterns, there may be significant discrepancies at small scales.

Several land cover datasets are available, most derived largely from remote sensing data. The ESA CCI 20m dataset used in this study has an unprecedentedly high resolution but is only available for one year (2016). An alternative dataset is the ESA CCI dataset with a 300m resolution, which is available annually for a period of almost 15 years. The latter dataset is more suited to studying land cover change. However, in practice the relatively coarse resolution of the dataset compared to the size of the project area has proven problematic. In the dataset, observed land cover changes between 1995 and 2015 in the project area are negligible. In reality, land cover change including wetland encroachment and deforestation has taken place. The most likely reason this is not visible in the land cover dataset is that the land cover changes are scattered and (much) smaller than the 300m resolution of the dataset. The finer level of spatial detail in the 20m and more recent acquisition date are the reasons this dataset was ultimately preferred above the 300m dataset.

There are also discrepancies between the ESA CCI land cover and AFcover wetland datasets used in this study. Wetlands and aquatic vegetation are underrepresented in the land cover dataset compared to the wetland dataset and field visits. This underestimation may be because they are harder to identify from the source imagery, especially where vegetation cover is relatively dense. In the Sio-Siteko wetland landscape, the grass and papyrus wetlands have mainly been classified as trees and scattered grasslands in the land cover dataset. This suggests that the dense papyrus and reed vegetation in these wetlands is more similar to the tree references used in the land cover classification than to the grassland references.

FIGURE 21: EXAMPLE OF WETLAND ENCROACHMENT ALONG THE TRIBUTARIES OF THE RIVER SIO: IN 2010 (ABOVE), THIS AREA NORTH OF LUANDA TOWN WAS LARGELY COVERED BY NATURAL VEGETATION. IN 2018 (BELOW), THE STRAIGHT LINES AND REGULAR SHAPES (GREY COLOUR) INDICATE AGRICULTURAL FIELDS.



#### 3.1 BIODIVERSITY

##### 3.1.1 Bio-geographical significance of Sio Siteko wetland area

The Sio Siteko wetland system is a transboundary wetland between Kenya and Uganda border. It consists of a number of interconnected secondary and tertiary wetland subsystems connected through a system that stretches along the Kenya-Uganda border and draining into Lake Victoria.

The Sio wetland system has varied habitat sub-types with a rich flora dominated by *Cyperus papyrus*, *Cyperus latifolius* and *Phragmites mauritianum*, interspersed with *C. articulatus*, *C. dives*, *Echinochloa pyramidalis*, *Leersia hexandra*, *Mimosa pigra*, *Persicaria decipiens*, *P. setosula*, and *Typha domingensis*. The edge of the wetland is mainly covered by *Mimosa pigra* and *Lantana camara* but these can reduce species diversity due to their invasive ability although good for feeding on by birds especially the Nectariniidae family.

The Sio-Malaba-Malakisi wetland is an IBA in which over 520 bird species have been documented including; the endangered Grey Crowned crane, the globally threatened *Papyrus Gonolek* and Pallid Harrier. Notable mammals found in the area include Vervet Monkey, Otter, Sitatunga, Hippopotamus and Water Mongoose. The wetlands provide habitat for many endemic plant, bird, mammal, amphibian, reptile, fish and insect species.

The Sio Siteko wetland landscape is endowed with abundant natural resources which present tremendous potential for social economic development. Agriculture is the major socio-economic activity in the catchment employing about 85% of the people in the basin. The wetland however faces many threats which have resulted into degradation of the habitat for biodiversity. The rivers not only include a complexity of problems related to upstream (Kenya) and downstream (Uganda) conditions but also a network of river threats along the international border (World Bank, 2009).

##### 3.1.2 Biodiversity assessments of Sio Siteko

Limited data is available on biodiversity in Sio Siteko. The following studies and surveys have been used a starting point for the biodiversity section in this monograph:

- Biodiversity assessment by Langdale-Brown

et al. (1964)

- Distribution of amphibians and reptiles in Majanji, during Lake Victoria Environmental Management Project (LVEMP, Ogutu-Ohwayo, 2000)
- Important Birds Area Assessment (2005)
- Survey Report on Mammals by Kiyemba and Kityo (2008)
- Biodiversity assessment by Kaddu and Busuulwa (2008)
- Opportunistic records of butterflies and dragonflies by Kaddu and Busuulwa (2009)
- Community Wetland Management Plan 2010-2019 Assessments Sio Malaba Malakisi Project (2012)
- Birds of Busia by Nalwanga (2019)

Besides the literature a wide variety of databases and reference literature was consulted, including, but not limited to the African Plants Database, Birds of East Africa by Stevenson & Fanshawe (2002), Uganda Bird Atlas by Carswell et al. (2005), Standard Habitat Classification by Bennun et al. (1996), The Uganda National Biodiversity Data Bank in the Department of Environmental Management, Herpetofauna by Schiøtz, (1999), Spawls et al., (2002) and Channing & Howell (2006), AmphibiaWeb (2015), and The Reptile Database by Uetz, P. & Jiri Hošek (eds.) (2015).

For this monograph the available data on biodiversity was collated and compared by researchers specialized in wetland habitats, and then species occurrence was checked against habitat records. The data from previous studies was mainly collected using the Timed Species Counts (Bibby *et al.* 2000) and the sectioned transect method (Nalwanga *et al.* 2012). Taxonomic literature was checked for information on habitats of the species and various published articles for their uses in the local areas. The IUCN Red List (IUCN, 2019) was checked for the conservation status of the species, whenever possible at global, country, regional and local levels. Species names were updated and harmonized, so that listing species under more than one name was avoided. Brief field visits were conducted to assess the general characteristics and nature of the sites, interview key informants, focus group discussions, and collect anecdotal evidence. Whenever available the conservation status of the species was registered in the IUCN-categories of Extinct (EX), Critically endangered (CR), Endangered

(EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE), Restricted – range (RR) species.

### 3.1.3 Plants

The Sio Siteko ecosystem is characterized by a continuous wetland habitat, with intertwined areas of open water, permanent swamps and seasonally flooded plains. An overview of plant species in the Sio Siteko is developed through a desk literature review and consultation of researchers, who have worked in the respective wetland areas (Namaganda, 2019).

The Sio Siteko ecosystem has a rich flora of which *Cyperus papyrus*, *C. latifolius* and *Phragmites mauritianum* form the dominant species. In total 208 species were recorded in the Sio – Siteko wetland system out of which are 149 herb species (72%), 36 shrubs (17%) and 23 tree species (11%). A few of the identified species (e.g. *Ageratum conyzoides*, *Digitaria ciliaris*, and *Tagetes minuta*) are not typical wetland plants as they are escapes from the cultivations that extend to the edges of the wetland ecosystem. Others are simply weeds of disturbance from human activities like papyrus harvesting and bush burning. 59 out of 208 species, most of which are herbs (44%) are of use to the communities adjacent to the Sio – Siteko wetland in the form of medicine, firewood, food, construction and other uses. None of the species can be found on the IUCNs red list of endangered species (Namaganda, 2019).

The edge of the wetland is mainly covered by *Mimosa pigra* and *Lantana camara*. These species can reduce the overall species diversity due to their invasive ability (see chapter 3.1.8), although they serve as a source of feed to birds, especially the Nectariniidae family (Nalwanga, 2019).

### 3.1.4 Birds

The wider Sio-Malaba-Malakisi catchment area is an Important Bird Area where over 520 species have been documented, including the endangered Grey Crowned crane, the globally threatened Papyrus Gonolek (*Laniarius mufumbiri*; IUCN Vulnerable), the Papyrus Yellow Warbler (*Chrolopetta gracillostris*) and Pallid Harrier (IUCN Near Threatened). According to the Avian Worlds Database 2018 at least 16 globally threatened species are present in Sio Siteko. Furthermore, four Lake Victoria biome-restricted species (Papyrus Canary, Carruthers's Cisticola, Papyrus Gonolek and Red-Chested Sunbird) and three Papyrus endemic species (Papyrus Gonolek, Carruthers's Cisticola and Papyrus

Canary) were recorded. The most common species including the White-crowned Coucal (*Centropus superciliosus*), Common Bulbul (*Pycnonotus barbatus*), Blue-spotted Wood-Dove (*Turtur afer*), Red-chested Sunbird (*Cinnyris erythrocerca*) and Speckled Mousebird (*Colius striatus*) among others (Nalwanga 2019).

Nalwanga (2019) suggests to protect the Sio Siteko wetland as an important bird area from further environmental deterioration by identifying it as a RAMSAR Site, which would give it international recognition and ensure national commitment for its protection. Furthermore, it is suggested that sensitization programmes regarding the importance of birds are implemented by schools and NGOs among the communities in the area.

### 3.1.5 Mammals

A recent desk study documented the status of mammals in the wetland landscapes (Martin, 2019). The Sio River is listed among proposed Key Biodiversity areas of Uganda (Plumptre et al. 2019) on account of its being an IUCN Freshwater Site and containing a critically endangered species. As a site, it has not received very much scientific survey attention. The only systematic survey report that has been found is of 2008. The mammal species diversity for the Sio Siteko Wetland is therefore not very well documented. The Sio Siteko area has 26 known species of mammals representing 5 orders (Martin 2019).

According to Martin (2019), it is not certain what the current status of the environment is in the Sio Siteko area- it is assumed though that there is still considerable expanse of the natural and/or semi natural wetland environment surviving. For the area therefore, it can be assumed that there could be a far richer mammal diversity than what is presented here. Species of small mammals (bats, rodents and shrews) and small sized carnivores (mustelids and viverrids) can survive quite well even in human modified habitats for which reason the potential list of mammals for this wetland could be richer than what is presented in this report.

A number of sources give some anecdotal information about mammal occurrence in the Sio-River catchment and its associated wetlands. Sources lists some of the mammals that commonly occur in the area to include the Vervet monkey, Otter, Sitatunga, Hippopotamus and water mongoose (presumably Marsh Mongoose). Species of conservation concern are also Bohor Reedbuck, Red river Hog, Leopard, African Spot-necked Otter and the spotted Hyena.

### 3.1.6 Amphibians and reptiles

Some data on distribution of amphibians and reptiles in the Sio Siteko wetland system was recorded from a few available locations in Majanji during Lake Victoria Environmental Management Project in 2000. The two main sites used as reference points were Maddwa Landing Site: 00° 14' 28"N, 33° 59, 36"E and Sio River: 00° 13' 53"N, 34° 00' 30"E. A total of 14 amphibian species belonging to one order anura, seven families and nine genera have been reported for the Sio Siteko transboundary wetland system, with the records documented for Uganda side and some referred to in the Kenyan side.

River Sio habitats had the highest amphibian diversity (13 spp) than locations around Madwa landing (8spp). This was because the micro and macro habitats around the river were lesser disturbed and more diverse than those around the Madwa landing, which were highly disturbed because of increased human activities in form of recreational activities and fishing. Examples of amphibian species reported are: the frogs *Afrivalus quadrivittatus*, *Hyperolius kivuensis* and *Ptychadena nilotica*, the *Common reed frog*, *Lake Victoria clawed frog* and *Lake Victoria toad*.

A total of seven reptile species belonging to three orders (Sauria, Crocodylia and Serpentes), seven families and seven genera are reported in the Sio Siteko transboundary wetland system, with the records documented for Uganda side and some referred to in the Kenyan side. All reptile species in the area are listed as of Least Concern (LC) globally and nationally. Examples of reptiles found in the area are the forest cobra (black cobra), Smooth chameleon, *Varanus niloticus* and the African rock python (Behangana 2019).

### 3.1.7 Fish

The Sio Siteko wetland landscape is also an important habitat for fish, which are found mainly in Lake Victoria, rivers, and ponds. Smaller water bodies such as rivers, ponds, reservoirs and floodplains, in particular, have been singled out as important faunal reservoirs for endangered species in the Lake Victoria catchments (Maithya and Jembe 1998, Katunzi et al. 2010), such as the Sio catchment. These smaller water bodies serve as gene banks and provide microhabitats for feeding and breeding (Katunzi et al 2010).

Before the 1980s, water quality in Lake Victoria was good and the diversity of species was high. Over 500 endemic haplochromine cichlid species and 36 other species, many of which were also endemic, were

present in the lake. Their numbers were dramatically reduced after the introduction of the Nile perch, a predator species, although some species have started to recover.

A total of 37 species representing eleven families (*Cichlidae*, *Mochokidae*, *Schilbeidae*, *Clariidae*, *Protopteridae*, *Cyprinidae*, *Characidae*, *Centropomidae*, *Mormyridae*, *Bagridae*, and *Mastercembalidae*) occur in the wetland system. Generally, tilapia and widely distributed cichlids species are the most common species (Masai et al 2001). *Oreochromis leucostictus*, *Tilapia zilli* Gervais and *Tilapia rendalli*, *Astatotilapia SP Ptychromis sp*, *Paralabidochromis sp* are rare and occur during the rainy season mainly in rivers and ponds. *Synodontis victoriae* Boulenger and *Synodontis afrofisheri* Hilgendorf belonging to the family Mochokidae are also available in this ecosystem, mainly in river mouths. *Schilbe intermedius* (Linnaeus), *Clarias gariepinus* Burchell, *Protopterus aethiopicus* Heckel occur in most of the fish landing station around the Sio Siteko wetland ecosystems while *Bagrus docmac*, and the fresh water eel *Mastercembelus frenatus* are rarely found particularly during dry season (Mwalo 1991). Where river Sio flows into Lake Victoria, Nile Tilapia *Oreochromis niloticus*, Nile Perch *Lates niloticus* and Sardines (*Silver cyprinid*) are dominant. For more information about the abundance and distribution of important fish species in the Sio Siteko region, see [Appendix B2](#).

### 3.1.8 Insects

Insects such as butterflies, dragon flies or dung beetles are very useful indicators for the overall biodiversity of an ecosystem. Advantages of surveying these larger insects as a proxy for biodiversity include ease of sampling and a well-defined taxonomy. Butterflies have widely been used as indicators of sustainable forest management, dragonflies have been used as flagship species in freshwater conservation, and dung beetles have been widely used in studying ecosystem functions such as nutrient recycling and parasite suppression (Akite 2019).

No comprehensive study on dragonflies and butterflies has been done in the Sio Siteko wetland landscape (Akite 2019), only opportunistic records are available with only four species of butterflies and seven species of dragonflies (Kaddu & Busulwa, 2009). Only aquatic micro and macro-invertebrates were sampled in 2009. The majority of the specimens were only identified to order or family level. A few others were identified to genus and species levels (Kaddu & Busulwa, 2009).

### 3.1.9 Vermin and invasive species

#### Vermin

Vermin control services are provided in areas where frequent inter-face between vermin and humans is reported. No common vermin are known in Sio Siteko wetland landscape.

#### Invasive species

The introduction of invasive species in this ecosystem has over time posed a serious threat to both plants and animals existing in these places. These invasive species compete with the native species for food and space, they also introduce disease which has led to the extinction of some species (TEEB study Sio Siteko, 2019b). The edge of the wetland is mainly covered by *Mimosa pigra* and *Lantana camara* flora species. These species can reduce the overall species diversity due to their invasive ability, although they serve as a source of feed to birds, especially the Nectariniidae family (Nalwanga, 2019).

#### Mimosa pudica

Widespread of Touch-me-not plant *Mimosa pudica* (Figure 22) affecting grass is predominant in the Sio Siteko wetland area. This has also continued affect the livestock keepers and crop farmers in the area. *Mimosa pudica* (also called sensitive plant or touch-me-not) is a creeping annual or perennial flowering plant of the pea/legume family Fabaceae and Magnoliopsida taxon. It's mostly known for its curiosity value: the compound leaves fold inward and droop when touched or shaken, defending themselves from harm, and re-open a few minutes later. It is not shade tolerant, and is primarily found on soils with low nutrient concentrations. The species can be a weed for tropical crops, particularly when fields are hand cultivated. Crops it tends to affect are

corn, coconuts, tomatoes, cotton, coffee, bananas, soybeans, papaya, and sugar cane. Dry thickets may become a fire hazard. In addition, *Mimosa pudica* can change the physico-chemical properties of the soil it invades. For example, the total N and K increased in significantly invaded areas.

#### Lantana camara

The edge of the wetland is mainly covered by the plant species *Lantana camara*, which is considered to be a weed with invasive behaviour. In agricultural areas or secondary forests it can become the dominant understorey shrub, crowding out other native species and reducing biodiversity. *Lantana camara* reduces the productivity in pasture through the formation of dense thickets, which reduce growth of crops as well as make harvesting more difficult. There are also secondary impacts, as mosquitos which transmit malaria and tsetse flies shelter within the bushes of *L. camara*. *Lantana camara* is known to be toxic to livestock such as cattle, sheep, and goats. The active substances causing toxicity in grazing animals are pentacyclic triterpenoids, which result in liver damage and photosensitivity.

#### Nile perch

The introduction of Nile perch in Lake Victoria has led to a strong reduction in native fish species that used to be common in and around the River Sio river mouth (anecdotal evidence). Nile perch were introduced to Lake Victoria in the 1950s to boost the fishing industry. The decline of the native fish species in Lake Victoria has been attributed to predation by the introduced Nile perch, together with use of wrong and destructive fishing gears especially around the river mouths and to some extent destruction of spawning and nursery grounds through human encroachment.



FIGURE 22: INVASIVE SPECIES - MIMOSA PUDICA SHOWING FLOWER HEAD AND LEAVES (PHOTO LEFT) AND WATER HYACINTH ON LAKE VICTORIA (PHOTO RIGHT), AN INDICATOR OF EUTROPHICATION.

The introduction of this species to Lake Victoria is one of the most cited examples of the negative effects alien species can have on ecosystems. Its introduction was ecologically disruptive and is attributed with causing the extinction or near-extinction of several hundred native species, with some populations fluctuating with commercial fishing and the actual Nile perch stocks. The Nile perch initially fed on native cichlids, but with decreasing availability of this prey, it now consumes mainly small shrimp and minnows. The introduction of Nile perch has also had additional ecological effects on shore. Native cichlids were traditionally sun-dried, but because Nile perch have a high fat content (higher than cichlids), they need to be smoked to avoid spoiling. This has led to an increased demand for firewood in a region already hard-hit by deforestation, soil erosion, and desertification.

### Water hyacinth

The common water hyacinth (*Pontederia crassipes*) has become an invasive plant species on Lake Victoria in Africa after it was introduced into the area in the 1980s. Water hyacinth was observed as mobile mats near the River Sio river mouth during the April 2019 field mission (Figure 22). When not controlled, water hyacinth clog waterways and can cover lakes and ponds entirely; this dramatically affects water flow

and blocks sunlight from reaching native aquatic plants which often die. The decay processes depletes dissolved oxygen in the water, often killing fish. The plants also create a prime habitat for mosquitos, the classic vectors of diseases such as malaria, and a species of snail known to host a parasitic flatworm which causes schistosomiasis (snail fever). Excessive nutrients from overfeeding and waste cause eutrophication and enhances growth of algae and water hyacinth.

### 3.2 ECOSYSTEM SERVICES

A wetland is any land area that has the ability to hold surface water and support aquatic flora and fauna. Wetlands in general are not only hotspots of biodiversity, they provide an array of ecosystem services (Figure 23). Ecosystem services provided by wetlands can be divided into provisioning functions (e.g. food, water and raw materials), regulating and supporting services (e.g. regulating climate through carbon capture and storage in wetland sediment and groundwater), habitat services (e.g. supporting aquatic flora and fauna, providing breeding grounds for birds and sustaining ecosystem health by maintenance of genetic diversity) and cultural and amenity services (e.g. green spaces for recreation and outdoor activities).

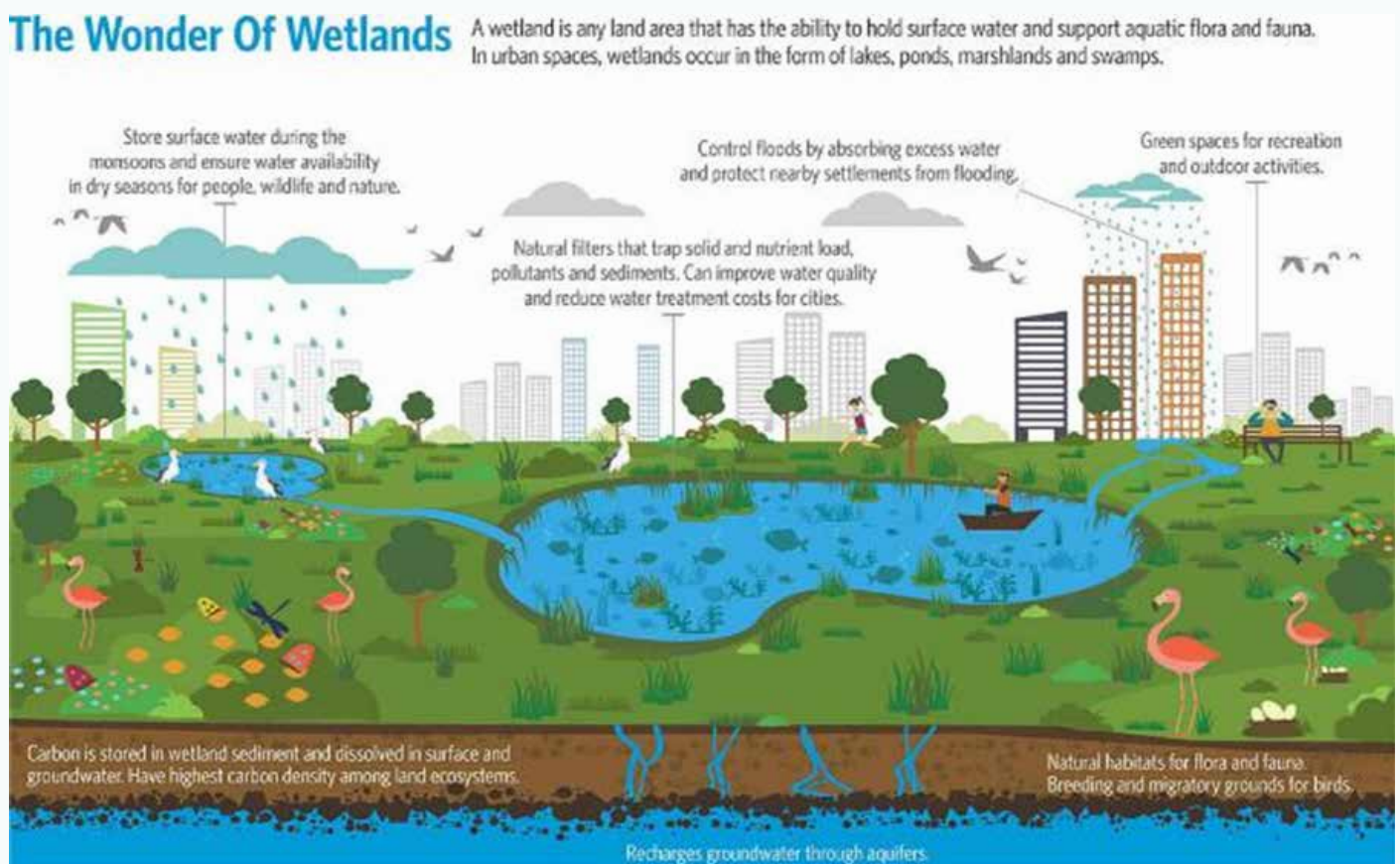


FIGURE 23. OVERVIEW OF WETLAND ECOSYSTEM SERVICES (SOURCE: THE NATURE CONSERVANCY INDIA).

The benefits to humankind that can be delivered by natural systems are known broadly as ecosystem services. The concept has developed over many years: through the Millennium Ecosystem Assessment (MEA, 2005) and now with a Common International Classification of Ecosystem Services (CICES). A useful analysis of ecosystem services and their value can be found in 'The Economics of Ecosystems and Biodiversity (TEEB)' project, which uses the categories as can be seen in Table 4. Ecosystem services include 'provisioning' services such as food, fibre, genetic materials, etc., which are obtained directly. Arguably, provisioning services can be

subdivided in carrier functions (use of wetland space for agriculture, livestock grazing etc.) and production functions (harvesting of natural resources). Then there are 'regulating' services, which are derived from ecosystem processes (nutrient supply/cycling, pollination, natural pest control, etc.) or which regulate essential parts of the ecosystem (temperature and humidity regulation, air or water quality, etc.). The concept of ecosystem services also recognises that there are other values that cannot be expressed in such mechanistic or utilitarian terms yet may be very important for cultural reasons, for amenity or habitat maintenance.

TABLE 4: CLASSIFICATION OF ECOSYSTEM SERVICES (ADAPTED FROM TEEB, 2010), AND SPECIFIC EXAMPLES OF THESE SERVICES IN SIO SITEKO STUDY AREA

Type of service	Ecosystem service	Examples in Sio Siteko
<b>Provisioning services</b>	1. Food	Fish, traditional salt, game meat, mushrooms, herbs, fruits, insects, crop farming, pasture for livestock
	2. Water	Drinking water (domestic and livestock), cooking, bathing, irrigation
	3. Raw materials	Grass (roofing, mulching, fodder, crafts), papyrus (mat making), sedge (construction, crafts), clay (pottery, brick making), wood (fuel, construction), sand (construction)
	4. Genetic resources	Gene banks for sustainable food and agricultural products
	5. Medicinal resources	Herbal medicine
	6. Ornamental resources	Decorations, materials for crafts including mats and furniture
<b>Regulating (and supporting) services</b>	7. Air quality regulation	Filtering of particles and chemicals
	8. Climate regulation	Wind breaks, rain formation, carbon sequestration (peatlands), weather regulation
	9. Moderation of extreme events	Water storage against flooding and drought
	10. Regulation of water flows	Natural drainage, buffering, water storage, irrigation, drought prevention
	11. Waste treatment	Water purification, nutrient retention
	12. Erosion prevention	Vegetated buffer strips, soil loss avoidance
	13. Maintenance of soil fertility	Soil formation, nutrient enrichment
	14. Pollination	Providing habitat to pollinators such as bees, birds, bats and butterflies, which are important for fertilization of crops
<b>Habitat services</b>	15. Natural regulation of pests, weeds and diseases	Natural pest control to better protect livestock and crops
	16. Maintenance of life cycles of migratory species	Bio-corridors and stepping stones
<b>Cultural and amenity services</b>	17. Maintenance of genetic diversity	Diverse habitat supporting many species (like fish nurseries, insects, micro-organisms)
	18. Aesthetic information	Sense of place
	19. Opportunities for recreation and tourism	Eco-tourism potential (important bird area), recreation
	20. Inspiration for culture, art and design	Animals with cultural significance
	21. Spiritual experience	Baptisms, religious celebrations, cultural heritage
	22. Information for cognitive development	Research (f.e. on insects, birds, weather)

The majority of the around 273,000 people living in the transboundary ecosystem (see chapter 6.1) depend heavily on the ecosystem services provided by the wetland to support their economic well-being and survival. Specific examples of ecosystem services falling under each of the four main types of services described above are shown in Table 4. These examples are based on field surveys undertaken by the project team in April 2019 as well as on expert judgement. The assessment involved participatory discussions by wetland stakeholders including government agencies, NGOs and community-based groups, whose perceptions and interests were collected.

Many of the resources in the wetland are related to multiple uses, and there are many interlinkages between the different types of services. For example, grass is used for livestock grazing (fodder), but also as a material for roofing and crafts, and is also serves as mulch for agriculture. Reeds are used for crafts, mat making but also for abstraction of traditional salts (see [Explainer 2](#)). Fish are used for food, but also for medicine and leather tanning. Regulating and supporting services are less tangible, but this does not mean they are less important. Specific examples include water storage in the wetland during times of high rainfall, which has the double benefit of reducing flood risk but also providing a water store that can be used in the dry season.

Trees, in particular, cover a wide range of eco-system services as they can be harvested, but also filter the air, serve as wind breaks and contribute to erosion control. Providing habitat to a wide range of species, including animals, birds, insects, microorganisms, and plants is an eco-system service in and of itself, especially regarding rare species such as the Grey crowned crane (*Balearica regulorum*), Papyrus Gonolek (*Laniarius mufumbiri*) and Speke's Sitatunga. However, this service is also crucial to support many other types of ecosystem services. Some species are harvested, others have other indirect use such as providing a basis for eco-tourism, while other species have no direct use for the local population yet are still crucial to ensure a strong ecosystem. These examples show how each eco-system service cannot be evaluated individually, but that each is part of a complex web that must be used sustainably to ensure its conservation for future generations.

### **Sand harvesting**

While sand harvesting is one of the major economic benefits that the local population derives from the wetland, it is one of the wetland utilization that is hardly sustainable since the rate of harvesting

rarely corresponds to the rate of sand disposition. Furthermore, the sites in which some harvests take place or the method of harvesting often lead to degradation of wetlands including destruction of fish breeding sites (TEEB study Sio Siteko, NBI 2019b). Sand mining is done both in-stream of River Sio, which involves the extraction of coarse sand suitable for concrete slabs, and mining at the Sio river mouth, where fine sands suitable for brick laying and plastering are mined. The need for infrastructural development creates an increased market for sand which escalates the mining activities Sio Siteko wetlands.

This has contributed to indiscriminate sand mining and severe environmental impacts such as habitat destruction, degradation of the aesthetic beauty of the surroundings, river bank erosion and modified stream structure and functionality.

### **Main ecosystem services Sio Siteko**

The Sio Siteko wetland landscape is under consideration for listing as a wetland of 'international importance' under the Ramsar Convention of Wetlands. This is because of its ecological value, which include providing essential habitat for rare and endemic species. It is also extremely productive, supporting many plants and animals during the seasonal climate and flooding/drying regime. The connection between human well-being and wetland ecosystems are connected through both material (anthropocentric) and non-material values. In this wetland landscape, there is socio-cultural importance attached to the wetland. This includes cultural heritage, spiritual values (e.g. during baptisms), sense of place, quality and recreation (potential for tourism development is acknowledged by stakeholders in both Kenya and Uganda).

Sio Siteko wetland offers a number of ecological, economic and socio-cultural services. These include: source of food, construction materials such as sand, clay and poles, filters and purifies polluted water from urban areas stores and supplies water for domestic and livestock use, supports agricultural crops such as arrowroot, sugar cane, potato, maize and millet, stores and purifies water that flows into Lake Victoria, has ecotourism potential, improves local community livelihoods which are currently primarily based on fishing and horticulture and the wetland is also an Important Bird Area (IBA). Birds themselves are of great economic importance as pollinators of crops. Some species are medicinal and act as a source of animal protein.

## Explainer 2 – Traditional salt made from reed

Several communities around River Sio in Busia district, Kenya, produce salt from reed using a traditional method. A village (Lat: 0,35885 / Lon: 34,13755 / 1169) known for its traditional salt making was visited on April 12<sup>th</sup> 2019. The idea of making salt from reeds might not be new but it is rare and unique in equal measure. *Munyu* is the name of the salt as it is known in this region but what is more intriguing about it is the way it is prepared. The *Muchua* plant, a type of thin reed (see image below), grows in the wetlands of the River Sio. Reaching a height of about two meters, it is ready for harvesting when the flowers wilt and the highest leaves are almost dried out; before this the salt concentration is too low. Bunches of reeds are arranged on stones by the river, cut into smaller pieces and allowed to dry in the sun (up to 2 days with warm sunny weather). They are then heated on a slow fire for up to 3 days. The residual ash is mixed with hot water (making the salts dissolve and the ashes float) and filtered. Water is extracted from the bottom, and then boiled in a large pan on a fire to extract the salts. When the liquid has completely evaporated, a pure salty mixture is left on the bottom. It is collected, packed into banana leaves (see image below) and dried under hot ashes overnight. Pepper is sometimes added, giving the salt a spicy flavor. The traditional salt is known to be healthy and better for people with bone diseases/issues than 'normal' salt. The salt is only produced on a small scale for local consumption. They try to sell it (a bag of salt costs 20 Kenyan shillings) but they lack a good market to sell the salt. It is not an easy task to carry out but it is worth it because it is part of the local culture.



In the areas of western Kenya historically cut off from the main salt routes, local communities have developed a distinctive method for extracting salt from an aquatic plant. It is thought that the origins of this practice date back to the 17<sup>th</sup> century when the Bukusu community migrated from the Congo to the east coast. Since then, the practice has been handed down over generations. Nowadays the production of reed salt is very limited: as it requires a demanding and time-consuming process, an imported marine salt first brought with British colonization has rapidly replaced it. Large-scale deforestation has also caused river levels to drop, with a consequent reduction in the marshy areas, where the reeds used to produce the salt grow.

<https://www.fondazioneSlowFood.com/en/slow-food-presidia/nzoia-river-reed-salt/>

Peter Wasike, an advocate of organic foods and farming in Western Kenya, says this salt cannot be compared to commercial salt due to its flavour. "Even the quantity used to season food is not as much as commercial salt. It also lacks sodium," says Mr Wasike. The salt, according to Wasike, is good for people who suffer from hypertension due to lack of sodium. The locals also use it to disinfect wounds. The salt is said to build marrow and help in strengthening bones.

<https://www.standardmedia.co.ke/article/2000106318/brothers-make-salt-with-more-flavour-from-reed>



## TEEB study for Sio Siteko

Currently, The Economics of Ecosystems and Biodiversity (TEEB) study is being undertaken for Sio Siteko (NBI 2019b). This TEEB study will help in supporting basin planning and investment agenda into the conservation and sustainable use of the wetland for sustainable provision of the ecosystem services for the local economies of Busia County in Kenya and Busia district in Uganda, and reduction in biodiversity loss. The study aims at generating

information on economic value of the wetland ecosystem services to inform the development of conservation investment plans and hence make a case for public and private investment for improved management of the wetland and trade-offs between different development trajectories. The objectives of the study include:

- 1) Identification of Sio Siteko wetland ecosystem services and their beneficiaries

- 2) Estimation of the current economic value of the Sio Siteko wetland biodiversity and ecosystem services
- 3) Identification of and economic assessment of the costs and benefits of potential management options for the Sio Siteko wetland
- 4) Comparison of the costs and benefits of the potential wetland management options

Data collection was conducted through household survey and key informant interviews and in some cases focus group discussions. The target populations were the local community who reside in the sub locations (Kenya) and parishes (Uganda) bordering the Sio Siteko wetland landscape, with a total sample size (household heads or their spouses) of 419. The Market Price Method (market prices of products that are traded in the market are used to estimate the total value of production) was used for valuation of ecosystem services. Table 5 shows the valuation of fourteen ecosystem services, according to the draft results of the TEEB study (NBI 2019b). The economic valuation of the Sio Siteko wetland landscape shows that it provide ecosystem services to more than 31,680 households across the border of Kenya and Uganda to an estimated value of USD 47 million.

TABLE 5: BASELINE ECONOMIC VALUE OF SIO SITEKO WETLAND LANDSCAPE ECOSYSTEM SERVICES (TEEB STUDY SIO SITEKO, NBI 2019B)

Ecosystem service	Gross aggregate value (in USD)
Capture Fisheries	24,945,744
Livestock Grazing	6,530,093
Sand Harvesting	3,691,353
Water Supply	3,374,640
Grass Harvesting	2,688,109
Crop Farming	2,302,360
Brick Making	1,254,485
Biodiversity Maintenance	965,877
Mat Making	459,103
Aquaculture	370,576
Herbal Medicine	326,340
Wood Energy	221,426
Flood Attenuation	36,787
Water Purification	Not yet determined
<b>TOTAL</b>	<b>47,166,893</b>

### 4.1 MAIN ACTORS AND INTERACTIONS IN THE WETLAND LANDSCAPE

Due to the transboundary nature of the Sio Siteko wetland landscape, actors at several different institutional levels influence the management of the landscape. The actors range from global and regional organizations, that are by definition transboundary in nature, to institutions at national level and local

institutions (Figure 24). Each actor has a different level of interest in the wetland landscape and a different level of influence to facilitate or impede changes to the wetland landscape. Proper identification of stakeholders and their motivations and interactions is a crucial step in recognizing the avenues of change within a landscape. A brief overview of the different levels and general delineation of the actors involved at each level is provided in this subchapter.

FIGURE 24: SCHEMATIZATION OF A SELECTION OF RELEVANT ACTORS AT DIFFERENT LEVELS.

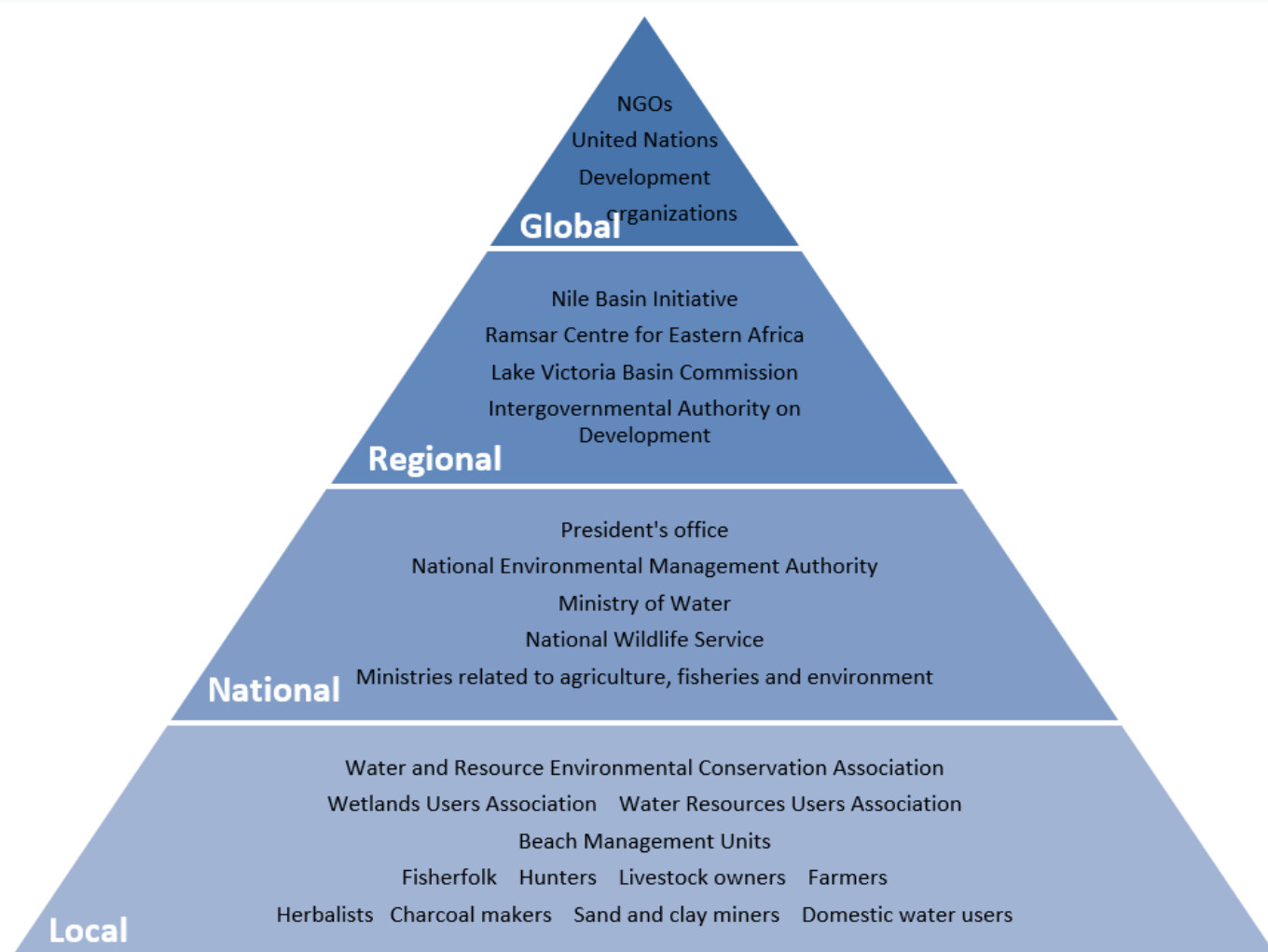


Figure 24: Schematization of a selection of relevant actors at different levels.

#### 4.1.1 Global level

At global level, there are several organizations that can influence the Sio Siteko wetland area, either directly or indirectly. Institutions linked to the United Nations, in particular, such as the FAO, are important global-scale actors. International NGO's, for example the World Wide Fund for Nature (WWF), are important funding sources for conservation projects around the world and at different scales. In the same way, development organizations and global financial institutions such as the World Bank have

great potential to influence wetland conservation and management through investments and projects.

#### 4.1.2 Regional level

Here, we define the regional scale as larger than national, but smaller than global scale. In this way, the regional scale may be defined by a set of neighbouring countries or may be defined by physical boundaries defining a water basin that lies within more than one country. One actor that is directly related to wetland conservation and promoting wise use of wetland

resources is the Ramsar Centre for Eastern Africa (RAMCEA), which supports East African Community countries. Both Kenya and Uganda have ratified the Ramsar convention. The Intergovernmental Authority on Development (IGAD) has developed regional policy and regulatory frameworks for water resources management to address transboundary water challenges, with eight participating countries in East Africa.

Other regional actors are those related to the sustainable development and/or management of basins. The Sio Siteko wetland drains into Lake Victoria. Several actors are involved in the management of the basin of the lake with varying scopes, including the Lake Victoria Basin Commission (LVBC) and the Lake Victoria Fisheries Organization (LVFO). The Lake Victoria Basin in turn falls within the Nile Basin. The Nile Basin Initiative (NBI), and the related Nile Basin Secretariat and Nile Council of Ministers, are important players at this level as they formulate and implement a wide range of activities aimed at cooperatively developing the river basin.

#### 4.1.3 National level

The national level is the first level that does not naturally adopt a transboundary approach, though many nations participate in transboundary efforts, whether formalized or informal. The national government, including the president's office and various ministries are important actors at this level. Actors directly involved with the conservation and management of the environment and water resources, including the National Environment Management Authority and Wildlife Services or, in the case of Uganda, the Wetlands Management Department, clearly have an interest in and impact on the management of the Sio Siteko wetland area. For example in Uganda, the Ministry of Water and Environment (MWE) is the lead agency for implementation of Catchment based Water Resources Management (CbWRM) through the Directorate of Water Resources Management (DWRM), who is operationalizing the CbWRM framework through the Victoria Water Management Zone (VWMZ).

In Kenya the Water Resource Authority implements guidelines on water source protection. However, decisions made by governmental bodies related to finance or livelihoods such as fishing and agriculture may also impact the wetlands. This influence can be direct, for example by determining which fishing methods are legal, or indirect by designing or affecting budgets. The national enforcement and judiciary branch are important, as the regulation

and enforcement of laws and policies depends on these actors. Aside from the governmental agencies, there are NGO's that operate within a country in particular and are involved with the environment and/or livelihoods. In Uganda, an example of such an NGO is the Uganda Environmental Education Foundation, which provides training and education services about agroforestry, water and sanitation and environmental rights.

#### 4.1.4 Local level

The local level is unique in that it may include organizations as well as collections of individuals. Local institutions include not only the local government, but also Wetland User Associations and Water Resource Users Associations, which aim to sustainably and cooperatively manage water resources, or wetland resources in particular. These may consist of volunteers who live or are otherwise bound to the area falling within the mandate of the organization. Institutions representing livelihoods are also important actors at this level, including for example Beach Management Units, which are involved in management of fisheries resources.

Finally, there are individuals that have an interest and/or influence on the Sio Siteko wetland area. Though some of these groups are represented by user associations and other local institutions, the interests of the institutions may not reflect the interests of all individual users. People who harvest resources from the wetland, including clay and sand miners, reed harvesters, herbalists and firewood collectors. Other actors make use of the supporting eco-system services, such as farmers and livestock keepers. In addition, local religious or cultural leaders may have a large influence at this level. In many cases, the local population does not fall into distinct groups, but have an interest in or impact on the wetlands through several channels. For example, one person may use water for domestic use, but also grow subsistence crops and harvest resources from the wetland.

## 4.2 POLICIES AND LEGISLATIONS

The sustainability of agriculture, livestock production, fisheries and aquaculture is of a global concern. There are international and regional policies, legal instruments and institutions to support f.e. fisheries development, establishments and practices in East Africa. These can influence the management of wetland landscapes directly or indirectly. These policies, if ratified by all countries containing the transboundary wetland, have the advantage that the objectives are aligned for the

entire wetland area. Other policies and institutions are active at national or sub-national levels. While these may be more specifically tailored to local conditions, it is also possible that differing policies between neighbouring countries can complicate the management of transboundary wetlands. This subchapter gives an overview of the most relevant policies and legislation at different levels for the Sio Siteko wetland landscape. An extensive list of all policies and legislations relevant for Sio Siteko can be found in the Wetland Management Plan.

#### 4.2.1 Global

Policies developed by international organizations at the global level can be adopted by national governments to support a range of sectors from agriculture and livestock production to the environment to governance issues and development. One example of an international treaty is the Ramsar convention, which has been ratified by both Kenya and Uganda. The contracting parties commit to cooperate in the management of transboundary wetlands. The convention also stipulates the need to include wetland management in river basin planning. In addition to the Ramsar convention, wetlands may be recognized and protected by being UNESCO biosphere reserves or parks. Another environmental global treaty that have been ratified by both Kenya and Uganda is the Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn convention). This convention not only aims to protect the migratory species, but also aims to conserve and restore their habitats and remove obstacles to their respective migrations.

Other global-scale policies may be more indirectly linked to wetland areas, such as policies set out by the Food and Agricultural Organization of the United Nations (FAO). These treaties are related to the regulation of fisheries, livestock production and agriculture.

#### 4.2.2 Regional

Regional policies and legislation are often developed at the level of the African Union, East African Community (EAC) or the Nile Basin Initiative (NBI). For example, the members of the EAC ratified a treaty in 1999 which aimed to promote the sustainable utilization of natural resources in the partner states. Specific articles cover the management of the environment and natural resources, which includes wetland areas like the Sio Siteko wetland. NBI has developed several policies and frameworks for the Nile riparian countries,

with the overall aim to promote joint development, protection and management of common Nile River Basin water resources. For example, the Nile Basin Sustainability Framework adopted in 2011 describes the priority thematic fields of activity for sustainable transboundary management. In addition, NBI has developed several strategies, including the wetland management strategy, a climate change strategy and an environmental flow strategy, which are all relevant for wetland management. Smaller scale transboundary policy, legal and institutional frameworks have been proposed by the Sio Malaba Malakisi River Basin management project, falling under the NBI's Sio Malaba Malakisi investment strategy. One of the main objectives of the overlying strategy is to reverse the ongoing environmental degradation and restore the ecological integrity of the basin (WREM 2008), including the sustainable management and conservation of wetlands.

#### 4.2.3 National

At national level, policies and legislation focusing on a large variety of sectors can directly or indirectly influence how wetlands are used and managed. The national government is an important initiator of policies at this level, though other national institutions may also be relevant. The most obvious examples of relevant policies, legislation and regulation are those related to wetland management specifically. For example, the Kenyan National Wetlands Conservation and Management Policy of 2015 aims to ensure wise use and sustainable management of wetlands to ensure their ecological and socio-economic functions for present and future generations.

In Uganda, the National Wetlands Policy of 1995 has the same objective and the Wetlands Sector Strategic Plan 2011 – 2020 aims to enhance the knowledge base and improve the institutional and technical capacities to ultimately improve wetland management. Recently Uganda published the first edition of the Communication Education Participation and Awareness (CEPA) Strategy for the Ministry of Water and Environment (MWE) for the period 2019 – 2024. Currently, the Environmental and Social issues are being addressed basing on the National Environment Management Policy and other guiding documents including the Environment Impact Assessment (EIA) guidelines and other Tools developed by National Environment Management Authority (NEMA) while some projects have been using the World Bank Environment and Social Safeguards Policies and other donor -specific ES policies. Other policies that more directly affect wetlands are environmental policies and those related to water resources. Both countries

have acts related the environment or environmental management and concerning wildlife. The policies related to wetland and environmental conservation may or may not be formalized into law, and should be translated into practical management to be effective. Other policies not directly linked to the environment and wetlands are equally important. For example, policies related to water and sanitation services may result in higher water extraction rates from wetland areas, potentially decreasing water availability. At the same time, improved sanitation has the potential to reduce contamination of water resources. Similarly, regulations related to water abstraction and wastewater affect water availability and water quality. In addition, policies and legislation related to agriculture, livestock production and fisheries, the most important livelihood activities that are likely to conflict with wetland conservation and restoration, are important to take into account.

Legislation related to the administration and stewardship of land and wetlands is particularly relevant in the development of a successful wetland management plan. In Kenya, the National Lands Commission Act of 2012 states that wetlands are public land that should be administered on behalf of communities therein by the National Lands Commission. In Uganda, the Land Act of 1988 states that the government or local government holds land in trust for the people and protects environmentally sensitive areas such as natural lakes, rivers, and wetlands.

#### 4.2.4 Local

The local government, but also Water User Associations, Beach Management Units and other local institutions, are responsible for the final level of

policies, legislation and regulation. Each institution has developed policies pertaining to their specific mandate. For the local government, this may span several sectors. For other institutions such as the BMUs these may be focused on a particular sector, such as fisheries.

### 4.3 PROTECTED AREAS

Sio Siteko wetland landscape is especially important as a source of livelihood for the surrounding communities and for biodiversity. It has been designated as an Important Bird Area (IBA) by Birdlife International, since the landscape is an important breeding and feeding site for thousands of birds. More than 300 bird species, including the globally threatened Papyrus Gonolek (*Laniarius Mufumbiri*) (Figure 25) and Pallid Harrier (*Circus macrourus*), have been recorded in this IBA (Birdlife International, 2018).

Despite the importance of the landscape for birds, Sio Siteko lacks formal protection that allows for coherent conservation action and management. It is threatened by intensive human activities such as papyrus cutting, burning, sand harvesting, siltation and cultivation on swamp edges which result into habitat disturbance. However, there have been attempts for formalisation. For example, in 2015, at Ramsar's 12<sup>th</sup> meeting of the Conference of the Contracting Parties held in Uruguay, the Government of Kenya, submitted Sio Siteko as one of four wetlands to be considered for designation as a Ramsar Site in the 2015-2018 triennium. The Kenya Wildlife Service (KWS) identified inadequate resources to finalise the information sheets and consultations with key stakeholders as two of the major challenges.



FIGURE 25: ADULT PAPYRUS GONOLEK (LEFT) AND A NORTHERN BROWN THROATED WEAVER (RIGHT) FOUND WITHIN THE WETLAND.

#### 4.4 NATURAL RESOURCES MANAGEMENT

Natural resource management refers to the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations. Natural resource management deals with managing the way in which people and natural landscapes interact. It brings together land use planning, water management, biodiversity conservation, and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry. It recognises that people and their livelihoods rely on the health and productivity of our landscapes, and that their actions as stewards of the land play a critical role in maintaining this health and productivity.

##### 4.4.1 Land tenure

The laws that govern ownership, control and use of land have relevance for the management of wetlands in both Kenya and Uganda, largely because tenurial arrangements impact on the conservation and wise use of wetlands. The national land policies in Kenya and Uganda designate that all land is either public, private or communally owned, albeit (in Kenya) systems may overlap where the tenure reform process has not yet been completed. In Sio Siteko most land is communally owned except in Busia town where individuals possess title deeds. Where the land is owned by the community, its use is traditionally controlled by a hierarchy of clan elders. Custom restricts access by women to these lands for usufructuary rights only (Cross 2002). Communal land is collectively managed by the clan and is characterised by a common pool of resources such as grazing fields and water sources. Land use is practiced under a dual system of both customary law and statutory legal systems. The communal land tenure system is, however, susceptible to the “tragedy of the commons”. Increased human pressure on the landscape level (partially resulting from high population growth rate), high levels of multidimensional poverty, weak enforcement of laws, low level of awareness on environmental degradation and inadequate capacities and resources for monitoring and community-based natural resources management have resulted in the overexploitation of natural resources at various locations.

Where land is under private tenure it can either be customary, freehold, leasehold or (in Uganda) Mailo. Under customary tenure land is owned in perpetuity; customary occupants are occupants of former public land and occupy land by virtue of their customary

rights. Freehold tenure derives its legality from the Constitution and its incidents from the written law. Under leasehold tenure is a system created either by contract or by operation of the law where the tenant has security of tenure and a proprietary interest in the land. It is a form under which the landlord of lesser grants the tenant or lessee exclusive possession of the land, usually for a period defined and in return for a rent. Mailo is a feudal ownership system introduced by the British in 1900 that is still a in the current Uganda Land Act. Where private title deeds are held by owners in the rural area, leasing to neighbours and incoming investors is common.

The available agricultural land per person has diminished considerably. This trend continuously exerts pressure on already exhausted soils, while increased population pressure remains a significant characteristic. The absolute number of households below the poverty line are increasing; therefore, exhaustion of land as well as its fragmentation will continue being common and as such leading to more severe multidimensional poverty.

Besides the Tragedy-of-the-commons there are other major challenges regarding land tenure in Sio Siteko. A plethora of statutes exists applying to land in both sides of the wetland landscape. This has an impact on land uses hindering effective protection of wetlands and riparian land. Article 62 (1) of the Constitution of Kenya, for example, defines Public land to include all rivers, lakes and other water bodies as defined by an Act of Parliament. Although these lands are public, they may border private land, prompting regulation of the use of land abutting the water body.

During field consultations, it was evident that the inconsistencies in understanding of the definition of riparian land directly impact land uses and hinder compliance and proper enforcement. For example, the Kenyan Water Act (2016) defines ‘riparian habitat’ as the dynamic complex of plant, animal and micro-organism communities and their non-living environment adjacent to and associated with a watercourse. On the other hand, the Environmental Management and Coordination (Wetlands, River Banks, Lake Shores and Sea Shore Management) Regulations, 2009 include riparian zones in the definition of wetlands, which are characterised according to the frequency of flooding (permanent or seasonal). This attachment of the element of flooding to riparian zones leads to misunderstanding and incorrect interpretation of riparian land, where users and regulators may incorrectly consider riparian land only on the basis of the frequency of flooding, leading to encroachment into the wetland during the dry season.

In addition to the above, there is conflicting institutional mandates over management of riparian on both sides of the border. In Kenya, NEMA and WRA, for example, are tasked with protecting the environment and regulating the management and use of water resources respectively. There is still lack of clarity on in determining the institution that will enhance protection of wetlands and riparian zones. There is also an urgent need to harmonise laws across the border. During consultations, for example, in Mundika Area one farmer mentioned different penalties and levels of enforcement for encroachment into the wetland area in Kenya and Uganda. With Uganda's being stricter residents are prompted to move into and encroach into the Kenyan side of the wetland, where there is laxity in enforcement.

#### 4.4.2 Roles and responsibilities

The county (Kenya) and district (Uganda) governments are obligated to implement specific national government policies on natural resources and environmental conservation including, soil and water conservation and forestry. These authorities are also supposed to ensure and coordinate the participation of communities and locations in governance at the local level and assist communities and locations to develop the administrative capacity for the effective exercise of the functions and powers and participation in governance at the local level. This includes groups such as Water Resource Users Associations (WRUAs), Micro-catchment Management Organizations (MCMOs), Community Forest Associations (CFAs) and Beach Management Units (BMUs) which are present in the wetland landscape.

The constitutional division notwithstanding, it is the responsibility of both the national and county governments to ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources.

#### 4.4.3 Community-based natural resources management

Community Based Natural Resource Management (CBNRM) is based on the premise that communities have a more intimate knowledge of their localities and have a greater stake in managing resources sustainably since their livelihoods depend on it (Malo et al., 2008).

CBNRM is an important approach to deliver public participation in natural resource governance and management. In Kenya, this is being done through

community-based institutions such as WRUAs (water and wetlands, riparian land and catchment areas), CFAs (forests, water towers and catchment areas) and BMUs (fisheries and fish landing sites). However, these community institutions are largely voluntary and carry an undue burden to facilitate co-management of the resources with governments. In some cases, this has resulted in conflict or mandate overlap between government institutions. Natural resources occur in ecosystems. For example, the Sio Siteko wetland landscape includes wildlife, flora, water, and other resources as interdependent units. This would, ideally, call for an integrated approach rather than a sectoral approach to governance and management of natural resources as is currently in place. A coordinated approach to public participation and an ecosystem approach to natural resource governance are key to achieving sustainability.

#### 4.4.4 Multilateral agreements and relevant transboundary institutional arrangements

Several relevant multilateral agreements exists that are applicable and should form a starting point for natural resources management in Sio Siteko wetland. These include:

- Convention on Biological Diversity (CBD), 1992
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), 1979
- Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), 1973
- Agreement on the Nile River Basin Cooperative Framework, 2010, and
- The East African Community Treaty, 2000

Besides, the expired Sio Siteko Wetland Management Plan (2009 – 2019) as part of its management instruments formed transboundary wetland management committees. These committees were largely ineffective due to limited funding to support adequate participation. Moreover, from consultations, it appears that participants in existing regional platforms are usually composed of elites, who are far removed from grassroots issues, interests and priorities.

#### Enforcement and monitoring

There exists both traditional/local and modern/

statutory institutions to monitor and enforce rules and regulations related to the wetland landscape. For example, council of elders who enforce by-laws; WRUAs who have a much broader mandate including water resources management at a sub-catchment level; Water Users Associations (WUAs) who have a limited mandate to the management of a water scheme such as borehole, shallow wells and

CFAs whose mandate includes sustainable forest conservation and management and BMUs who strengthen the management of fish-landing stations, fishery resources and the aquatic environment. These community groups have inadequate financial and technical capacity to monitor natural resource use and require assistance from the 'parent' institutions whose key mandate they support.

### 5.1 LIVELIHOOD AND ECONOMIC SYSTEM

The towns of Busia, Kenya and Busia, Uganda are very busy border towns that account for the bulk of trade and human traffic between the two East African Community countries. The one-stop-border-post (OSBP) at Busia, is the busiest in the East African Community, with Uganda's exports through the post being valued at US\$798 billion (approximately US\$220 million) in the 2016/2017 financial year, according to a high-ranking official of the Uganda Revenue Authority (Daily Monitor 2018). Outside the border town of Busia, in the rural part of the district (comprising the project area fully), 82% of the people are dependent for their livelihoods on subsistence farming. 6% make their living through employment, another 6% depend on family support, and 4% live on business enterprises (UBS 2014).

Healthy landscapes not only exhibit healthy ecosystems, but also sustain productive agriculture and communities. Within the Sio Siteko wetland landscape, people's livelihoods comprise a wide spectrum of activities, including agricultural production, livestock production and fishing, as well as trade. In order to develop wetland management and conservation investment plans that strike an appropriate balance between social, environmental and economic concerns, it is necessary to identify and optimise trade-offs that can best be achieved by considering the wetland landscape in an integrated manner. The key socio-economic and livelihood practices in and around Sio Siteko for consideration in this integration are described in the sub-sections to follow.

#### LIVESTOCK PRODUCTION AND AGRO-PASTORAL SYSTEM

In the Sio Siteko wetland landscape, livestock farming is a major activity. In fact, according to the Kenya National Bureau of Statistics (KNBS, 2017) livestock production as a whole contributes about 13.4 percent (USD 3.1 billion) to agricultural value added. The main animals reared are indigenous breeds (Zebu) and exotic species of cattle, goats, sheep, pigs, rabbits and poultry. However, dairy farming is the dominant enterprise in the livestock subsector. According to the TEEB study of Sio Siteko, the proportion of the sampled population who reported to graze their cattle in the wetland was 57%. The average number of cattle grazed by a household was seven and the reported frequency of grazing during the dry months (December to November) was six times in a week and twice a week during wet months, a period in which

over forty percent (47%) of the households typically graze in the wetland never take their cattle for grazing in the wetland (NBI 2019b).

Several farmers in the region are also practicing bee keeping. In rural households, cattle offer more than income and nutrition. The manure is often used to fertilise cropland that would otherwise require external inorganic fertilizers, thus offer efficiency in nutrient cycling. The Sio Siteko wetlands provide water for livestock use. In addition to this they are also sources of fodder to these livestock; they present valuable areas for the production of fodder. The grasses and supply of running water are very beneficial to livestock farming.

In any livestock production system, there are multiple dimensions, which include both monetary and non-monetary benefits for producers and actors along the value chain. The main value addition activities on livestock products include milk processing, cooling of milk, processing and packaging of honey and leather tanning. However, the production potential is usually not fully utilised, attributable to several factors including; inadequate sector infrastructure and facilities, inadequate knowledge on animal husbandry and animal diseases. Livestock attributes detailing for both Busia County in Kenya and Busia District, Uganda is provided in Table 5.

In Kenya, the County government of Busia has planned the renovation and construction of cattle dips, crush pens (animal husbandry), construction of slaughter houses and upgrading of existing ones (Busia County CIDP 2018-2022).

Table 6 shows livestock numbers for the project area at different administrative levels (numbers are from 2009 for Kenya and 2002 for Uganda). On national level, Kenya has 17 million cattle, 28 million goats, 0.33 million pigs and 34 million chickens. Uganda shows similar amounts of despite it being a much smaller country, as well as almost ten times as much pigs. Cattle numbers are more proportionate, with Kenya having relatively more goats. Zooming in to regional level (Eastern province for Uganda and Western region for Kenya), cattle and chickens proportionately increase, which is visible at district/county level as well (Busia district for Uganda and Busia county for Kenya). Finally, the project houses around 19,000 cattle, 16,000 goats, 8,300 pigs and 110,000 chickens, when combining the data at the respective time of their censuses (GoU 2009). It is reasonable to assume numbers have grown since however, discussed in the next paragraph. On the Kenyan side, 68.3% rear livestock, and the Ugandan

side, 68% of households raise livestock (KNBS 2009), with a median landholding size of livestock rearing households of 0.8 ha of which 62% of it used for agriculture and 27% for pasture (MoA 2009).

TABLE 5: LIVESTOCK ATTRIBUTES WITHIN THE SIO SITEKO LANDSCAPE (BUSIA COUNTY, KENYA AND BUSIA DISTRICT, UGANDA)

LIVESTOCK ATTRIBUTES	BUSIA, KENYA	BUSIA, UGANDA
LAND SIZE HOLDINGS	Majority small holder farmers <1 ha	Majority small holder farmers <1 ha
PRODUCTION SYSTEMS	<p><b>Dairy cattle:</b> 90% is semi-intensive (semi-grazing), whereas 10% is small-scale intensive</p> <p><b>Beef cattle:</b> 100% semi-intensive</p> <p><b>Broilers:</b> 50% backyard (improved free range/semi intensive) and 40% free range extensive</p>	Both intensive and semi-intensive systems of both beef and dairy cattle keeping are being practised
CATTLE ATTRIBUTES	<ul style="list-style-type: none"> <li>• In Matayos, Busia sub-county, improved dairy cross breeds are about 3590, followed by local dairy at about 20,900.</li> <li>• The use of both improved dairy cattle and the locals is production of milk, manure and breeding stock sale (income). In addition, locals are use cattle for paying dowry (bride price).</li> <li>• Annual milk production is at 5.3 million litres.</li> <li>• Bulls are mostly used for breeding, and few farmers use Artificial insemination that cost between 12 - 15 USD.</li> <li>• Livestock production systems; Zero-grazing, semi-zero grazing, tethering and free grazing</li> <li>• Livestock population stood at 163,795 in 2009 (KEBS, 2009 Census)</li> </ul>	
FORAGE AND FEED USED	<ul style="list-style-type: none"> <li>• Grazing is usually on natural and improved pastures.</li> <li>• Napier grass is the main fodder, with some cases being purchased by some households.</li> <li>• Improved cattle are often supplemented with concentrates but often not in adequate amounts due to cost. Local cattle are allowed to graze Crop residues (maize stovers) are also part of the diet including also sweet potato vines</li> </ul>	<ul style="list-style-type: none"> <li>• Grazing is usually on natural and improved pastures.</li> </ul>
CONTRIBUTION OF LIVESTOCK IN HOUSEHOLD INCOMES	Dairy contributes at least 17% while food crops and cash crops contribute the most of about 25%. The other sources include poultry, and employment	
CHALLENGES IN LIVESTOCK PRODUCTION	<ul style="list-style-type: none"> <li>• High cost of livestock inputs- feeds, Artificial insemination and drugs.</li> <li>• Within the year, feeds and Forage availability is usually constrained for four months (November, January, February and March).</li> <li>• Lack of improved breeds</li> <li>• Inadequate technical knowledge on fodder and feeding management</li> </ul>	

**TABLE 6: LIVESTOCK POPULATION NUMBERS FOR UGANDA AND KENYA AT DIFFERENT ADMINISTRATIVE LEVELS**

	Kenya				Uganda			
	Cattle	Goats	Pigs	Chickens	Cattle	Goats	Pigs	Chickens
<b>National</b>	17 million	28 million	0.33 million	34 million	11 million	12 million	3.2 million	37 million
<b>Region/province</b>	1.1 million	0.26 million	88,000	4.4 million	2.5 million	2.6 million	0.70 million	11 million
<b>District/county</b>	71,000	19,000	21,000	360,000	3,800	10,000	3,000	21,000
<b>Project area</b>	17,200	12,000	6,400	97,000	1,900	3,800	1,900	9,400

Livestock population patterns for the whole of Uganda (MoA 2009) show a rapid growth since 1991, especially between 2002 and 2008 with numbers of cattle and goats doubling and the number of pigs quadrupling. Livestock numbers can be volatile however (demonstrated in the year 2002 for pigs), so it is hard to say whether this growth has continued over the last decade and even more difficult to predict future livestock numbers.

### 5.3 CROP PRODUCTION AND FORESTRY

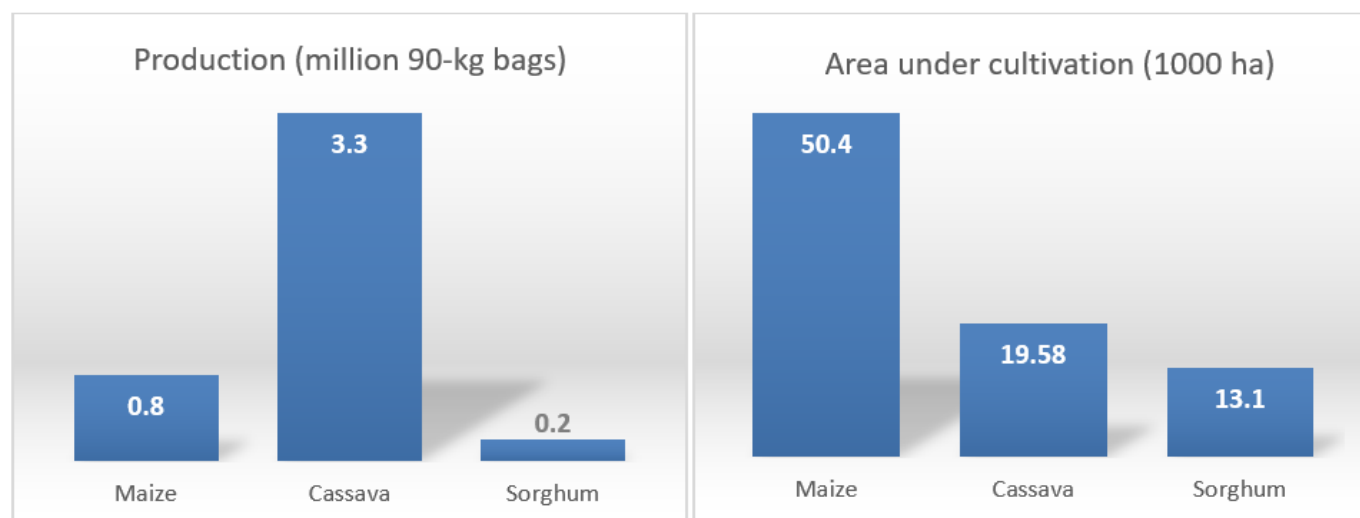
The climate in the Sio Siteko project area is conducive for agriculture, and a majority of the land cover consists of croplands (see the Land cover map in Appendix A). Agriculture is an important activity and is the main source of income in the area. To illustrate, agriculture employs about 78% of the workforce and contributes about 50% to the household incomes in Busia, Kenya (GoK 2013). The majority sell a portion of the crop yield to be able to purchase clothes and other consumer goods such as kerosene, food oil, salt, and other household requirements.

Farm sizes range from 0.4 to 6 hectares, though

farming is typically practiced by small-holder farmers who apply traditional farming methods for subsistence use. To illustrate, 84 % of the crop output in Busia, Kenya is used for household consumption (USAID 2014). Only 31 % of farmers in Busia, Kenya have title deeds (GoK 2013), which may be due to the fact that only one member of the family, usually the adult male, owns the deed for an extended family, even after land subdivision. Residents in close proximity to urban areas with government offices are likely to have title deeds (GoK 2014).

Most of the agriculture is rain-fed, though small-scale irrigation was observed in the valleys during the field visits. The main crops that are grown include yams, beans, groundnuts, potatoes and sweet potatoes, millet, sorghum, cabbages, tomatoes, kales and cassava. Irrigation has enabled crops like sugarcane, arrowroots, rice and maize to thrive well in the area. Rice and sugarcane are often cultivated within the wetland areas on the valley floors, while beans and maize are generally cultivated on the higher ground near the settlements. In Busia, Kenya, less than one-fifth of the cultivated area is under cash crops such as sugarcane, tobacco and cotton. The vast majority of

**FIGURE 26. THE PRODUCTION (IN MILLION 90-KG BAGS) AND THE AREA UNDER CULTIVATION (IN 1000 HA) OF THREE IMPORTANT CROPS FOR FOOD SECURITY IN BUSIA, KENYA FOR THE YEAR 2014 (GOK 2015).**



the agricultural land is used to cultivate food crops such as maize, cassava and sorghum. These three crops are important for food security and livelihoods in the region (Figure 26 and Figure 27). One crop that is important for food security is maize. This crop is a staple food with a high dietary value, but is also cultivated for livestock. Maize is cultivated on farms with an average size of two acres and is grown during both the short and the long rains. In Busia, Kenya, more than 80 % of the population is engaged in the value chain of maize (Figure 27).

A second important crop in the Sio Siteko region is cassava. In fact, Busia is the largest producer of cassava in Kenya. Producers, input suppliers, processors and wholesalers operate at small scale, with farm sizes ranging from 0.5 to about 5 acres. The crop is considered a woman’s crop though both male and female farmers participate in production of cassava. The common variety is the local cultivar Magane (Njoroge et al. 2016). Cassava is a major component of the diet of Busia residents, though they consume only the tuber (as opposed to also consuming the leaves, as in neighbouring communities), and is considered to be of medium importance for food security and livelihoods (Figure 27).

The most important crop in terms of food security and livelihoods according to Figure 27 is sorghum. Sorghum can be inter-cropped with maize and cassava and is cultivated on plots with an average size from 1 - 2 acres. This crop is relatively tolerant of climatic extremes such as flooding and drought, and local varieties are especially preferred for these qualities. Sorghum is also beneficial to producers

and consumers because the prices is relatively stable. Despite the importance for food security and livelihoods, fewer people are involved with the value chain of this crop than with maize and cassava (Figure 27). The cultivation of sorghum is however increasing significantly, mainly because of the resolution of the East African Breweries Limited to procure all of its sorghum requirements in the country of Kenya.

The Busia County Agricultural Development Fund Act of 2014 established the County Agricultural Development Fund whose objective is to provide funding for eligible intervention to cover the agricultural sector including fisheries, livestock and veterinary services.

Eucalyptus tree species have been planted in and around the wetland on a massive scale. Eucalyptus is a high water intensive species, which has led to water uptake particularly during the dry seasons resulting in the drying up of the wetlands. This is predominant in Busumba and Buyengo areas, and Mundulusia along Mavale River which is a tributary of River Sio. Eucalyptus and pine trees have been planted around the wetland areas to provide tree resources to the local communities. The idea is that the local communities will use these trees for timber instead of the remaining natural vegetation in the wetlands. In general trees can be good for shade (cooling) and preventing soil erosion. However, if they are newly introduced in water logged areas the consequences can be overall negative due to drying out of wetland area, as well as creating a mono vegetation versus diverse vegetation.

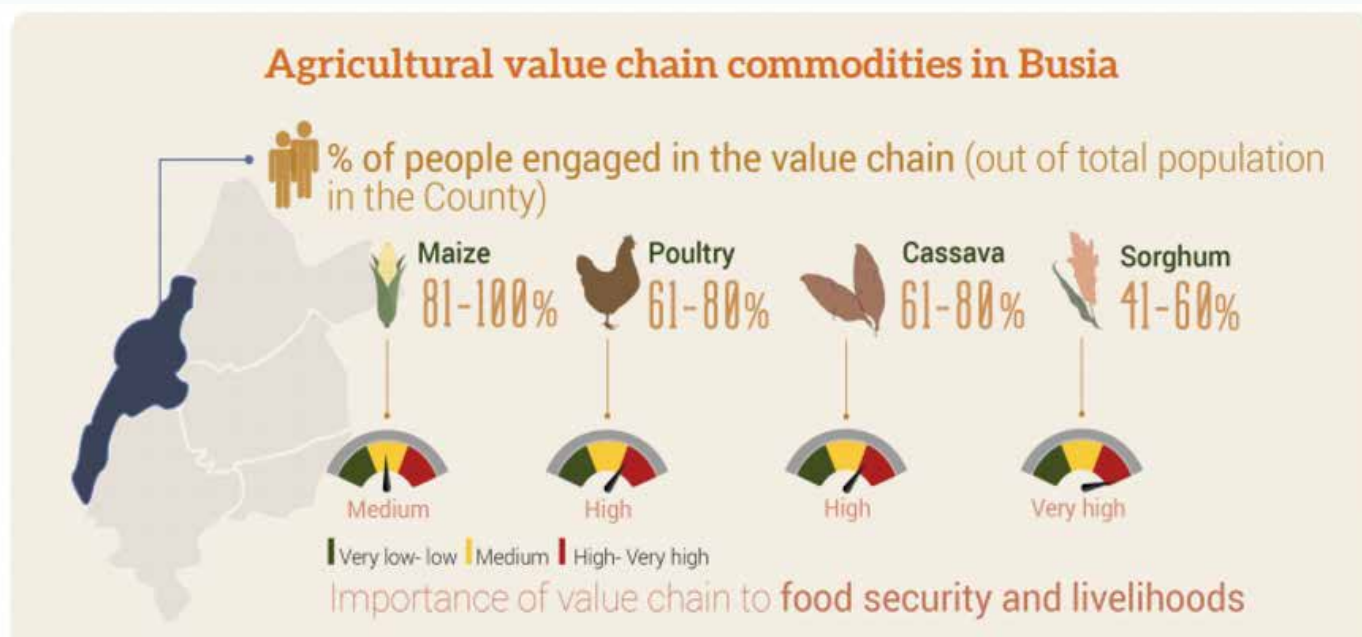


FIGURE 27: AGRICULTURAL VALUE CHAIN COMMODITIES SHOWING ENGAGEMENT IN THE VALUE CHAIN OF VARIOUS AGRICULTURAL GOODS, AND THEIR IMPORTANCE TO FOOD SECURITY AND LIVELIHOODS IN BUSIA COUNTY, KENYA (SOURCE: CGIAR, 2018).

## 5.4 FISHERIES AND AQUACULTURE

Fishing, both in Lake Victoria and in surrounding wetlands is one of the major economic activities in the landscape, despite the fishing industry being quite underdeveloped. To illustrate, 17% of households in Busia County earn 600,000 - 1,000,000 UGX annually from fishing, while another 23% earn more

than 1,000,000 UGX. Within the project area, there are five fish landing sites, of which Sio Beach is the largest. A total of about 400 fishing boats are active in the area. The local community are involved in Beach Management Units (BMUs), which are the backbone of cooperative management of fisheries.



FIGURE 28: AFRICAN CATFISH OR KAMBALE (*CLARIAS GARIEPINUS*) AND TILAPIA SPECIES (LEFT) AND NILE PERCH (RIGHT).

Most of the fishing is done in Ugandan waters, though trade is mainly in Kenya. Important species are tilapia species, Nile perch, lung fish, the silver cyprinid, *Barbus* species, and the African catfish or Kambale (see Figure 28). Of these, the tilapia and Nile perch species are the most important for fishers with boats. The fish are sold at local and regional markets and to industrial processors, depending on their size and quality.

Fishing within the wetland is largely artisanal, however, at the delta there are commercial harvesting of small fish species largely as baits for Nile perch fishermen. The wetland is dominated by riverine fish species and those that typically breed at the wetlands such as Tilapia. The riverine fish species commonly fished at the wetland include; Mud fish, Eningu, Esire, Obuyako, Duri, Obudokori, Efulu, Obuduba, Vidonge, others fish species caught included Imonye, Ekhanganga, and Masurubanaas they are commonly referred to in the local dialect. The government of Uganda has recognized the wetland as one of the four most important fish breeding sites in Lake Victoria and is calling for the protection of the delta against human activities that might degrade fish breeding

and the breeding sites. During the TEEB study survey, 27% of the households reported to harvest fish from the wetland. The most harvested fish is the *Synodontis* (locally known as Vidonge) with 28% of the fishermen reported to be actively involved in harvesting it. According to the Ugandan fisheries officials, the *Synodontis* is on high demand by Nile perch fishermen as baits (TEEB study Sio Siteko, NBI 2019b).

Several fishing techniques are used in the Sio Siteko area:

- Seine fishing: a vertical net is hung in the water, and fishers ensure fish are going toward the net by diving, splashing or drumming the water
- Use of natural herbs ('amofyee' or water lily) to stun or kill fish
- Long line fishing
- Reeds set along the river mouth (Figure 29)
- Monofilament nets (which are illegal) (Figure 29)



FIGURE 29: REEDS SET ALONG THE STREAM TO CATCH FISH IN A TRIBUTARY OF THE RIVER SIO (LEFT) AND MONOFILAMENT NETS IN A FISHING BOAT AT SIO BEACH LANDING SITE (RIGHT). PHOTOS WERE TAKEN ON APRIL 11<sup>TH</sup> AND 12<sup>TH</sup>, 2019, RESPECTIVELY.

Fish catches in Lake Victoria have been declining, while demand for fish is increasing. Therefore, there is a real threat of overexploitation of fish species, some of which are rare or endangered. One way to address this issue is through aquaculture. While land-based pond aquaculture has not been very successful in the region, cage farming in lakes seems to be more promising. Cage farming of Nile Tilapia on Lake Victoria started in 2006 but is expanding rapidly. By 2015 there were over 2000 cages producing about 8,000 tons per year (AGL 2017).

Fish farming is also practiced in the Sio Siteko landscape, mainly by individual farmers rather than within BMUs. Aquaculture is practiced in both Uganda and Kenya though in small scale. There were records of aquaculture obtained from the fisheries department in Busia Uganda for the year 2018. These showed that there were a total of 186 fish farmers on the Ugandan side of the wetland who mainly kept Tilapia and Catfish and earned a gross value of \$ 117,642.5. The total number of fish farmers was 186 and the total area under fish farming was approximately 49 acres.

In Kenya, there were plans to put up an approximately 100 fish ponds of 300 m<sup>2</sup> each in Bukani area with future plans for expansion into all other areas. However, during the household survey, some fish farmers were encountered especially in the sub locations of Bujwanga, Buloma, sibinga, Muyafwa, and Nangoma in which main fish kept included Tilapia, Catfish (both Eduri and Esire). The total production was estimated at \$ 252, 933 for a total 246 farmers whose cumulative pond size was estimated at 55 acres (TEEB study Sio Siteko, 2019b).

This practice has the potential to improve livelihoods by providing employment, increasing income and providing a ready supply of fish protein. It also reduces pressure on native fish by diverting the harvesting of wild fish to farmed fish. However, there are also potential adverse effects on the environment if cage fish farming is not managed and regulated properly. For example, excessive nutrients from overfeeding and waste cause eutrophication and enhances growth of algae and water hyacinth.

In addition, a large portion of cages (>45%) are located within 200 m of the shoreline, which are breeding grounds for fish. This location close to shoreline can cause conflicts with other lake users, especially fisherman who do not have outboard engines and therefore fish close to shore. More information about cage fish farming and the potential adverse effects of this practice can be found in [Appendix B2](#). To minimize conflicts and the risk of environmental consequences, an effective policy framework is needed. For instance, zonation may ensure all stakeholders make optimal use of the available resources without impinging on the development opportunities of others.

## 5.5 ENERGY SOURCES AND TRANSPORT

The main source of energy in both the Ugandan and Kenyan side of the wetland landscape is biomass, such as charcoal or firewood (Figure 30). Only one in every 16 households (6%) use a type of fuel other than firewood for cooking. Similarly, more than half (52%) of households use 'tadooba' lamps, or kerosene lamps, for light as electricity is only available for one in every five of households (20%). The over reliance



FIGURE 30: FIREWOOD IS THE MOST COMMONLY USED FUEL FOR COOKING. PHOTO TAKEN ON 12-04-2019 AT SIO PORT BEA



FIGURE 31: BOATS ARE FREQUENTLY USED TO TRANSPORT PEOPLE AND GOODS ACROSS THE RIVER SIO. PHOTO TAKEN ON 12-04-2019.

of people on biomass for energy production and the absence of alternative options results in the over dependence of wetland vegetation results in over exploitation of the resources rendering them prone to depletion (TEEB study Sio Siteko, NBI 2019b).

Residents of the Sio Siteko area use several means of transport, mainly by boat and over the road network. Boats are frequently used to cross the River Sio (Figure 31) and cross Lake Victoria, as there are few bridges over the river. In addition, many residents own property on both sides of the river, and intermarriage is common. The main bridge across the River Sio is along the road between Busia and Bumala. This is one of the few paved roads in the project area, though road construction was underway between Busia and Majanji in early 2019.

## TRADE AND INDUSTRIES

Trade is thriving in the study area, especially in Busia. Thanks to its status as entry point between Kenya and Uganda, there is bustling trade in livestock, agricultural products, and manufactured goods in this town. Besides Busia, there are many smaller trading centres, including Bumala, Majnanji, Samia, and Sio Port. Most of the markets in the county are open air markets, which require planning, and the main activity is sale of agricultural produce and second-hand clothes.

There are no industrial parks in the Sio Siteko landscape, though some Jua Kali sheds can be found in Busia, Moding and Nambale. In Busia, Kenya,

there are two sugar factories located barely 10 km apart. Busia Sugar is based at Busibwabo in Matayos while West Kenya is located at Olepito in Teso South. Other industries found in the county include: Flour Mills Deluxe and Fish Fileting in Port Victoria. There are also several non-functional cotton ginneries at Nambale, Amukura and Mulwanda. However, there are plans to revive cotton ginneries in this area. A fish cooling plant at Marenga in Bunyala is awaiting commissioning, while a cassava factory at Simba Chai in Teso South Sub - County is almost complete.

Sand mining is important for livelihoods in the Sio Siteko wetland landscape. The sand is mined from the river banks and from Lake Victoria and is mainly used in construction (Figure 32). Potential environmental threats of sand mining are to river bank degradation and increased erosion and sediment loads in rivers. In addition, the practice can disturb organisms that live in the sediments, and which are crucial elements of a healthy ecosystem.

A final economic activity is salt harvesting (Figure 33). This activity is currently done at small scale by specific villages within the study area. Salt is extracted from vegetation growing in the wetlands in a multi-step process. The greatest limiting factor for this activity is finding a suitable market for the final product. Each of these industries and activities will have a direct or indirect impact on water quality and quantity. It is necessary to ensure that the management plan identifies measures for effective stakeholder engagement.



FIGURE 32: SAND MINING IS A COMMON ACTIVITY IN THE SIO SITEKO WETLAND LANDSCAPE. PHOTO TAKEN ON 12-04-2019 AT SIO PORT BEACH.



FIGURE 33: RESIDENTS HARVESTING WETLAND VEGETATION FROM WHICH SALT IS EXTRACTED. PHOTO TAKEN ON 12-04-2019.

## 5.7 ECO-TOURISM

Although Kenya and Uganda are one of the leading tourism destinations in the world, the tourism industry in and around the wetland locations in the two countries is not fully developed. There are however, some attractive tourist sites and significant potential in that sector. Nature based activities such as bird watching, sport fishing, canoeing and water sports were identified in the Community Based Wetland Management Plan developed in 2009.

Some of the tourist attractions that fall within the administrative location of the Sio Siteko wetland (Busia County, Kenya and Busia District, Uganda) are:

- Kakapel National Monument - a UNESCO World Heritage Site located on a huge rock site in the Chelelemuk Hills - a few kilometers

from the Kenya, Uganda border (Figure 34). The site that was gazetted as a National Monument in 2004 comprises spectacular rock art that is believed to have been crafted by a group of hunters about 4,000 years ago. Kakapel has red paintings (drawn with fingers) illustrating animals, geometric designs and ceremonial symbols. The rock art at Kakapel is believed to have been done by the Twa (Abatwa) hunter gatherer group. It has paintings illustrating wild animals, rain-making and initiation symbols.

- Nature based activities such as bird watching, sport fishing, canoeing and water sports were identified in the now expired Community Based Wetland Management Plan developed in 2009. These activities have not been developed to date.



FIGURE 34: KAKAPEL ROCK ART SITE (LEFT) AND CLOSE-UP OF THE ROCK ART (RIGHT).

## 6. SOCIAL DIMENSION

### 6.1 HUMAN DEMOGRAPHY

The total population of Sio Siteko wetland landscape in 2019 was calculated from census data (UN 2019; KNBS 2010; UBS 2014). In Table 7 population estimates for 2019 are shown, from national level to project area level. Kenya, on the eastern side of the project area, has a population of 53 million, and Uganda has a population of 44 million. Busia county in Kenya and Busia district in Uganda have

1.0 million and 0.38 million respectively. Within the project area, about 180,000 people live on the Kenya side and 93,000 on the Ugandan side, for a total of 273,000 people. Figure 35 shows the population forecast of the project area, from 2009 (year of latest census in Kenya) to 2030. It shows that population is expected to increase from the current estimated 273,000 (2019) to 340,000 in 2025 and over 370,000 people in 2030.

TABLE 7: POPULATION ESTIMATES FOR THE YEAR 2019 AT DIFFERENT ADMINISTRATIVE LEVELS

	Kenyan side		Ugandan side		Sio Siteko total	
	Population	Growth rate	Population	Growth rate	Population	Growth rate
<b>Country level</b>	53 million	2.32	44 million	3.59		
<b>County/district level</b>	1.0 million	3.03	0.38 million	3.00		
<b>Project area level</b>	180,000	3.03	93,000	3.00	~ 273,000	~ 3.02

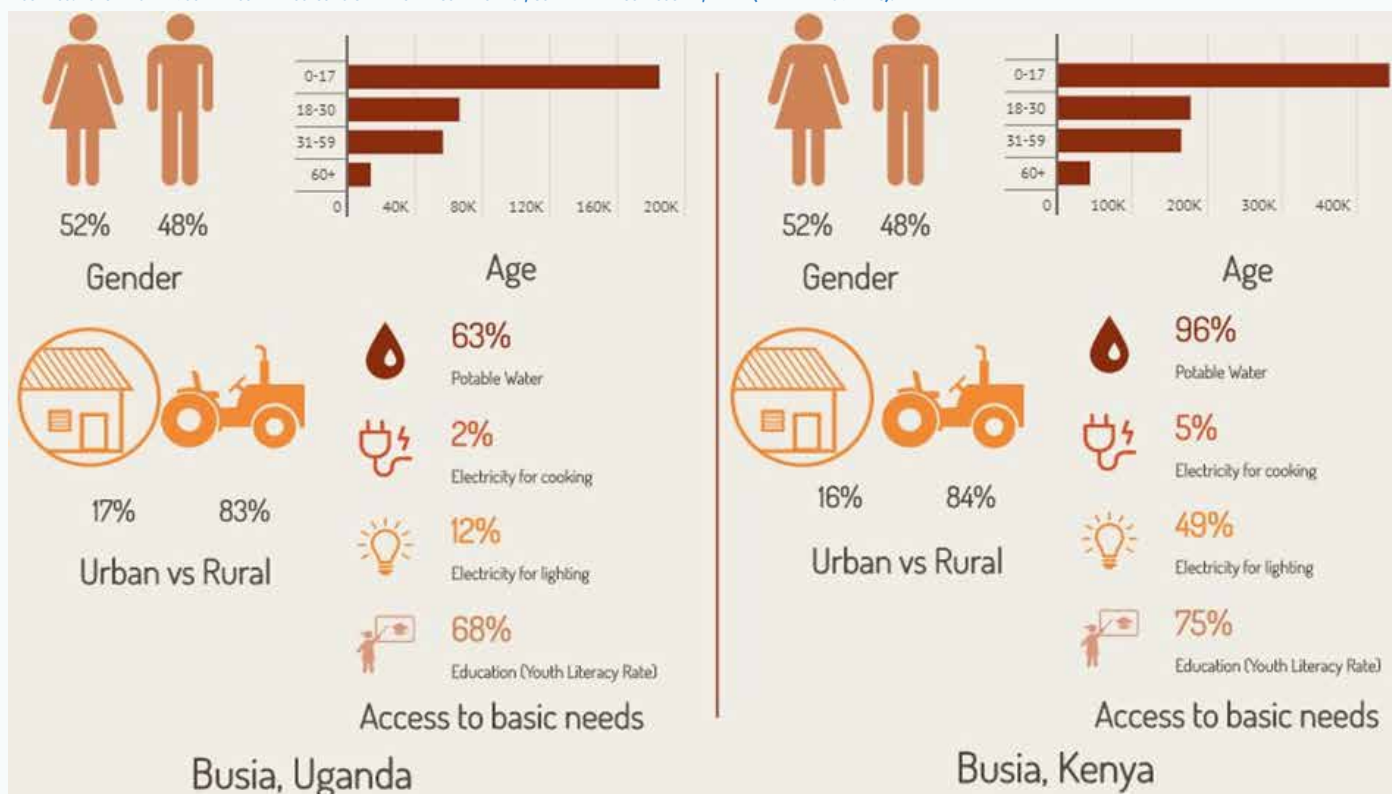
Population forecast for Sio-Siteko



According to the Uganda 2014 National Housing and Population Census, Busia district in Uganda had a population of approximately 325,000 people in 2014, with the males comprising 48.3 percent (156,000), and females constituting 51.7 percent (169,000). 83 percent of the population live in the rural area and largely depend on subsistence farming. The

Kenya National Bureau of Statistics estimates the population of Busia County at 744,000 people in 2009. An overview of the population demographics of Busia Districts in Uganda and Kenya is presented in Figure 36.

FIGURE 36. POPULATION DEMOGRAPHICS AND ACCESS TO UTILITIES IN BUSIA DISTRICT, UGANDA AND BUSIA COUNTY, KENYA (ADAPTED FROM KNBS).



In the Ugandan side, the wetland landscape lies within Lumino, Majanji, Buhehe and Masinya sub-counties in the south and Dabani, Western and Eastern sub-counties in the north. These sub-counties are inhabited by Basamia, Bagwe, Iteso, Basoga, and Bagisu ethnic groups. In comparison, in the Kenyan side, five ethnic groups are predominant around the Sio Siteko wetland landscape, namely the Bakhayos, Banyalas, Samias, Iteso and Luos. Other inhabitants include Kikuyus, Kisiis and Somalis. Inter-marriages between these tribes both within and across the border are very common. Most of the residents are Christians, although there is a significant population of Muslims in the urban centres.

## 6.2 SOCIAL ORGANIZATIONS

### 6.2.1 Pastoralist organisations

Stakeholders and governmental bodies in the livestock and pastoral, agro-pastoral and semi-intensive cattle and poultry systems in Uganda include the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) and the Dairy Development Authority (DDA). On a local level, PENHA is a distinguished non-governmental organisation with 30 years of experience working on the African pastoral and environmental issues. PENHA's mission is to reduce poverty among the pastoralists in the Horn of Africa through the empowerment of communities and to

foster sustainable and dignified livestock-based and non-livestock-based livelihoods.

### 6.2.2 Nature and wildlife reserve management

The Uganda Wildlife Authority (UWA) and the Wildlife Conservation Society (WCS) are two of the governing bodies that regulate wildlife conservation in Uganda. On a local level, the Districts Environment officer, Forest officer, Land officer, Entomologist, Natural resource officer, as well as LUMA, BUDA, BUMASI and Beach Management Units (BMU's) are recognized in Uganda and Kenya.

### 6.2.3 Forestry management

In Uganda, in terms of land ownership, 70% of the forest area is on private and customary land, while 30% is in the permanent forest estate (PFE), such as Forest Reserves (central and local), National Parks and Wildlife Reserves. Most of these forests are managed by the National Forestry Authority (NFA) or the Uganda Wildlife Authority (UWA). In Kenya, the responsibility for management and protection of Kenyan forest areas lies with the Kenya Forest Service (KFS). Other actors are National Environmental Management Authority (NEMA), East African Wild Life Society (EAWLS), Forestry Society of Kenya (FSK), Kenya Forests Working Group (KFWG).

Local actors recognized in forestry management of Sio Siteko are the Uganda Forest office, Nature Uganda, Community, LVFO, NEMA, MAAIF, MoF, NFA, UWA, LVBC, District Authorities, Sub County officials, LC II, LC I, LUMA, BUMASI, BUTA (all Uganda) and KFS, NEMA, CGB Nature Kenya, CSO-Eco green, Community, Count Govt of Busia, LVFO, NEMA, MoE&F, KEFRI, MoWS, Sio Siteko Wetland Users (all Kenya).

#### 6.2.4 Fisheries management

Local actors recognized in fisheries management of Sio Siteko are SSWA, WRUAs, Community BMUs (in Kenya), MAAIF, NaFIRRI, LVFO, LUMA, BMUs BUMASI, BUDA (in Uganda).

#### 6.2.5 Water and sanitation sector

The Water and Sanitation sector comprises of the rural water supply, sanitation and mobilization of benefiting communities. This sector is a self-funded sector of works and technical services. The sector is mandated to carry out supervision, construction of water points, rehabilitation of boreholes, sanitation awareness, mobilization and monitoring of community responses on issues concerning operation and maintenance constructed facilities. However, there are constraints to the performance of the water supply and sanitation sectors such as weak local private sector plays (contractors, consultants and private operators) and insufficient funding to meet the high population demands and limited financing options such as infrastructure bonds.

The national Ministries of Water and Environment (MoWE) in Uganda and of Water and Irrigation (MWI) in Kenya are the key institution responsible for the water sector. On local level, some Community Based Organisations (CBO's) or involved in the water and sanitation sector such as BUDA CBO, BUMASI CBO, LUMA CBO, as well as some NGO's.

The Uganda Water and Sanitation NGO Network (UWASNET) is the national umbrella organisation for Civil Society Organisations (CSOs) in the Water and Environment sector. UWASNET is crucial in helping government realise its targets of alleviating poverty and achieving Millennium Development Goals (MDGs) through universal access to safe, sustainable water and improved sanitation. UWASNET plays this vital role in partnership with other key sector players such as the Government of Uganda, Development Partners (DP's) and the private sector. In Kenya, Water User Associations (rural areas) and Water Service Providers (urban area) act as commercially

oriented public enterprises responsible for water and sanitation services.

### 6.3 WATER SUPPLY AND SANITATION

#### 6.3.1 Water supply

Water use in the Sio Siteko area includes household use, livestock watering and occasional irrigation. The population uses water from a variety of different protected and unprotected sources, including lakes, rivers, rainwater harvesting techniques, springs, boreholes, and piped water supply.

*As per June 2019, the rate of access to a safe source of water (safe water coverage) in Busia District, Uganda, was estimated at 79%, with a functionality of 94%. The current strategic directive by the Uganda government is to ensure provision of at least one improved water source per village. In Busia District, a total of 464 villages (85%) are with a source of safe water, against 79 villages (15%) that are still without a source of safe water supply (MWE 2019).*

In Busia county, Kenya, less than two-thirds of the population has access to clean drinking water. Only about 25% of the population are served by the Busia Water and Sewerage Services Company, though it aims to increase this to 80% of the population (KIWASH, 2019). This should be achieved through projects such as the Kenya Integrated Water, Sanitation and Hygiene project. The availability of water from different sources, especially that of groundwater and surface water, varies during the year, which means that the main source for each use type may also vary.

Groundwater is abstracted from shallow wells and boreholes, springs (Figure 37), and scoop holes. Boreholes are more common on the Ugandan side of the study area than on the Kenyan side. The water sources on the Ugandan side tend to be installed by the local or central government but are managed by the community (Uganda Water Supply Atlas, 2017). Most boreholes are equipped with handpumps. Electric pumps are less common and are generally limited to private boreholes. Springs are mainly located in the northern part of the study area (Figure 38). Occasionally, chlorine is available next to the boreholes or springs to disinfect the groundwater before use (Figure 37). Other water treatment methods include boiling, decantation and sieving. Some of the wells provide highly mineralized water





FIGURE 39: THE MUNDIKA WATER INTAKE FROM THE RIVER SIO, NEAR THE BRIDGE BETWEEN BUSIA AND BUMALA, WHICH SUPPLIES WATER TO THE PIPED WATER SYSTEM IN BUSIA.

- Destruction of water pumps and other equipments as a result of poor awareness, poor knowledge and lack of understanding of how to use them
- Poor rehabilitation and maintenance schemes of streams and water wells
- Long distance from safe water sources to human settlement in rural area

### 6.3.2 Sanitation and hygiene

Sanitation in the study area remains a challenge, as thirty percent of households do not have improved toilet facilities. The majority of residents use open pit latrines and many households do not even have toilet facilities at all, meaning that open defecation is not uncommon, especially in rural areas. In urban areas, access to sanitation is somewhat higher. However, untreated sewage or inadequate water treatment remains a risk, especially where sanitation infrastructure development cannot keep up with rapid urbanisation rates. This insufficient water treatment, as well as open defecation and overflowing latrines can allow microbes to enter nearby groundwater and surface water. This can cause waterborne diseases such as cholera and diarrhoea to spread. Furthermore,

most residents dump their waste in compost heaps instead of burying or burning it, which can contribute to contamination of water resources.

The risks of insufficient water treatment have already been observed in the study area. For example, while there are sewage ponds near the town of Busia, the effluent is not fully treated. Indeed, during the field visits, locals reported that water quality is degrading downstream from the sewage ponds to the extent that vegetation is changing, and papyrus is disappearing. The sanitation and waste treatment challenges can have serious implications for water quality in the Sio Siteko landscape.

In Sio Siteko, sanitation and hygiene conditions are worsening. Among others, this is due to:

- Lack of access to sanitation facilities in rural areas compared to urban centers
- Poor construction and unprotected water wells – causes contaminations from animal and human solid and liquid wastes
- poor rehabilitation and maintenance of sanitation facilities
- Poor arrangement in separating water sources

for domestic and animal use and domestic use, e.g. lake area, rivers and ponds

- Water sources used as dumping areas e.g lakes and rivers (defecating and urinating while bathing, dumping liquid and solid wastes, bathing etc)
- Poor water handling facilities – e.g. containers for fetching water are left near the wells in poor condition
- Investment in water sector is still at high percentage by governments (relying on NGO support), private sectors have not well invested in this crucial sector
- Pollution from upstream socioeconomic activities – e.g. agriculture, fish landing sites, fishing activities (fuel, oil etc)
- There is localized nomadism during the prolonged dry periods when water and pastures are in short supply, leading to movement of cattle in water sources which

results to pollution and contamination

- Over population/high concentration in human settlements – e.g. in Sio Beach landing site in Kenya

## 6.4 PUBLIC HEALTH

### 6.4.1 Public health facilities

Busia District (Uganda) and Busia District (Kenya), like other districts in the region, has been experiencing shortage of health facilities, medical personnel such as assistant medical officers, clinical officers, dental surgeons, radiologists and radiographic assistants as well as medical equipment and medicines. These shortages have caused unnecessary loss of peoples' lives due to incomplete treatment of preventable diseases. The number of specialized doctors is limited, especially because they are not motivated to work in rural areas.

The TEEB study of Sio Siteko shows that a total of 16% of households reported to use herbal medicine

obtained from the wetland. From the sampled households, some of the ailments mentioned by respondents included; stomach aches, malaria, skin infections, teeth infections, diabetes, high blood pressure, ulcers, respiratory infections, loss of appetite, libido boosting among others. Slightly more than half (54%) of herbal medicine users are just for subsistence use, while 46% of them use herbal medicine for commercial gain (NBI 2019b).

### 6.4.2 Health issues

The national health indicators for Kenya and Uganda are shown in Table 8.

TABLE 8: HEALTH INDICATORS AT NATIONAL LEVEL (SOURCE: WHO 2018A AND WHO 2018B).

	Uganda	Kenya
<b>Child health</b>		
Infants exclusively breastfed for the first six months of life (%) (2011)	63.2	61.4
DTP3 immunization coverage among 1-year-olds (%) (2016)	78	89
<b>Demographic and socio-economic statistics</b>		
Life expectancy at birth (years) (2015)	62.3 (Both sexes)	63.4
	64.3 (Female)	65.8
	60.3 (Male)	61.1
% population under 15 (2015)	48.1	41.9
% population over 60 (2015)	3.8	4.5
Multidimensional Poverty Index (population in multidimensional poverty) – (2019)	0.269 (55.1%)	0.178 (38.7%)
Literacy rate among adult aged >= 15 years (%) (2007-2012)	73	87
Gender Inequality Index rank and value (2018)	127 (0.531)	134 (0.545)
Human Development Index rank (2018)	159	147
<b>Health systems</b>		
Total expenditure on health as a percentage of gross domestic product (2014)	7.22	5.72
Private expenditure on health as a percentage of total expenditure on health (2014)	75.06	38.75
General government expenditure on health as a percentage of total government expenditure (2014)	10.97	12.8
Physicians density (per 1000 population) (2015)	0.093	0.204
Nursing and midwifery personnel density (per 1000 population) (2015)	0.648	1.582
<b>Mortality and global health statistics</b>		
Neonatal mortality rate (per 1000 live births) (2016)	21.4	22.6
Under-five mortality rate (probability of dying by age 5 per 1000 live births) (2016)	53	49.2
Maternal mortality ratio (per 100,000 live births) (2015)	343	510
Births attended by skilled health personnel (%) (2011)	57.4	61.8
<b>Public health and environment</b>		
Population using safely managed sanitation services (%)		
Population using safely managed drinking water services (Urban) (2015)	18	54

The Multidimensional Poverty Index use a range of indicators to calculate a summary poverty figure for a given population, in which a larger figure indicates a higher level of poverty (UNDP 2019b). On a national level, diarrhoea has the highest disability-adjusted life years (DALYs) per 1000 capita in both Uganda and Kenya, followed by Malaria and Respiratory infections (Table 9; source WHO 2009).

TABLE 9: ENVIRONMENTAL BURDEN BY DISEASE CATEGORY [DALYS/1000 CAPITA], PER YEAR

Disease	Lowest rate	Uganda	Kenya	Highest rate
Diarrhoea	0.2	35	24	107
Respiratory infections	0.1	19	13	71
Malaria	0	22	13	34
Other vector-borne diseases	0	1.1	0.4	4.9
Lung cancer	0	0.1	0.1	2.6
Other cancers	0.3	1	0.9	4.1
Neuropsychiatric disorders	1.4	1.7	1.7	3
Cardiovascular disease	1.4	2.1	1.9	14
COPD	0	0.6	0.6	4.6
Asthma	0.3	1.8	1.7	2.8
Musculoskeletal diseases	0.5	0.5	0.6	1.5
Road traffic injuries	0.3	4.7	3.6	15
Other unintentional injuries	0.6	10	6.8	30
Intentional injuries	0	2	1.4	7.5

Table 10 show the health indicators for Busia county, Kenya, based on information from the Kenyan Ministry of Health (MoH 2015).

TABLE 10: HEALTH INDICATORS AT FOR BUSIA COUNTY, KENYA

	Busia 2015	Kenya
Underweight children (%)	9	22
Stunted children (%)	22	26
Children immunised (12-23 months) (%)	75	67.5
Births delivered at health facility (%)	58.4	61.2
Contraceptive prevalence (%)	56.5	53.2
Number of people tested for HIV	141,000	7,160,000
Number of people with HIV under ART treatment	8,500	561,000
Mother-to-child transmission of HIV (%)	6.7	8.5
Malaria test positivity rate (%)	59	41
Malaria cases (per 100,000 people)	78,000	20,000
Malaria admission	8,300	180,000
Tuberculosis prevalence (per 100,000 people)	266	208
Tuberculosis incidence (per 100,000 people)	81	79
Nurses (per 100,000 people)	69	55
Doctors (per 100,000 people)	13	10
Clinical officers (per 100,000 people)	22	21
Public health facilities	66	4,929
Non-governmental health facilities	5	347
Faith-based health facilities	12	1,081
Private health facilities	14	3,797
Total government health spending (per capita, KES)	1,467	1,585
Health insurance coverage (%)	31	27

### 6.4.3 Waterborne diseases

Waterborne diseases are conditions caused by pathogenic micro-organisms that are transmitted in water. Disease can be spread while bathing, washing, drinking water, or by eating food exposed to contaminated water. Contaminated water can cause many types of diarrheal diseases, including Cholera, and other serious illnesses such as Guinea worm disease, Schistosomiasis (also known as snail fever or

bilharzia), Typhoid Fever, Hepatitis A and E, Salmonella, E.coli and Dysentery. The World Health Organization estimates that 58% of the waterborne diseases, almost a million deaths per year, is attributable to a lack of safe drinking water supply, sanitation and hygiene (WHO, 2014).

Many people in and around Sio Siteko, particularly in fishing communities, experience a lack of access to clean drinking water and improved sanitation. Waterborne diseases can be spread via groundwater which is contaminated with faecal pathogens from pit latrines (Figure 40), and as a result cholera and diarrhoea are common amongst communities within the wetland.

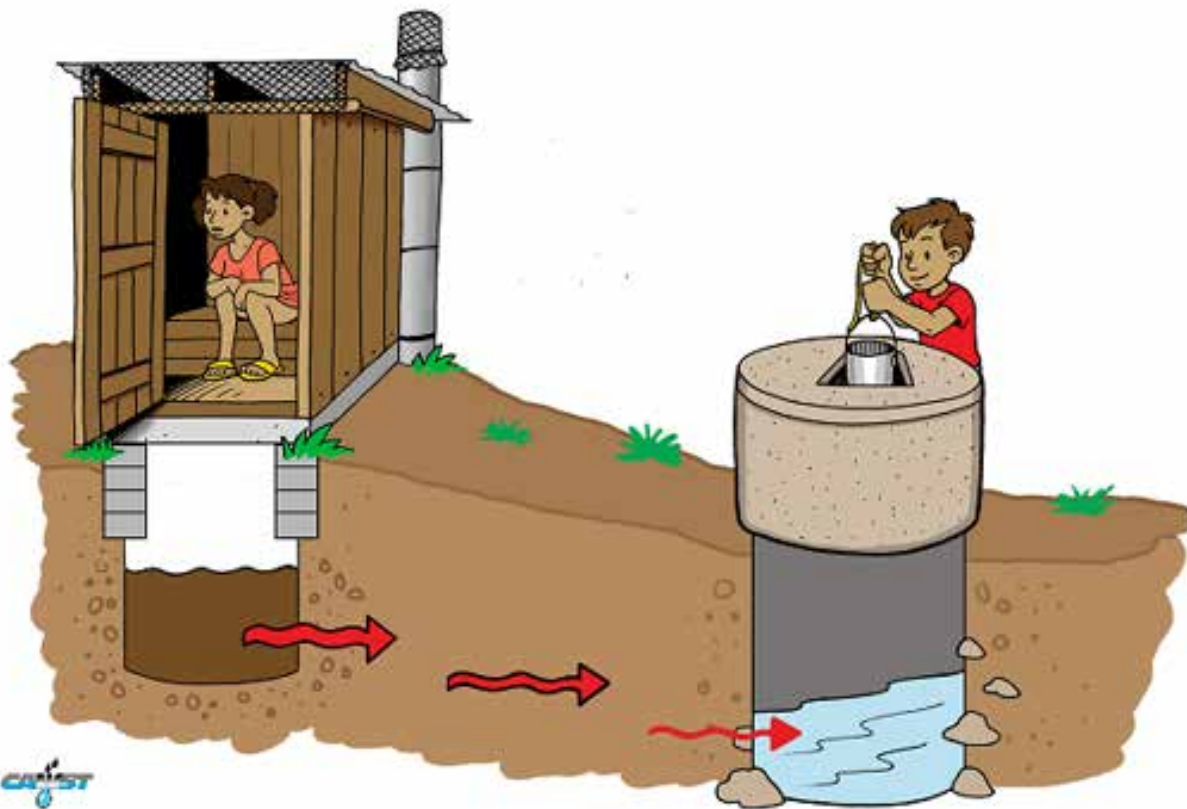


FIGURE 40: WATERBORNE DISEASES CAN BE SPREAD VIA GROUNDWATER WHICH IS CONTAMINATED WITH FAECAL PATHOGENS FROM PIT LATRINES. SOURCE: CENTRE FOR AFFORDABLE WATER AND SANITATION TECHNOLOGY

Since 1994, cholera is reported annually in Uganda, fluctuating between 250 and 5,000 cases per year with the exception of a large outbreak in 1998 with almost 50,000 cases (Figure 41). In Busia district, less than 15 people per 100,000 hospitalized with cholera between 2005-2010 (Bwire et al; 2013). Kenya experienced widespread cholera outbreaks in 1997-1999 and 2007-2010. The re-emergence of cholera in Kenya in 2015 indicates that cholera

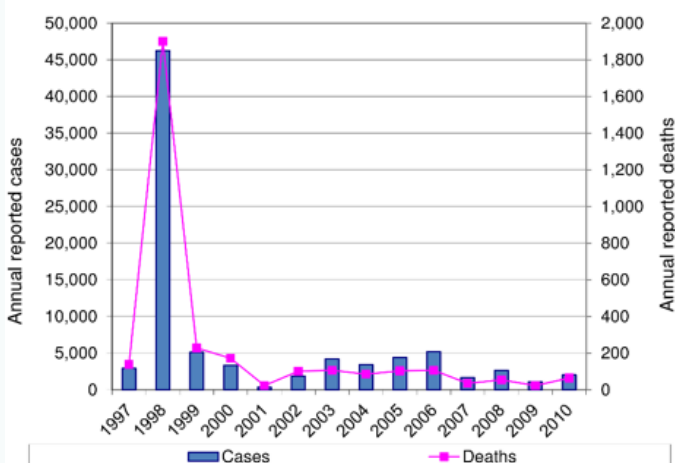
remains a public health threat (Cowman et al; 2017). In the latest outbreak of 2015-2016, over 1500 cases were reported all over Kenya (UNICEF 2016). For this outbreak 50 cases of cholera were reported in Busia county (MoH 2017b).

#### 6.4.4 Airborne diseases

Airborne diseases are caused by pathogens (viruses, bacteria or fungi) that can be transmitted through the air, spread through breathing, talking, coughing, sneezing, raising of dust, spraying of liquids, toilet flushing or any activities which generates aerosol particles or droplets. Many common infections can spread by airborne transmission at least in some cases, including Chickenpox, Influenza, Measles, Smallpox, Cryptococcosis, and Tuberculosis.

The second most common disease in Busia district of Uganda is Acute Respiratory Infection (ARI), accounting for 20% of all reported cases of disease (GoU 2009) which can be fatal especially in children. TBC is the most common airborne disease in Uganda with a reported 45,300 cases in 2014/2015, decreasing to 45,900 cases in 2016/2017 (MoH 2017a). Main constraints on Tuberculosis prevention are weak management and procurement of TBC drugs, weak

FIGURE 41: ANNUAL NUMBER OF CHOLERA CASES AND DEATHS REPORTED IN UGANDA 1997-2010.



mechanism for tracing defaulters and new cases, and inadequate numbers and trained health workers in treatment and diagnosis of TBC.

#### 6.4.5 Endemic and epidemic diseases

Malaria is a major public health problem associated with slow socio-economic development, a high multidimensional poverty index and the most frequently reported disease at both public and private health facilities in Uganda. Clinically diagnosed malaria is the leading cause of morbidity and mortality, accounting for 30-50% of outpatient visits at health facilities, 15-20% of all hospital admissions, and up to 20% of all hospital deaths. 27.2% of inpatient deaths among children under five years of age are due to malaria. A significant percentage of deaths occur at home and are not reported by the facility-based Health Management Information System (HMIS). Malaria is endemic (a disease that exists permanently in a particular region or population) in approximately 95% of the country, affecting over 90% of the population of 3 million. The 2009 Malaria Indicator Survey (MIS) reported high prevalence of malaria parasites in children <5 years of age ranging from 5% in Kampala to 63% in mid northern region, with a national average of 45%.

Malaria remains a major public health challenge in Uganda as the country with Uganda having the fourth highest number of annual malaria cases accounting for 4% of the estimated 220,500,000 global cases in 2016. In 2013/2014, 460 cases per 1000 people were reported (MoH 2017a). The main malaria vectors in Uganda are *A. gambiae*, *A. Funestus*, *A. arabiensis*, *A. bwambae*. The total malaria deaths in Uganda has gradually decreased between 2012 and 2016 (Figure

42), with a case fatality rate of circa 0.5%. Malaria accounts for 59% of all reported cases of disease in Busia district of Uganda (GoU 2019). In Busia county of Kenya, there were 78 cases of Malaria reported per 100 people in 2013 (MoH 2015).

#### Constrains on Malaria prevention

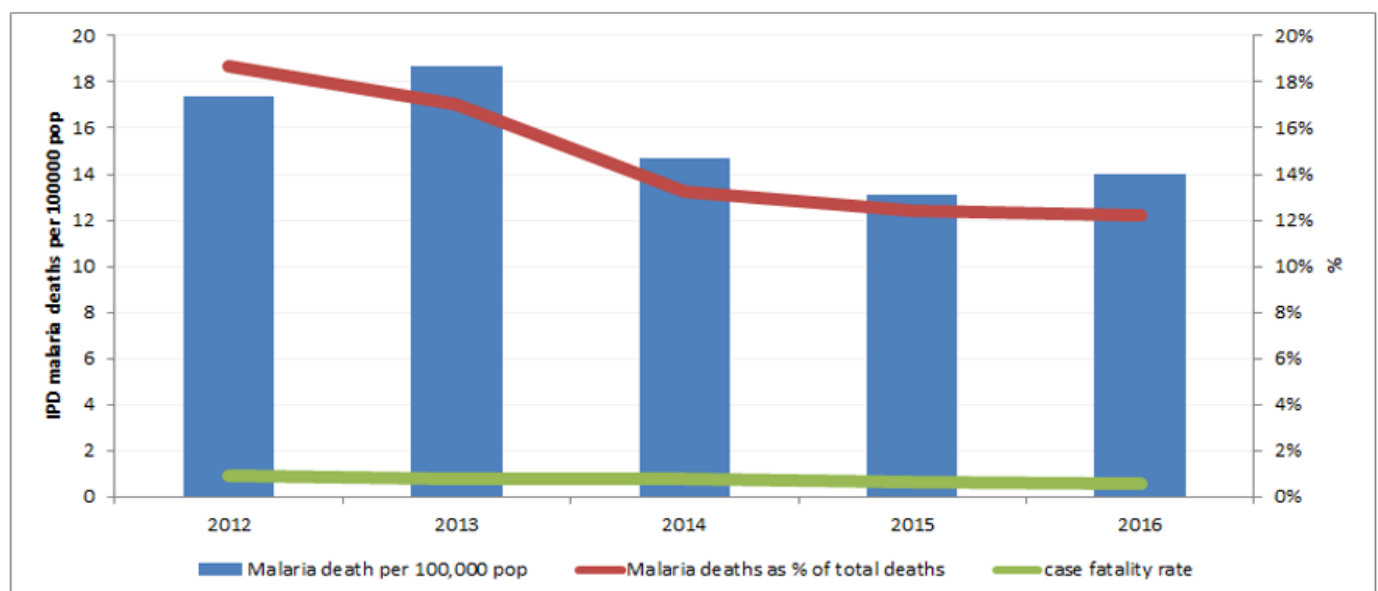
- Weaknesses in the procurement which lead to delayed delivery of malaria commodities especially Coartem.
- Inadequate trained workers.
- Inadequate laboratory infrastructure for malaria diagnosis.
- Weak malaria partnership forum.
- Weak implementation of a comprehensive policy on malaria and diagnostics treatment.
- During the field mission it was reported that mosquito nets are used for fishing or keeping poultry.

#### HIV/AIDS epidemic

The HIV virus is transmitted through certain body fluids and weakens the immune system by destroying cells that fight disease and infection. Left untreated, HIV reduces the number of CD4 cells in the body, making it more difficult for the immune system to fight off infections and other diseases, which can lead to the development of AIDS (acquired immunodeficiency syndrome).

In Sio Siteko, social services such as health facilities are poor and there is still fear, stigma and ignorance around HIV/AIDS. Many people living with HIV

FIGURE 42: 2012-2016 TREND IN DEATHS IN UGANDA DUE TO MALARIA



or at risk for HIV infection do not have access to prevention, treatment, and care, and there is still no cure. HIV statistics for Uganda and Kenya (UNAIDS 2018a and UNAIDS 2018b) show that each year a total of 53,000 and 46,000 people get newly infected with HIV in Uganda and Kenya respectively each year. The number of deaths from an AIDS-related illness is 23,000 (Uga) and 25,000 (Kenya) people per year (Table 11).

TABLE 11: NATIONAL HIV STATISTICS FOR UGANDA AND KENYA

	Uganda	Kenya
Number of people with HIV	1,400,000	1,600,000
HIV incidence (%)	1.4	01.02
HIV prevalence (%)	5.7	4.7
Number of people newly infected with HIV	53,000	46,000
Number of deaths from an AIDS-related illness	23,000	25,000
Percentage of people with HIV aware of their status	84	89
Percentage of people with HIV receiving treatment	72	68

drivers. Mother-to-child transmission is 6.7% (MoH 2015) and 87% of people with HIV is receiving treatment (UAC 2017).

#### Constrains on HIV/AIDS prevention

- Increased prevalence of HIV/AIDS due to absence of a coherent strategy to control the disease.
- High rates of discordance in marriage and in stable sexual relationships.
- High level of complacency.
- Inadequate provision of the PMTCT.
- Shortage of safe blood.
- Inability to provide comprehensive HIV/AIDS care
- Inability to provide home based care.

## 6.5 EQUITY AND GENDER

Most of the wetland resources are used by all sectors of society. However, gender roles can be relevant in harvesting and utilization of various resources. For example, males are more likely to harvest and use clay for construction and brick-making, while females are more likely to use clay for pottery. Collecting water for domestic use is mainly performed by girls and women, while livestock watering tends to be a task for boys. For a detailed overview of gender roles for different activities, see the meeting reports of the Regional Workshop (Wetlands International 2019a) and the

HIV prevalence is estimated at 11% for Busia district in Uganda and at Busia county, Kenya estimated at 7% (GoU 2009; NACC 2015), much higher than the national average of about 5.7 percent and 4.7 percent in both countries (Table 11). Most residents in the border towns of Busia in Uganda and Kenya are migrants who moved in search of employment, mainly in-service provision to long-distance truck

community level meetings (Wetlands International 2019b and 2019c). Women play essential roles in agriculture - providing inputs, managing production, stewarding natural resources and generating off-farm income - but often benefit less than men. High-value agricultural production chains are usually run by male-dominated institutions, while women are often limited to local markets where they sell low-quality and residual products. All landscape-level interventions therefore need to attend to this imbalance through gender mainstreaming, in order to maximize the benefits of agriculture to women farmers, providing incentives to increase their productivity.

Uganda and Kenya are ranking #127 and #134 respectively (out of 189 countries) on the Gender Inequality Index rank of 2018 (Table 8; UNDP 2019). The Gender Inequality Index is 0.531 for Uganda and 0.545 for Kenya, where a value of 0 expresses perfect equality, while a value of one represents perfect inequality. Within Sio Siteko wetland landscape difficulties/challenges are still experienced in enhancing gender mainstreaming due to the following:

- Inadequate funding of gender programmes and lack of facilitation for the gender focal point person because of lack of clarity of gender investments and gender outcomes.
- Intangibility of gender mainstreaming initiatives because there is not direct benefits visible from carrying out gender related activities, hence little or no commitment in

investing in such activities.

- Inability to transform women's representation in gender sensitive decision making that is in spite of the fair representation of women in the decision-making process, gender sensitive decisions are rarely made.
- Non utilization of key guidelines for gender mainstreaming by respective officers in respective sector programmes.
- During the gender trainings, the process and role of mainstreaming is still conceived as a responsibility of the gender officer.
- The centrality and cross cutting influence of gender on outcomes of poverty eradication programmes has not been fully realized by programme designers and implementers.
- Absence of the line ministry technical support to the department of gender and other departments.
- Gender mainstreaming is not emphasized in most project designs and guidelines from ministries, and gender is not well emphasized in project implementation monitoring and supervision guidelines.
- Some bad traditions and culture which prohibit women from advancements.
- Central and Local governments often aim at overall livelihood improvement of people but should concern more whether poverty eradication programmes benefit the marginalized groups or actually increase inequality.

In Uganda, the Ministry of Gender, Labour and Social Development (MGLSD) is responsible for gender responsiveness and community development/mobilisation. It assists the sector in gender responsive policy development and supports districts to build staff capacity to implement sector programmes. The percentage of Water User Committees, Water Boards, Environmental management/Water catchment management committees with women holding key positions has been stable in Uganda in rural areas (86% in 2015/2016 and 85% in 2018/2019) and increased in urban areas (67% in 2015/2016 and 82% in 2016/2017), according to the Sector Performance Report (MWE 2019).

Most of the wetland resources are used by all sectors of society. However, gender roles can be relevant in harvesting and utilization of various resources. For

example, males are more likely to harvest and use clay for construction and brick-making, while females are more likely to use clay for pottery. Collecting water for domestic use is mainly performed by girls and women, while livestock watering tends to be a task for boys. For a detailed overview of gender roles for different activities, see the meeting reports of the Regional Workshop (Wetlands International 2019a) and the community level meetings (Wetlands International 2019b and 2019c).

### **Climate change and gender inequality**

Women tend to be responsible for procuring and providing food in households and are the primary workers engaged in subsistence agriculture. They make up an average of 43 percent of the agricultural workforce in developing countries. Even so, they experience inequitable access to land and agricultural inputs, which can affect their productivity in the sector, generating a gap in comparison with men's productivity. In Ethiopia, Malawi, Rwanda, Tanzania and Uganda the gender gap in agricultural productivity ranges from 11 percent to 28 percent (UNDP 2019). The difference is due to access to credit, ownership of land, use of fertilizers and seeds, and availability of labour.

As in many other dimensions, gendered norms and traditions at the household level are behind the inequitable allocations of production factors, thus limiting women's agency, decision-making power and participation in the labour market. Furthermore, the gender agricultural gap hinders poverty reduction, inequality reduction and the mitigation of climate change effects and environmental degradation. Greater female participation in natural resource management, productive agricultural activities and natural disaster responses can enhance the effectiveness and sustainability of policies and projects. Closing the gender gap in agricultural productivity would increase crop production by 7–19 percent in Ethiopia, Malawi, Rwanda, Tanzania and Uganda (UNDP 2019).

Climate change can affect women's income, education, access to resources, access to technologies and access to information. It is entangled with economic and social consequences for women. Women in developing countries are highly vulnerable when they depend heavily on local natural resources for their livelihood. Yet women are powerful agents of change. As key players in core productive sectors, they are well placed to identify and adopt appropriate strategies to address climate change at the household and community levels.

This monograph describes the historical and current situation of the Sio Siteko wetland landscape, including its issues and causes, threats and pressures. This chapter summarizes the main challenges in the wetland landscape, which is the starting point for the (improved) management of the wetland area and possible interventions and investments, which will be discussed in the Wetland Management Plan and Conservation Investment Plan respectively.

### 7.1 MAIN CHALLENGES

#### 7.1.1 Destruction of the wetland

Encroachment, soil erosion and sedimentation and invasive species are the main drivers of wetland destruction in the Sio Siteko wetland landscape. This destruction has resulted in a greatly **compromised ecological functioning**, the **loss of biodiversity** that thrives in the riparian vegetation, and in **undermining of natural resources** vital for lives and livelihoods of riparian communities.

One of the most important examples of wetland destruction is the **cultivation of crops on the river banks and the encroachment into the wetlands**. The land cover dataset does indicate that built up areas have increased significantly, increasing more than tenfold between 1995 and 2015. Google Earth imagery (as in Figure 21) suggests that encroachment has doubled or even tripled between 2010 and 2019 in some branches of the wetland. Expansion and encroachment occur as a result of a shortage of land, which is further increasing due to soil degradation associated with poor agricultural practices that forces farmers to leave the land fallow to recover. Besides local farmers, increasingly it is the big investors that purchase or lease large tracks of land adjacent to the wetland areas to subsequently expand their operations into the wetlands. **Deforestation** not only affects the local ecology, but also contributes to lower groundwater levels in downstream areas since by lowering the natural groundwater recharge rate.

Changes in erosion and sedimentation patterns are another visible result of wetland destruction and also contribute to further degradation. In the upstream reaches of River Sio planting of Eucalyptus and other water-intensive trees has accelerated **soil erosion and reduced flow in streams and rivers** in the wetlands, particularly around Busumba, Buyengo, Mundulusia and Busimba in Uganda, and northeast of the road Busia-Bumala in Kenya. Due to

**sedimentation**, higher surface runoff rates due to environmental degradation and clogging of the main river channel flooding is increasingly a problem. At the mouth of River Sio the inundation after heavy rainfall may span a width of up to three kilometres. Waterlogged conditions are affecting those crops and natural vegetation that are intolerant to the prolonged low oxygen wet conditions.

Several **invasive species** impact the Sio Siteko wetland system, by competing with native species for food and space and introducing disease. The **touch-me-not plant (*Mimosa pudica*)** is a creeping flowering plant of the pea/legume family that changes soil physical and chemical properties, effecting crops and slowing down grass growth affecting livestock keepers. **Common lantana (*Lantana camara*)** is becoming a dominant understorey shrub that is reducing the productivity of pastures through the formation of dense thickets, which reduce growth of crops as well as make harvesting more difficult. **Water hyacinth (*Pontederia crassipes*)** spreads prolifically in Lake Victoria and affects communities and biodiversity at the Sio river mouth by obstructing (fishing/transport) boats, forming perfect breeding ground for malaria mosquitoes and other vector-spread diseases, and locally it deoxygenizes water having a huge negative on young fish.

The clogging of waterways with such invasive species, along with predation by the introduced Nile perch, the use of destructive fishing gears especially at the river mouths (including mosquito nets), and the destruction of spawning and nursery grounds due to encroachment into the wetlands are the main causes for **fish stock reduction** (Ogutu-Ohwayo et al. 1990, Ochumba et al. 1990). Fish species such as Echachu, Labue, Schilbe, Mumairus, mud fish/lung fish, P. Eels, Vidonge and fish-Syodonta have disappeared, and other populations and under great pressure.

#### 7.1.2 Overexploitation of natural resources

Wetland resources such as papyrus, wood, fish, sand and grassland are being overharvested. Indiscriminate sand harvesting at local scale is contributing to the degradation. **Overfishing** and the use of **illegal fishing methods** is reducing fish stock and breeding sites are disappearing. With 19,000 heads of cattle and 16,000 goats in the project area (numbers as per 2009 and approximately doubling every five to ten years) **overgrazing** is a major threat Sio Siteko wetland landscape. Livestock keepers keep large herds without having access to

proper grazing lands. This has not only led to reduced wetland vegetation, but has also been a major source of conflict in the area. Often, the cattle wanders through farmlands and destroys crops, leading to disharmony amongst farmers and livestock keepers. Communities advocate for zonation of grazing lands and promotion of Napier grass growing, but till now it has been difficult to implement such ideas at scale.

The **overexploitation of timber**, mainly for firewood and charcoal production, is a reflection of the overreliance of the population on these resources for energy production. This is exacerbated by the lack of alternative options, rendering these resources are prone to depletion. Local communities **harvest papyrus in mass and without control** on quantity, period for regeneration or harvesting methods and load it on trailers for sale to UAE traders. Hotspot areas for these activities are Siteko and Buduluku. Finally, **Overabstraction of water** resources is an important contributor to lower groundwater levels, decreasing the yield of springs and boreholes or even causing them to run dry.

### 7.1.3 Decreasing access to safe and clean water

The **supply of safe and clean water is low and** in some areas water availability is **decreasing**, as springs, shallow wells, boreholes dry up due to falling groundwater levels and diversion of water courses (anecdotal evidence). The water shortages were reported in Busia Township and in the surrounding villages of Mayenje, Bwarira, and Busumba. Access to safe water, however, is an equally big problem in the rural areas, albeit for different reason, such as shortage of infrastructure and broken infrastructure.

This challenge is complicated by **poor water quality** in the wetland area. **Point source pollution** including open defecation and improper waste disposal are poisoning fish in f.e. in Buyende, Buyisa, Hadoda, Sidonge, Lugala, Buradi, Mayenje, Buradi, Rukada, Bukhwamba, Buyingi, Mramba and Sigalame. Altogether the poor water quality is a major threat not only to communities, but also to the ecological functioning – including survival of fish – in the wetland.

### 7.1.4 Conflicts between wetland users

An increasing number of **conflicts** has been reported between various wetland users. Local communities and other wetland users do not always adhere to set rules and regulations in their operations in the

wetland, posing a threat to the ecological functioning of the wetlands, and leading to an ever-increasing number of conflicts between different users and between users and the responsible authorities. The latter type of conflict is enhanced when clear demarcation of different landscape zones and the policies and laws that must be adhered to are lacking. Conflicts between crop farmers, herdsmen, plant harvesters, grass harvesters, clay miners, sand miners and more are intensified by decreasing land and resource availability. In addition, the encroachment and disappearance of natural vegetation has increased the frequency of human-wildlife conflicts.

### 7.1.5 Institutional challenges

Further challenges include the inadequate political support for local institutions, limited incorporation of scientific knowledge in management policies, as well as limited application and sustainability of the interventions. Additionally, **sporadic and limited funding** jeopardizes the functioning of institutions and increases the dependence on NGOs

## 7.2 ROOT CAUSES

### 7.2.1 Widespread poverty

A **high Multidimensional Poverty Index** (39% of the population in Kenya and 55% in Uganda is in multidimensional poverty; UNDP 2019b), as a consequence of low income, large families, high incidence of diseases, and loss of crops and livestock to droughts and floods, is a serious concern. The continuous striving for a better life has put unprecedented pressure on water and environment resources in the Sio Siteko wetlands. Only by addressing the environmental and nature challenges in combination with strengthened livelihood resilience can conservation become a success.

### 7.2.2 Rapid population growth

The challenges listed above are exacerbated by **high population growth rate** (2.8% per year). The rapid population growth increases pressure on natural resources by increasing demand for raw materials, food and water, and land for settlements, livestock grazing and agriculture. In addition, solid and liquid waste accumulation increases, creating a higher risk of pollution of water resources, especially where sanitation services are not developed at the same rate.

### 7.2.3 Weak law enforcement and institutional capacity

Institutional challenges, including **weak policy and law enforcement** increase the occurrence and impact of wetland destruction and overexploitation. Local communities and other wetland users do not always adhere to set rules and regulations in their operations in the wetland, posing a threat to the ecological functioning of the wetlands. There is also a lack of a wetland-specific law to combat rampant degradation and support effective conservation efforts. This is further enhanced by weak institutional capacity on land, water resources and catchment management. Weak law enforcement of existing policies and legislation is increasing the occurrence and impacts of illegal overexploitation of natural resources and destruction of the wetland system. Finally, the enforcement is challenged by a general lack of demarcation of areas that should be protected, conserved or restored. Furthermore, when there is agreement on the boundaries of protected or designated restoration zones, it is typically unclear which policies, by-laws and regulations apply.

An underlying contributor to the weak law enforcement and institutional capacity is a **limited understanding of transboundary issues** (only on paper) and **limited transboundary implementation of policies and laws**. Principles and guidelines need to be cascaded to local governments. An important component of transboundary implementation of policies and laws is harmonisation. For example, the definition of riparian land, which is 20 km in Kenya and 100 km in Uganda attributed to availability of land. There is a need for harmonisation to effectively address issues of resource use and prevent transboundary conflicts.

### 7.2.4 Lack of awareness, education and participation

There is a **need for better communication, education, participation and awareness on the value of wetland landscapes and its ecosystem services**. For many years, Ugandans and Kenyans have taken water and environment resources for granted, expecting these resources to always be available. The continuous striving for a better life and high population growth rate have put unprecedented pressure on water and environment resources. The drastic changes in weather and climate across the globe, the declining condition of the rivers, lakes, groundwater, forest and wetland cover as a result of unregulated conflicting human action represent an important aspect of environmental

issues that require urgent attention. The balance in Sio Siteko is a fragile one. The population is fully dependent on the wetland natural resources for their livelihoods, but there is little awareness on the need for conservation and sustainable utilization. Lack of participation also leads to silent and open resistance to wetland management from the public.

### 7.2.5 Poor access to safe water resources and sanitation facilities

While the quantity of water resources is sufficient overall, the access to safe and clean water resources is not guaranteed. Reported water shortages are in part caused by overexploitation of (ground)water and diversion of water courses (anecdotal evidence). In rural areas, the main reason for limited access to water is a shortage of infrastructure. In some areas there may be **insufficient infrastructure**, but present but non-functioning infrastructure is equally relevant. Poor access to safe and clean water resources also results from locally poor water quality in the wetland landscape, which is in turn mainly caused by human activities. **Inadequate waste disposal and poor access to sanitation and water treatment services** throughout the catchment of River Sio are the main drivers of point source pollution. In Busia Town the sewerage company is a big polluter as it discharges untreated waste water into the river, and so are the hospitals that dispose biomedical waste into the river. In addition, the local population wash bikes and vehicles near surface water resources.

### 7.2.6 Climate change

**Climate change** already has an observable effect on development in the Sio Siteko landscape, especially with its high dependency on rain-fed agriculture and cattle grazing, and is expected to continue to do so in the future. The main threats are the **increasing variability in rainfall and rising temperature**. Although highly uncertain, models indicate that rainfall may increase during the short rain season months of October and November, and during the dry season from January to February. Temperatures may increase with 1.2°C to 2.0°C. Rising temperatures and shifting or increasingly unpredictable rainfall patterns can reduce the amount of grazing areas and agricultural land, shorten growing seasons, hamper crop production, undermine the (ground) water resources and alter the occurrence and distribution of pests. Therefore, climate change is a threat to the resources in the wetland region and could aggravate the impact of rapid human population growth, conflicts over resources and widespread poverty.

### 7.3 THREATS AND PRESSURES

A major threat to the Sio Siteko wetland is the **acceleration of land use change**. The natural system is being changed into one at the mercy of mankind, where loss of ecosystem services and key habitats, sedimentation, pollution and eutrophication are increasingly problematic.

This threat is exacerbated by the pressures that the landscape is facing, which have largely already been identified as root causes for the main challenges the wetlands are facing (see previous section). Climate change and increasing population are pressures that are steadily increasing, and therefore their effects on the wetland can be expected to be enhanced throughout the coming years and decades.

### **PHYSICAL LANDSCAPE**

#### **Location and delineation**

The Sio Siteko project area is located northeast of Lake Victoria and lies along the border between Uganda and Kenya. This area lies within the Busia District of Uganda and mainly within the Busia County of Kenya. The boundaries of the wetland landscape are consistent with the boundaries of the study area of the previous wetland management plan and are based on a combination of topography and the road network.

#### **Topography, geology and soils**

The altitude of the Sio Siteko study area is located mainly between 1,135 and 1,200 m asl, with the only exception being several elongated NW-SE orientated rocky outcrops ranging up to 1,450 m asl in the most southern part of the catchment. The geology of the River Sio basin is mainly composed of Precambrian intrusive and metamorphic rocks, Tertiary volcanic and intrusive rocks, and Pleistocene unconsolidated sediments.

#### **Hydrology and water resources**

Annual precipitation varies between approximately 2000 mm per year in the upper reaches of the catchment and 1400 mm per year in the lower reaches near Lake Victoria. There are two rainy seasons, the long rains between March and May and the second rainy season between late September and November.

The River Sio originates south of Mount Elgon and flows in a south-westerly direction before draining into Lake Victoria. The river discharge is highest in the wet season, with an average discharge of 35 m<sup>3</sup>/s in May, and lowest in the dry season, especially January to March when discharge decreases to about 5 m<sup>3</sup>/s. Trends show that discharge in the rainy months May and November were around 25% higher in the period 1990-2018 compared to 1958-1989, while extreme low flows were 5-10% lower. These changes suggest lower buffering capacity in the catchment, which is in line with the increasing encroachment in wetland areas.

The dramatically increased flow in the wet season frequently results in flooding of the areas near the river and its tributaries. The flooding can extend hundreds of meters up to even a couple of kilometers wide and can last two to three months, usually in the period March to May. At the end of the dry season, water retreats to the stream channel. In some locations, the stream may even run dry or contain only standing water. Groundwater resources can

be found in the Precambrian crystalline basement rocks when weathered and/or fractured. Most boreholes in the region tap groundwater from these basement aquifers. There is anecdotal evidence that groundwater levels are decreasing.

#### **Water quality and hydrological functions of wetland system**

One of the most important threats to water quality is faecal contamination. Though Busia has water treatment in the form of sewage ponds, most residents of the study area use open pit latrines. A second threat is domestic waste. This is especially important at the landing sites, or in other settlements close to surface water. The last important threat to water quality is the use of fertilizers and pesticides. The Sio Siteko wetland landscape plays an important role by supporting ecosystem processes and regulating the dynamics of the hydrological system (buffer function) for the waters entering Lake Victoria, reducing peak flow and contamination, and storing potable water.

#### **Climate change and carbon sequestration**

Water resources of the wider Sio Siteko area are likely to be increasingly strained in the future climate. Precipitation is projected to change by less than 5% per month, except in February, October and November, which show 5–15% higher precipitation by 2050. However, the projections are very uncertain, meaning that more significant increases or decreases in precipitation cannot be ruled out. Temperatures are expected to rise by up to 2°C by 2050. Increasing temperatures can result in higher drought and flooding frequencies and intensities, which will likely reduce crop yields and cause a loss in livestock, which will have important implications for food security. Wetlands are an effective sink for carbon, playing a key role in buffering the drivers of climate change, thereby supporting climate change mitigation. Therefore, the Sio Siteko wetland landscape needs better protection from human disturbance and warming, to avoid the release of major heat-trapping greenhouse gases, including carbon dioxide.

Wetlands are an effective sink for carbon, playing a key role in buffering the effects of climate change, thereby supporting climate adaptation and resiliency. Therefore, the Sio Siteko wetland landscape needs better protection from human disturbance and increasing temperatures, to avoid the release of carbon dioxide. The unsustainable use of Sio Siteko peatlands could turn these peatlands from a carbon sink to a huge carbon source (NBI Carbon Study; Elsehawi et al. 2019).

## **Land use and land cover**

The Sio Siteko wetland landscape largely consists of cropland (80%), with wetland areas immediately surrounding the River Sio and its tributaries. Scattered within the catchment are patches of tree cover and built-up area. Encroachment of agricultural land into the wetlands has increased dramatically in recent years, especially for rice and sugarcane. The land cover dataset does indicate that built up areas have increased significantly, increasing more than tenfold between 1995 and 2015. Google Earth imagery (as in Figure 21) suggests that encroachment has doubled or even tripled between 2010 and 2019 in some branches of the wetland. Encroachment has increased more significantly near settlements and roads, and along the tributaries of the River Sio, than along the River Sio itself. Agriculture on the slopes between the settlements on higher ground and the valley floors is also more common now than in previous decades.

A possible explanation for increasing agricultural activity is the high population growth rate (2.8% per year) in and around the wetland areas. Increasing encroachment is also attributed to poor agricultural practices, which have caused soil fertility to decline in fields on the higher ground near the settlements. Tree cover has decreased as trees are cleared for agricultural fields and to provide firewood. The deforestation and increasing agricultural area on the slopes also increase erosion and the risk of landslides.

## **BIODIVERSITY AND ECOSYSTEM SERVICES**

### **Biodiversity**

The Sio-Malaba-Malakisi wetland is an IBA in which over 300 bird species have been documented including; the endangered Grey Crowned crane, the globally threatened Papyrus Gonolek and Pallid Harrier. Notable mammals found in the area include Vervet Monkey, Otter, Sitatunga, Hippopotamus and Water Mongoose. The wetlands provide habitat for several other species including 206 plant, 29 fish, 25 mammal, eight reptile and several invertebrate species.

### **Wetland ecosystem services**

Wetlands provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and cultural benefits and ecosystem health services that maintain the conditions for life on earth, such as nutrient cycling. The Sio Siteko wetland has ecological and socioeconomic impact

by improving water quality, water supply, flood control, storm protection, and is a source of fish to the people of the area, of medicinal plants, of grazing land and of raw materials for building and making crafts. Furthermore, the wetland provides cultural services, including providing a sense of place and hosting baptisms and other religious services.

## **POLICIES AND INSTITUTIONAL CONTEXT**

### **Main stakeholders**

The main actors range from global and regional organizations, that are by definition transboundary in nature, to institutions at national level and local institutions; see Figure 24.

### **Policies and legislations**

The main policies that have direct bearing on wetlands include Environment, Water, Agriculture, Forestry, Livestock, Fisheries, Tourism, Land and Wildlife Policies. The transboundary Sio Siteko wetland system calls for a multi-layered participatory approach which should carefully be linked to the transboundary conservation interests.

### **Protected areas**

The Sio Siteko wetland landscape has been designated as an Important Bird Area (IBA) by Birdlife International, since the landscape is an important breeding and feeding site for thousands of birds. Despite the importance of the landscape for birds, Sio Siteko lacks formal protection that allows for coherent conservation action and management. In 2015 the Government of Kenya, submitted Sio Siteko as one of four wetlands to be considered for designation as a Ramsar Site in the 2015-2018 triennium. However, the Kenya Wildlife Service (KWS) identified inadequate resources to finalise the information sheets and consultations with key stakeholders as one of the major challenges.

### **Natural resource management**

There are four distinct ownership of resources: Private land, Central government resources, Communal resources and Local/District council resources. Transboundary institutional arrangement on natural resources is fairly absent, except for project supported initiatives.

## **SOCIO-ECONOMIC SYSTEM**

### **Livelihood and socio-economic system**

Agriculture is the backbone of the Missenyi and Kyotera District Councils economy and most of

its residents depend on it as their main source of livelihood. A big proportion of the population is peasants whose livelihood is basically ensured through subsistence crop farming. Multidimensional poverty remains widespread in most parts of Uganda as well as Kenya, and is generally perceived differently by the different categories of people.

### **Livestock and agro-pastoralism**

Within the Sio Siteko wetland landscape, people's livelihoods comprise a wide spectrum of activities, including agricultural production, livestock production and fishing, as well as trade. Agriculture is the main source of income in the area.

### **Crop production and forestry**

Agriculture is an important activity and a majority of the land cover consists of croplands. Most of the agriculture is rain-fed, though small-scale irrigation was observed in the valleys during the field visits. The main crops that are grown within the county include maize, beans, groundnuts sweet potatoes, millet, sorghum, cassava, cotton, rice, tobacco and sugarcane. Massive planting of Eucalyptus tree species in and around the wetland has resulted in the drying of the wetlands.

### **Fisheries and aquaculture**

Fishing, both in Lake Victoria and in surrounding wetlands is one of the major economic activities in the landscape, despite the fishing industry being quite underdeveloped. Within the project area, there are five fish landing sites, of which Sio Beach is the largest. Most of the fishing is done in Ugandan waters, though trade is mainly in Kenya. Important species are tilapia species, Nile perch, lung fish, the silver cyprinid, Barbus species, and the African catfish or Kambale.

### **Energy sources**

The main source of energy in both the Ugandan and Kenyan side of the wetland landscape is firewood. Only one in every 16 households use a type of fuel other than firewood for cooking. Similarly, more than half of households use kerosene lamps for light as electricity is only available for one in every five of households. More efforts are highly needed to promote the use of solar energy especially in the rural areas in order to avoid and reduce environmental degradation through charcoal burning.

### **Trade and industries**

Trade is thriving in the study area, especially in Busia. Thanks to its status as entry point between Kenya

and Uganda there is bustling trade in livestock, agricultural products, and manufactured goods in this town. In Busia, Kenya, there are two sugar factories located. Sand mining is important for livelihoods in the Sio Siteko wetland landscape.

### **Eco-tourism**

Although Kenya and Uganda are one of the leading tourism destinations in the world, the tourism industry in and around the wetland locations in the two countries is under-developed. There are however, some attractive tourist sites and significant potential in that sector, such as nature based activities such as bird watching, sport fishing, canoeing and water sports. More efforts are needed to promote community based low-impact eco-tourism, combining both income generation and nature conservation.

## **SOCIAL DIMENSION**

### **Human demography**

High population growth rate in Sio Siteko exerts pressure on meagre land resources and complicates and exacerbates environmental problems, mismanagement of the land, natural resource depletion and environmental degradation. The Population and Housing Census shows that at Busia District (UGA) the population stood at 325,000 in 2014, with the males comprising 48.3 percent (156,000), and females constituting 51.7 percent (169,000). At Busia District (KEN) the population stood at 826,000 in 2015, with the male comprising 48.2 percent (399,000) and females constituting 52.8 percent (427,000). The total population in Sio Siteko wetland landscape is calculated to be currently 273,000 (2019) and is expected to rise to 340,000 in 2025 and 370,000 in 2030 with an average population growth rate of 2.77% per year (see Table 7 and Figure 35).

### **Water supply and sanitation**

A shortage of water for domestic consumption, livestock watering and irrigation is experienced especially during the dry season in Sio Siteko wetland area. This can be explained in terms of both inadequate resources exploitation and poor technology as well as resource scarcity. Deep groundwater has not yet been explored but shallow groundwater is found to be brackish and hard in some areas (isolated spots), due to deposits of gypsum and calcium carbonates of volcanic origin. This results in locally highly mineralized groundwater (brackish) causing corrosion and borehole breakdown in some areas. There is limited access to adequate sanitation in most of Sio Siteko wetland area.

## Public health and diseases

Many people in and around Sio Siteko, particularly in fishing communities, experience a lack of access to clean drinking water and improved sanitation. Waterborne diseases can be spread via groundwater which is contaminated with faecal pathogens from pit latrines (Figure 40), and as a result cholera and diarrhoea are common amongst communities within the wetland. Malaria accounts for 59% of all reported cases of disease in Busia district of Uganda (GoU 2019). In Busia county of Kenya, there were 78 cases of Malaria reported per 100 people in 2013 (MoH 2015). HIV prevalence is estimated at 11% for Busia district in Uganda and at Busia county, Kenya estimated at 7% (GoU 2009; NACC 2015), much higher than the national average of about 5.7 percent and 4.7 percent in both countries (Table 11).

## Equity

Uganda and Kenya are ranking #122 and #126 respectively on the Gender Inequality Index rank of 2014 (Table 7) with a coefficient of human inequality of 28.2 and 26.3. The national inequality in income is for Uganda 24.2% and for Kenya 33.1% (UNDP 2017). The Gini coefficient measures the inequality between levels of income. A value of 0 expresses perfect equality, while a value of one represents perfect inequality. The value of this coefficient at national scale over the period 2010 – 2017 was 48.5 in Kenya and 41.0 in Uganda (UNDP 2019).

## MAIN CHALLENGES

### Main challenges

The destruction of wetlands, overexploitation of natural resources, decreasing access to safe and clean water, conflicts between wetland users and institutional challenges are the main challenges the Sio Siteko wetlands are facing. The destruction of wetlands is mainly the result of severe wetland encroachment and deforestation, especially in the last decade, often replacing natural vegetation for crop cultivation on the riverbanks. Changes in erosion and sedimentation patterns have reduced flow in streams and rivers of the wetlands, and clogging is increasingly common even in the main channel of River Sio. Invasive species of vegetation and fish compete with

native species and can introduce disease. At the same time, wetland resources including papyrus, wood, water, grazing land and sand are being overexploited.

The impact of wetland destruction and overexploitation on the availability of land and wetland resources is linked to increasing conflicts between wetland users. In addition, poor water quality as a result of point source pollution is increasingly common. Finally, political and financial support of local institutions is inadequate and there is limited incorporation of scientific knowledge in management policies. Together, these challenges are undermining the health of natural resources that form the basis of ecological functioning as well as the livelihoods of riparian communities.

### Root causes, threats and pressures

The challenges and increasing pressure on the wetland landscape are attributed to a set of root causes. First, the continuous striving for a better life and to escape the effects of poverty along with rapid population growth increase demand for raw materials, water and food, as well as land. Second, enforcement of existing policies and legislation is lacking and complicated by a general lack of demarcation of protected areas and restoration zones and understanding of which policies and laws are relevant in which area, as well as differences in policies and legislations between Kenya and Uganda. Third, a lack of awareness of the value of wetland landscapes as well as their hydrological and ecological functioning hinders more sustainable use of the resources. In addition, poor access to sanitation and waste disposal services is an important cause of pollution and poor water quality. Finally, climate change is expected to increase precipitation in the short rain and main dry season, as well as increase the frequency and intensity of droughts and floods.

The main threat the wetland faces is the acceleration of land use change, which is closely linked to rapid population growth and a lack of enforcement of laws and policies. Only by addressing the environmental and socio-economic issues listed here in combination with strengthened livelihood resilience can the threats and challenges be addressed and will conservation become a success.

- 1) African Great Lakes Conference (2017) Report
- 2) Akite, P (2008a). *Biodiversity Monitoring for Ecology and Conservation: a case study of butterflies of selected sites in the Sango Bay and Iriiri Areas*. MSc thesis. Makerere University, Kampala
- 3) Akite, P (2008b). *Effects of anthropogenic disturbances on the diversity and composition of the butterfly fauna of sites in the Sango Bay and Iriiri areas, Uganda: implications for conservation*. *Afr. J.Ecol.*46 s1, Biodiversity in inhabited areas of Eastern Africa, pg 3-13.
- 4) Akite, P. (2019). *Status of selected insect fauna (Butterflies and dragonflies) of the selected wetland systems: Sio – Siteko, Sango Bay – Minziro and Semliki Delta*. Dept. of Zoology Entomology and Fisheries Sciences, Makerere University, Uganda.
- 5) Alberto et al. (2016). Monitoring stream sediment loads in response to agriculture in Prince Edward Island, Canada. Alberto A., St-Hilaire A., Courtenay SC., van den Heuvel MR. *Environ Monit Assess.* 2016 Jul;188(7):415. doi: 10.1007/s10661-016-5411-3. Epub 2016 Jun 17.
- 6) APHA (2005). *American Public Health Association Standard Methods for the examination of water and wastewater*, 21st edn. Washington, DC: APHA-AWWA-WEF. ISBN 0875530478.
- 7) Aura, M. C., Musa, S., Yongo, E., Okechi, J., Njiru, J. M., Ogari, Z., Abwao, J. (2017). *Towards balancing lake use and culture fisheries off Lake Victoria beaches, Kenya: Mapping and socio-economic assessment of cage culture*. *Aquaculture Research*, 00, 1–14. <https://doi.org/10.1111/are.13484> Barel C.D. N et al (1985) Destruction of Fisheries in Africa's Lakes. *Nature Lond.* 315 (614):19-20.
- 8) Behangana, M. (2019). *Status of biodiversity of herpetofauna in three selected wetlands in Uganda: Sio Siteko, Sango Bay – Minziro and Semliki Delta*. Dept. of Environmental Management, Makerere University, Uganda.
- 9) Bibby C.J. et al (2000). Bibby C.J., Burgess N.D., Hill D.A., and Mustoe S. 2000. *Bird Census Techniques*. 2nd Edition. Academic Press, USA.
- 10) Birdlife International, 2018.
- 11) Bwire et al 2013. Bwire, G., Malimbo, M., Maskery, B., Kim, Y. E., Mogasale, V., & Levin, A. (2013). The burden of cholera in Uganda. *PLoS neglected tropical diseases*, 7(12), e2545.
- 12) Climate Change Profile Uganda, Ministry of Foreign Affairs of the Netherlands, April 2018
- 13) Climate Service Center Germany (2015). Climate-fact-sheet. Uganda. Updated version 2015 <[https://www.climate-service-center.de/products\\_and\\_publications/fact\\_sheets/climate\\_fact\\_sheets/index.php.en](https://www.climate-service-center.de/products_and_publications/fact_sheets/climate_fact_sheets/index.php.en)>
- 14) CIDP 2018. <http://www.cidp.org/>. County Government of Busia (CIDP)
- 15) Cowman et al; 2017. *Factors associated with cholera in Kenya, 2008-2013*. *Pan African Medical Journal*. 28. 10.11604/pamj.2017.28.101.12806. Cowman, Gretchen & Otipu, Shikanga & Njeru, Ian & Achia, Thomas & Thirumurthy, Harsha & Bartram, Jamie & Kioko, Jackson. (2017).
- 16) Cross S. (2002). A Comparative Study of Land Tenure Reform in Four Countries: Uganda, Tanzania, Malawi and Kenya. LADDER Working Paper No. 31
- 17) Daily Monitor 2018. <<https://www.monitor.co.ug/Business/Markets/Who-will-gain-most-Busia-joint-border-post/688606-4322344-vkvdqrz/index.html>>
- 18) Elsehawi, S., Berthelme, B., Beer, F., Joosten, H. (2019) *Assessment of Carbon (CO<sub>2</sub>) emissions avoidance potential from the Nile Basin peatlands*. Technical report, as part of Biodiversity Conservation and Sustainable Utilisation of Ecosystem Services of Wetlands of Transboundary Relevance in the Nile Basin. *Greifswald Mire Centre, Germany*. NBI 2019.
- 19) ESA CCI Land Cover 2019. Land cover maps at 300 m resolution. Downloaded from: <[http://maps.elie.ucl.ac.be/CCI/viewer/download.php\\_on\\_31-01-2019](http://maps.elie.ucl.ac.be/CCI/viewer/download.php_on_31-01-2019)>

- 20) ESA CCI Land Cover 2017. Prototype land cover map over Africa at 20 m resolution. Downloaded from: <<http://2016africallandcover20m.esrin.esa.int>> on 10-02-2017
- 21) FAO 1993. Field measurements of soil erosion and runoff. Food and Agricultural Organization of the United Nations, Rome, 1993. From: <<http://www.fao.org/3/To848E/to848e-10.htm>>
- 22) Fryer, G.& T. D. Iles, (1972). *The Cichlid Fishes of the Great Lakes of Africa: Their biology and evolution*. Oliver and Boyd, London, 641pp.
- 23) Funk, C., Verdin, A., Michaelsen, J., Peterson, P., Pedreros, D., Husak, G. (2015). A global satellite-assisted precipitation climatology. *Earth System Science Data*, 7, 275-287.
- 24) GAIN index, The GAIN index summarizes a country's vulnerability to climate change and other global challenges in combination with readiness to improve resilience. <<https://gain-new.crc.nd.edu/ranking>> Accessed in August 2019
- 25) Government of Kenya (2013). Busia County Integrated Development Plan.
- 26) Government of Kenya (2014). Ministry of Agriculture Livestock and Fisheries, Government of Kenya, Agricultural Sector Development Support Programme.
- 27) Government of Kenya (2015). Economic Review of Agriculture. Government of Kenya (GoK), Nairobi, Kenya.
- 28) GoU 2009; Higher local government statistical abstract. Busia district. Government RDL, editor. Government of Uganda. (2009).
- 29) GoU (2018). *Resettlement Action Plan for Water Supply in Busia District and other sub-counties*. 122pp.
- 30) Guya, F. J. (2013). *Bioavailability of particle-associated nutrients as affected by internal regeneration processes in the Nyanza Gulf region of Lake Victoria*. *Lakes and Reservoirs: Research and Management*, 18, 1–15.
- 31) IPCC, 2014b: IPCC, 2014b: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.
- 32) IUCN (2019). IUCN Red List of Threatened Species. Version 2019.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 15 July 2019.
- 33) Kaggwa, D.K. (1995). *The abundance, diversity and distribution of butterflies in the Sango Bay project area*. MSc thesis, Makerere University, Kampala.
- 34) Kakuru, W. and Raburu, P. (2009). *Sio-Siteko Transboundary Wetland Community Based Management Plan*. 103pp.
- 35) Katunzi et al 2010; Katunzi E.F.B, A. Mbonde, R. Waya,2 and H. D. J. Mrosso (2010). Minor water bodies around southern Lake Victoria—a replica of lost biodiversity. *Aquatic Ecosystem Health & Management*, 13(3):277-283, 2010.
- 36) Kaufman, L. (1992). Catastrophic Change in Species-Rich Freshwater Ecosystems. *BioScience* 42:846- 858.
- 37) Kenya National Bureau of Statistics (2018). Economic Survey 2018. Downloaded from: <[www.knbs.or.ke/download/economic-survey-2018/](http://www.knbs.or.ke/download/economic-survey-2018/)>
- 38) KIWASH (2019) Busia County, USAID Kenya Integrated Water, Sanitation and Hygiene Project, [kiwash.org/busia\\_county](http://kiwash.org/busia_county), visited on 14 October 2019.
- 39) KMFRI. (2016) *Fish kills in cages off beaches in Lake Victoria, Kenya: Imprinting the possible causes*. Technical Report for Kenya Marine and Fisheries Research Institute (KMFRI) Kisumu. 12 pp.

- 40) KNBS 2009; Kenya National Bureau of Statistics. (2009). Livestock population in Kenya.
- 41) KNBS 2010; The 2009 Kenya population and housing census (Vol. 1). Kenya National Bureau of Statistics. (2010).
- 42) Kudhongania, A. W. and A. J. Cordone, (1974) *Batho-spatial distribution pattern and biomass estimate of the major demersal fishes in Lake Victoria*. Afr, J. Trop. Hydrobiol. Fish. 3:15-31.
- 43) Lowe-McConnell, R. H. (1987) *Ecological Studies in Tropical Fish Communities*. Cambridge University Press, London.
- 44) Masai D.M, J.E Ojuok and W. Ojwang (2001). Fish species composition, distribution and abundance in Lake Victoria basin, Kenya. 13pp
- 45) Maithya, J. and Jembe B.T. (1998). A survey of the Ichthyofauna of Lake Kanyaboli and small water bodies: Alternative Refugia for endangered Fish species. Afr. J. Trop. Hydrobiol. Fish. Vol. 8. NOS 1&2.Pg 9-12.
- 46) Martin, K.R. (2019). *Documentation of the status of mammals in three wetland basins in Uganda: Sio Siteko, Sango Bay – Minziro and Semliki Delta*. Dept. of Zoology Entomology and Fisheries Sciences, Makerere University, Uganda.
- 47) Masai D.M, J.E Ojuok and W. Ojwang (2001). *Fish species composition, distribution and abundance in Lake Victoria basin, Kenya*. 13pp
- 48) MEA (2005). Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, DC
- 49) MoALF (2016). Climate Risk Profile for Busia. Kenya County Climate Risk Profile Series. The Kenya Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya.
- 50) MoA 2009; Ministry of Agriculture, Animal Husbandry and Fisheries & Uganda Bureau of Statistics. (2009). The National Livestock Census Report 2008.
- 51) MoH 2015. *Busia county, health at a glance*. Ministry of Health, Kenya (2015).
- 52) MoH 2017a. Annual health sector performance report, financial year 2016/2017. Ministry of Health, Uganda (2017).
- 53) MoH 2017b. *Sanitation profile for Busia county 2017*. Ministry of Health of Kenya, World Bank, and UNICEF, (2017).
- 54) Mu Q., Zhao M., Running S. W. (2011). Improvements to a MODIS global terrestrial evapotranspiration algorithm. *Remote Sensing of Environment* 115: 1781-1800.
- 55) Munguti, J. M., Kim, J. D., & Ogello, E. O. (2014a). *An overview of Kenyan aquaculture: Current status, challenges, and opportunities for future development*. Journal of Fisheries and Aquatic Science, 17(1), 1–11. <https://doi.org/10.5657/FAS.2014.0001>
- 56) Munguti, J. M., Musa, S., Orina, P. S., Kyule, D. N., Opiyo, M. A., Charo- Karisa, H., & Ogello, E. O. (2014b). *An overview of current status of Kenyan fish feed industry and feed management practices, challenges and opportunities*. International Journal of Fisheries and Aquatic Studies, 1(6), 128–137.
- 57) Mwalo O, M. (1991). The biology and distribution of *Haplochromis* Spp in the Nyanza gulf prior to the Total invasion of the gulf by Nile perch, *Lates niloticus* (L) *Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on The Lake Victoria Fisheries*, 25-27th September 1991, Kisumu, Kenya; 73-83.
- 58) MWE (2019). *Uganda Water and Environment Sector Performance Report 2019*. Government of Uganda, Ministry of Water and Environment.

- 59) NACC 2015. Busia County HIV & AIDS Strategic Plan. National AIDS Control Council & The Global Fund (2015).
- 60) Nalwanga, D. et al (2012). Dianah Nalwanga, Derek Pomeroy, Juliet Vickery & Phillip W. Atkinson. (2012). *A comparison of two survey methods for assessing bird species richness and abundance in tropical farmlands*. Bird Study, 59: 83-95.
- 61) Nalwanga, D. (2019). *Report on avian diversity: Status of biodiversity in the Sango Bay – Minziro, Semliki Delta and Sio – Siteko Wetlands*. NatureUganda, Uganda.
- 62) Namaganda, M. (2019). *Documenting plant diversity in the transboundary wetlands of Semliki Delta, Sango Bay – Minziro and Sio – Siteko, Uganda*. Dept. of Plant Sciences, Microbiology and Biotechnology, Makerere University, Uganda.
- 63) NBI 2019b. *Economic Assessment of Wetland Biodiversity and Ecosystem Services as an Input for Development of Wetland Investment Plans: A Case Study of the Sio-Siteko Transboundary Wetland in Kenya and Uganda*. Draft version 30 November 2019. Prepared by Philip Otieno, Environmental Consultant at Devlink Resources Consultants
- 64) NEMA (2009), Uganda: Atlas of Our Changing Environment, National Environment Management Authority (NEMA) P. O Box 22255 Kampala Uganda
- 65) Njiru, J.M, Aura C. M and Okechi, J.K (2018). *Cage fish culture in Lake Victoria: A boon or a disaster in waiting?*. Fisheries Management and Ecology · DOI: 10.1111/fme.12283
- 66) Njoroge, M. K., Kilalo, D. C., Miano, D. W., & Mutisya, D. L. (2016). Whiteflies species distribution and abundance on cassava crop in different agro-ecological zones of Kenya.
- 67) Ochumba, P. B. O. (1990). Massive fish kills within the Nyanza Gulf of Lake Victoria, Kenya. *Hydrobiologia* 208:93-99.
- 68) Ochumba, P.B.O., M. Gophen, and U. Pollinger, (1991). *Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on The Lake Victoria Fisheries*, 25-27th September 1991, Kisumu, Kenya; 29-39.
- 69) Ogutu-Ohwayo, R. (1988). Reproductive potential of the Nile perch, *Lates niloticus* L. and the establishment of the species in Lakes Kyoga and Victoria (East Africa). *Hydrobiologia* 162:193-200.
- 70) Ogutu-Ohwayo, R. (1990). The decline of the native fishes of lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*. *Environmental Biology of Fishes*, 27:81-96.
- 71) Ogutu-Owayo, R., R. T. Twongo, S. B. Wandera and J. B. Balirwa (1991) *Suggestions to set mesh size limits and restrict the fishing methods and the type of fishing gears on Lakes Victoria and Kyoga*. Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on The Lake Victoria Fisheries, 25-27th September 1991, Kisumu, Kenya; 139-152.
- 72) Ogutu-Ohwayo, R., Wndera, S.B., Namulemo, G. and Mbabazi, D., (1998). *Effort Toward Conservation of Endangered Fish Species in The Victoria and Kyoga Lake Basins*. A Paper presented for an international Conference for the Paradi 74 Association and the Fisheries Society Africa, African Fishes and Fisheries : Diversity Utilizations: Grahamstown, South Africa, 13-19 September 1998.
- 73) Reynaldo, V., Banwart, S., Black, H., Ingram, J., Joosten, H., Milne, E., ... & Baskin, Y. (2012). The benefits of Soil Carbon-Managing soils for multiple economic, societal and environmental benefits. *UNEP Year Book*.
- 74) Ruegner et al. (2013): Turbidity as a proxy for total suspended solids (TSS) and particle facilitated pollutant transport in catchments. Ruegner, Hermann & Schwientek, Marc & Beckingham, Barbara & Kuch, Bertram & Grathwohl, Peter. (2013). Environmental earth sciences. 10.1007/s12665-013-2307-1.

- 75) Semazzi, F. (2005): Opportunities for Collaboration with Uganda Institutions in Climate Change Education & Development of Adaptation Strategies. North Carolina State University. <[http://climlab02.meas.ncsu.edu/confpres/Semazzi\\_Uganda\\_July\\_2010Talk\\_v6.pdf](http://climlab02.meas.ncsu.edu/confpres/Semazzi_Uganda_July_2010Talk_v6.pdf)>
- 76) Shoko, A. P., Limbu, S. M., Mrosso, H. D., & Mgaya, Y. D. (2014). *A comparison of diurnal of water quality parameters in Nile tilapia (Oreochromis niloticus, Linnaeus, 1758) monoculture and polyculture with African sharp tooth catfish (Clarias ariepinus, Burchell, 1822) in earthen ponds.* International Aquatic Research, 6, 56. <https://doi.org/10.1007/s40071-014-0056-8>
- 77) SMMR-BMP (2009). Proposed policy, legal and institutional framework for sustainable management and development of water resources in the Sio-Malaba Malakisi River Catchments. Unpublished Report by NELSAP.
- 78) TAFIRI (2013) *Technical report on biological and environmental monitoring in satellite lakes and rocky habitats in Tanzania side of the Lake Victoria basin.* Submitted to LVEMP II
- 79) TAFIRI (2014) *Technical Report on Biological and Environmental Monitoring in Satellite lakes in Tanzanian side of the Lake Victoria, Basin Tanzania.* National Working Group. Lake Victoria Environmental Management Project Phase II. Tanzania 43pp.
- 80) Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An Overview of CMIP5 and the Experiment Design. *B Am Meteorol Soc*, 93, 485-498. 10.1175/bams-d-11-00094.1. CCKP data products: prepared and processed by National Center for Atmospheric Research - Research Applications Laboratory (NCAR-RAL).
- 81) TEEB (2010). The economics of ecosystems and biodiversity for national and international policymakers.
- 82) TIES 2015. The International Ecotourism Society (TIES)
- 83) UAC 2017. Uganda AIDS Commission & The Uganda HIV/AIDS Partnership. (2017). Uganda HIV/AIDS Country Progress Report July 2016-June 2017. Theme: “Reaching men, girls and young women to reduce new HIV infections”.
- 84) UBS 2014; National population and housing census 2014. Uganda Bureau of Statistics. (2014).
- 85) Uganda Water Supply Atlas (2017). Uganda Water Supply Atlas, Directorate of Water Development, Ministry of Water & Environment, The Republic of Uganda.
- 86) UN 2019; World Population Prospects 2019, Online Edition. Rev. 1. United Nations, Department of Economic and Social Affairs, Population Division (2019).
- 87) UNAIDS. (2018a). Country factsheets Uganda 2018.
- 88) UNAIDS. (2018b). Country factsheets Kenya 2018.
- 89) UNDP 2017. <<http://hdr.undp.org/en/composite/IHDI>> visited on: 15 October 2019.
- 90) UNDP 2019, Human Development Report 2019, Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century, United Nations Development Programme, 2019, <<http://hdr.undp.org/en/data>> visited on: 15 October 2019.
- 91) UNDP 2019b, Multidimensional Poverty Index: developing countries, [http://hdr.undp.org/sites/default/files/mpi\\_2019\\_table\\_1.pdf](http://hdr.undp.org/sites/default/files/mpi_2019_table_1.pdf)
- 92) UNICEF 2016. Kenya: Cholera outbreak overview as of 9-May- 2016. UNICEF (2016)
- 93) USAID (2014). Household and community experiences and perceptions on climate change impacts due to floods, and expectations on policy in Bunyala Sub-County, Western Kenya. United States Agency for International Development.
- 94) Wetlands International (2019a) *Sio Siteko Focus Group Discussion – Wetland monograph*, notes, Wetlands Across Borders regional workshop, Kampala, Uganda, held on April 9, 2019. (REGIONAL

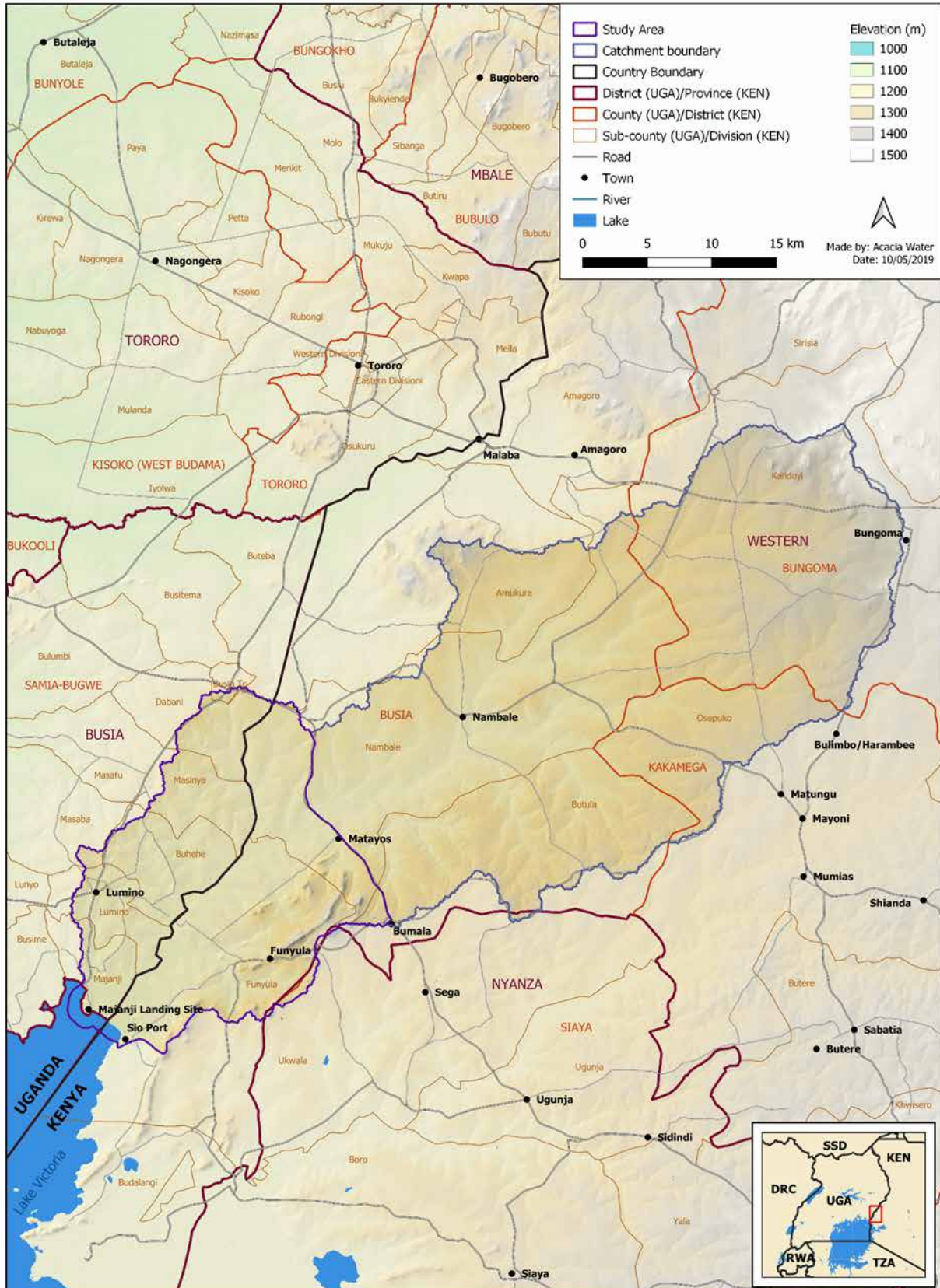
WORKSHOP, KAMPALA)

- 95) Wetlands International (2019b) *Sio Siteko acitivity report towards review of transboundary wetland landscape management plan – Stakeholders and resources analysis for wetlands management plan development report*, Wetlands Across Borders project, May 2019. (COMMUNITY AND DISTRICT, UGA)
- 96) Wetlands International (2019c) *Sio Siteko transboundary wetland management plan review and development – Stakeholders and resources analysis for wetlands management plan development report*, Wetlands Across Borders project, May 2019. (COMMUNITY, BUSIA COUNTY AND NATIONAL GOVERNMENT, KEN)
- 97) Wetlands International (2019d) *Sio Siteko transboundary wetland management plan 2020-2030 – Progress report*, Wetlands Across Borders project, July 2019. (COMMUNITY AND DISTRICT/ COUNTY LEVEL)
- 98) WHO 2009. *Country profile of Environmental Burden of Disease*. World Health Organization, (2009).
- 99) WHO 2011, Nitrate and nitrite in drinking-water, Background document for development of World Health Organisation Guidelines for Drinking-water Quality
- 100) WHO 2014, *Burden of disease and cost-effectiveness estimates*, World Health Organization, February 13, 2014
- 101) WHO 2017, *Guidelines for Drinking-water Quality: Fourth Edition Incorporating the First Addendum*. World Health Organization. Geneva, Switzerland. Licence: CC BY-NC-SA 3.0 IGO.
- 102) WHO 2018a. Country Cooperation Strategy at a glance, Uganda. World Health Organization (2018).
- 103) WHO 2018b. Country Cooperation Strategy at a glance, Kenya. World Health Organization (2018).
- 104) Witte, F., T. Goldschmidt, J. H. Wanink, M. J. P. Oijen, P. C. van, Goudswaard, E. L. M. Witte Maas, and N. Bouton, (1992) *The destruction of an endemic species flock: quantative data on the decline of the Haplochromine cichlids of Lake Victoria*. Env. Biol. Fish.34: 1-28.
- 105) WREM (2008). Sio-Mala-Malakisi Transboundary Integrated Water Resources management and Development project Investment Strategy. Report Number NBI/NELSAP/SMM-TIWRMDP/ RFP01/2006. 148PP.

APPENDIX A MAPS

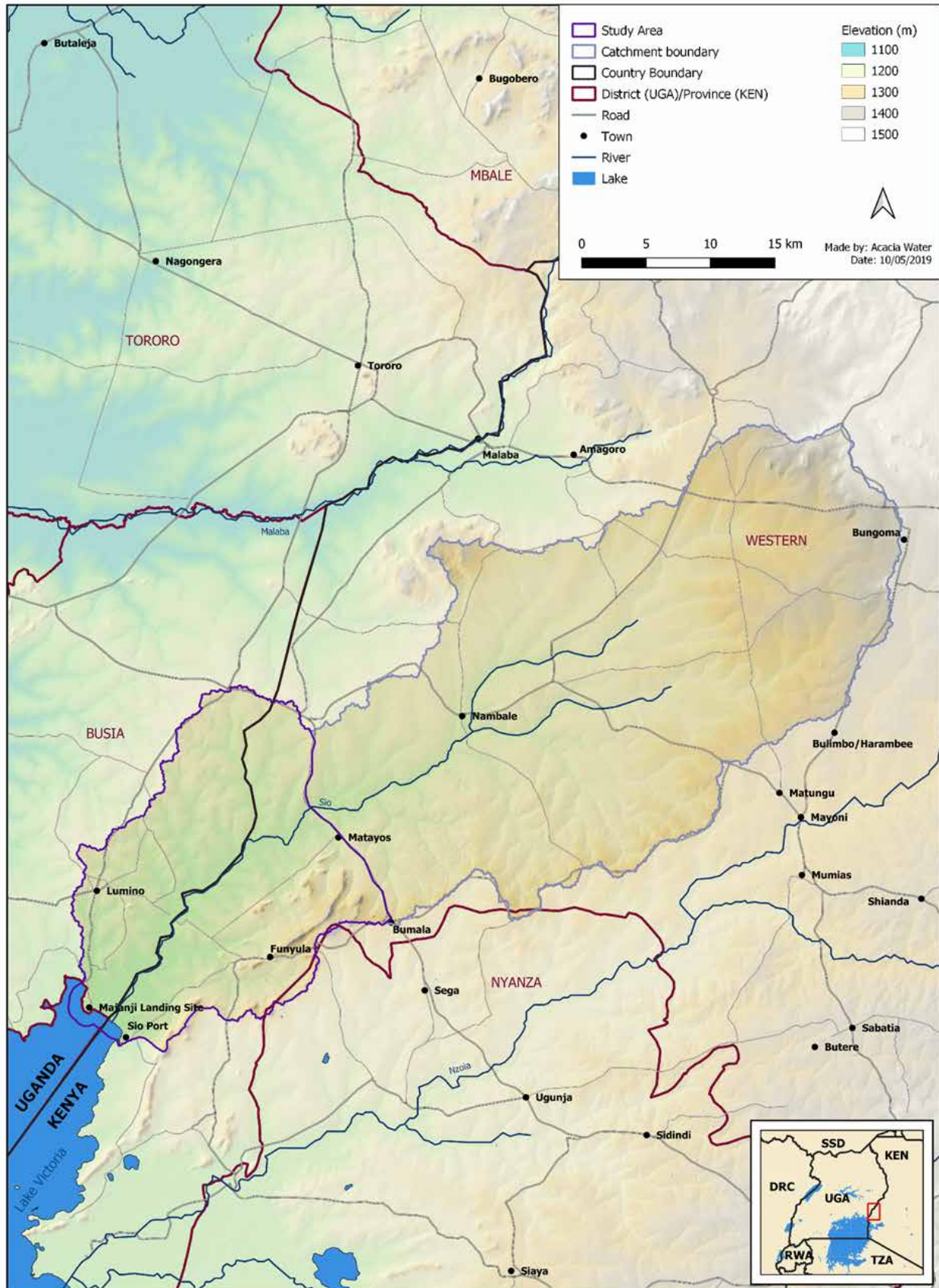
A1. Sio Siteko - Administrative boundaries

SIO - SITEKO WETLANDS



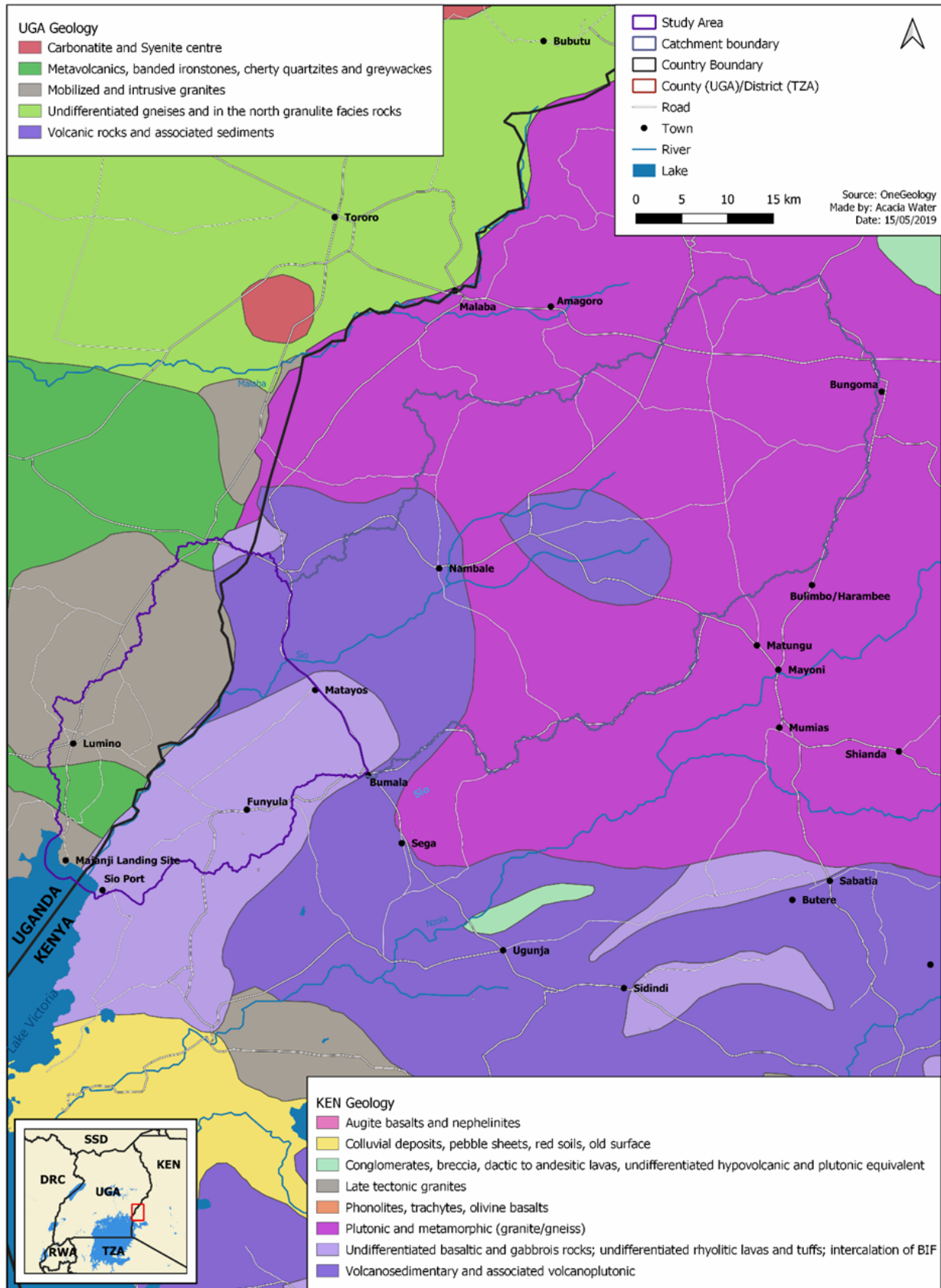
## A2. Sio Siteko – Elevation

### SIO - SITEKO WETLANDS



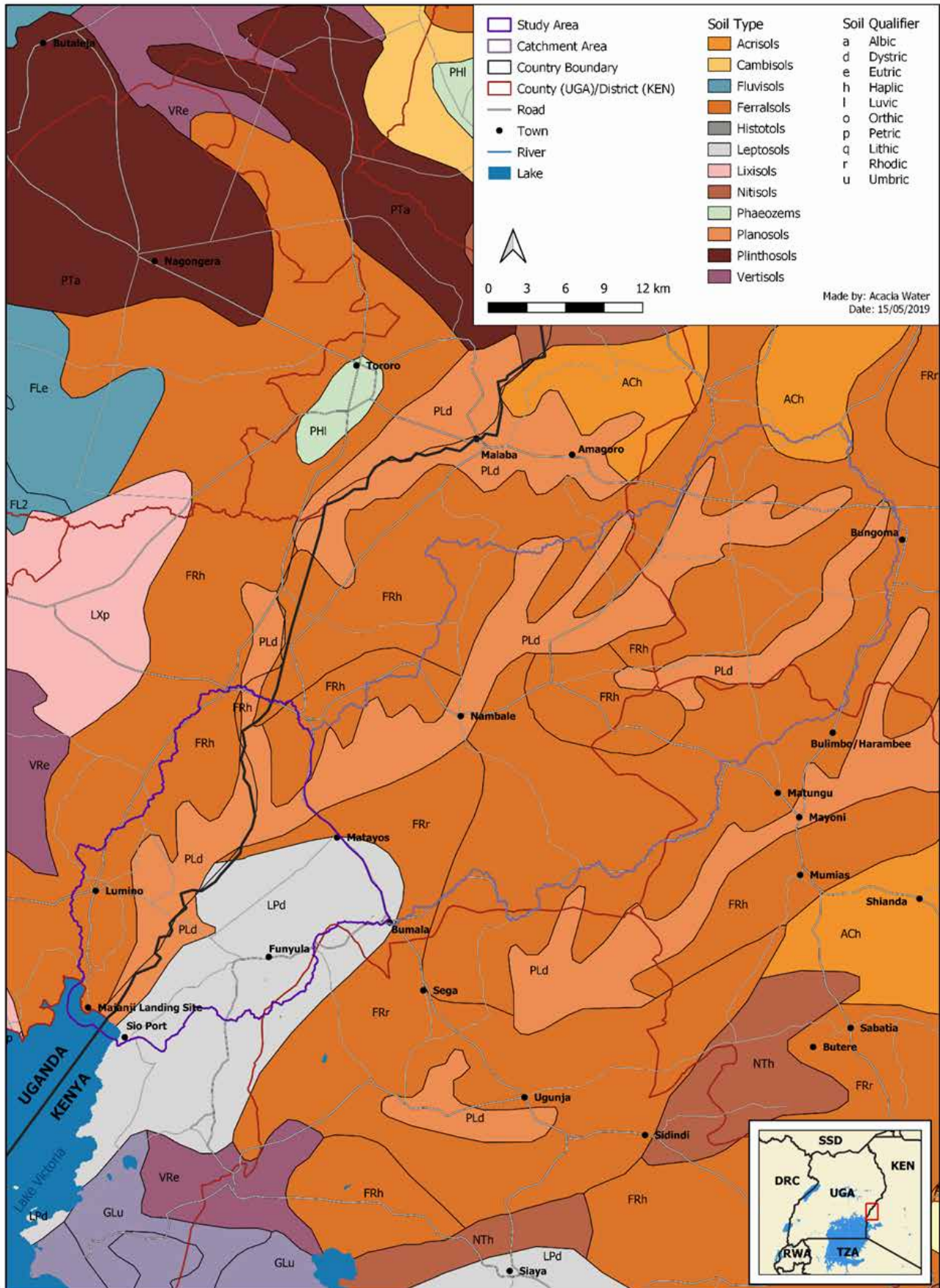
### A3. Sio Siteko – Geology

## SIO - SITEKO WETLANDS



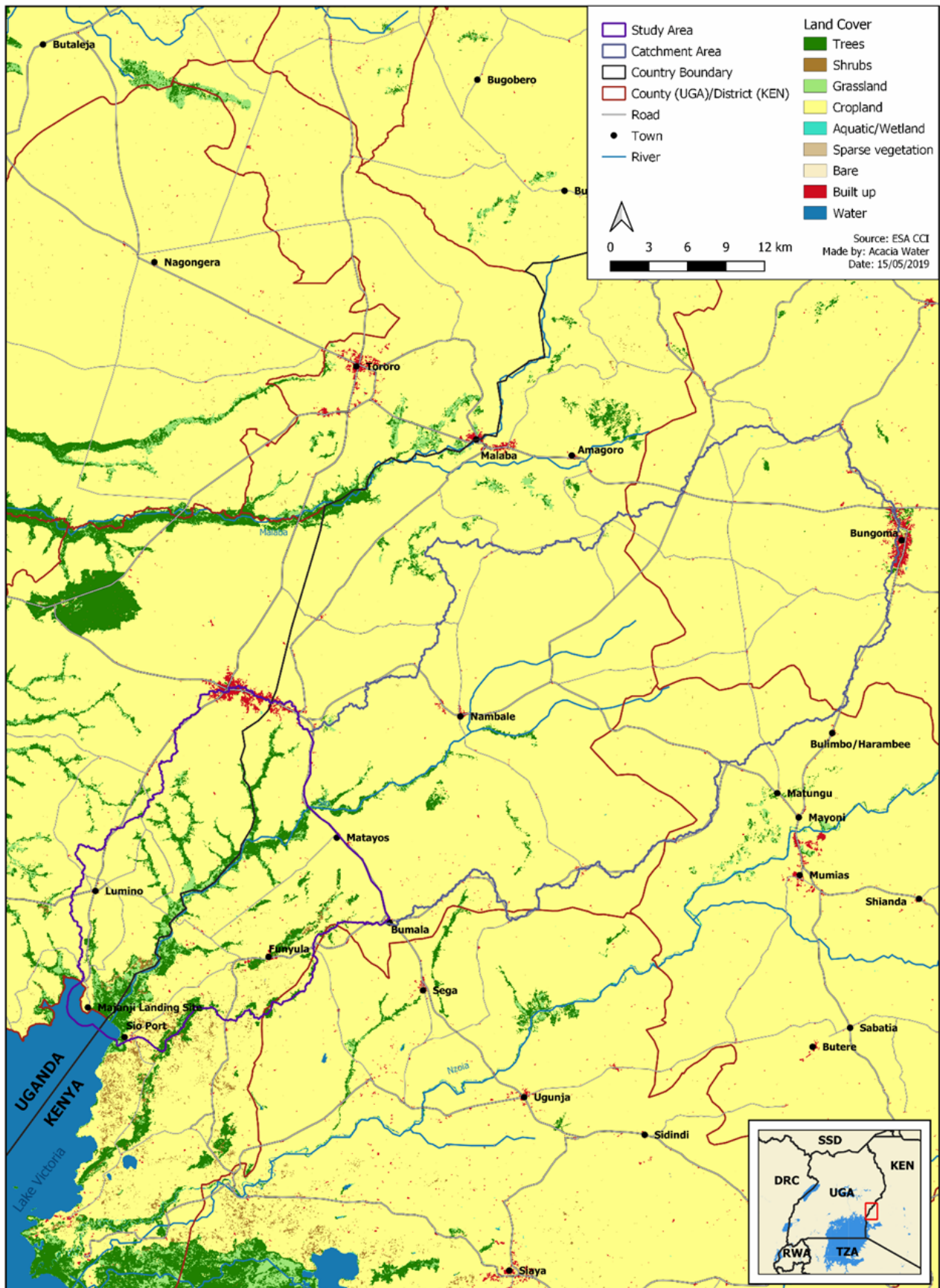
## A4. Sio Siteko – Soils

### SIO - SITEKO WETLANDS



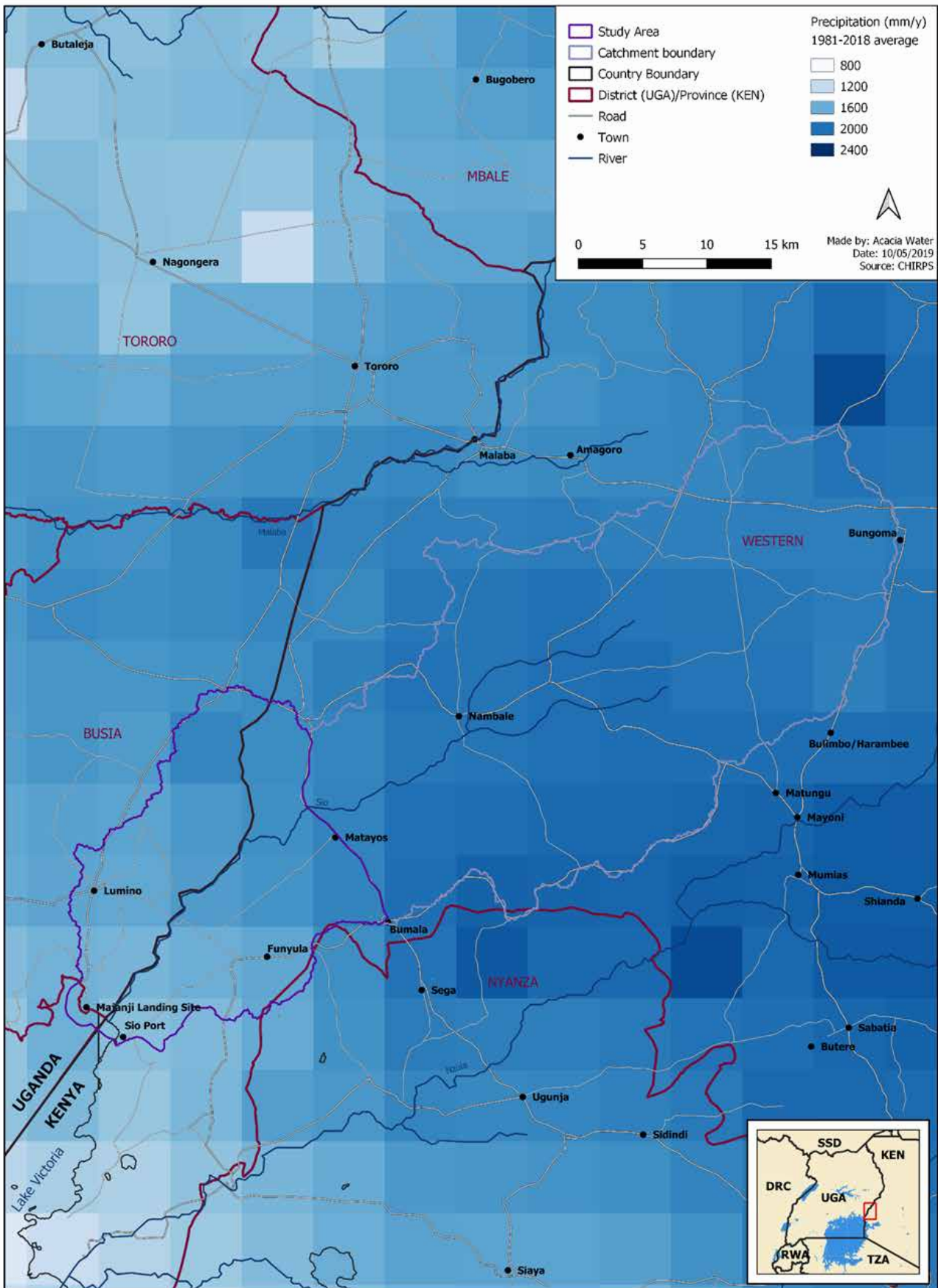
A5. Sio Siteko - Land cover

### SIO - SITEKO WETLANDS



A6. Sio Siteko – Precipitation

### SIO - SITEKO WETLANDS



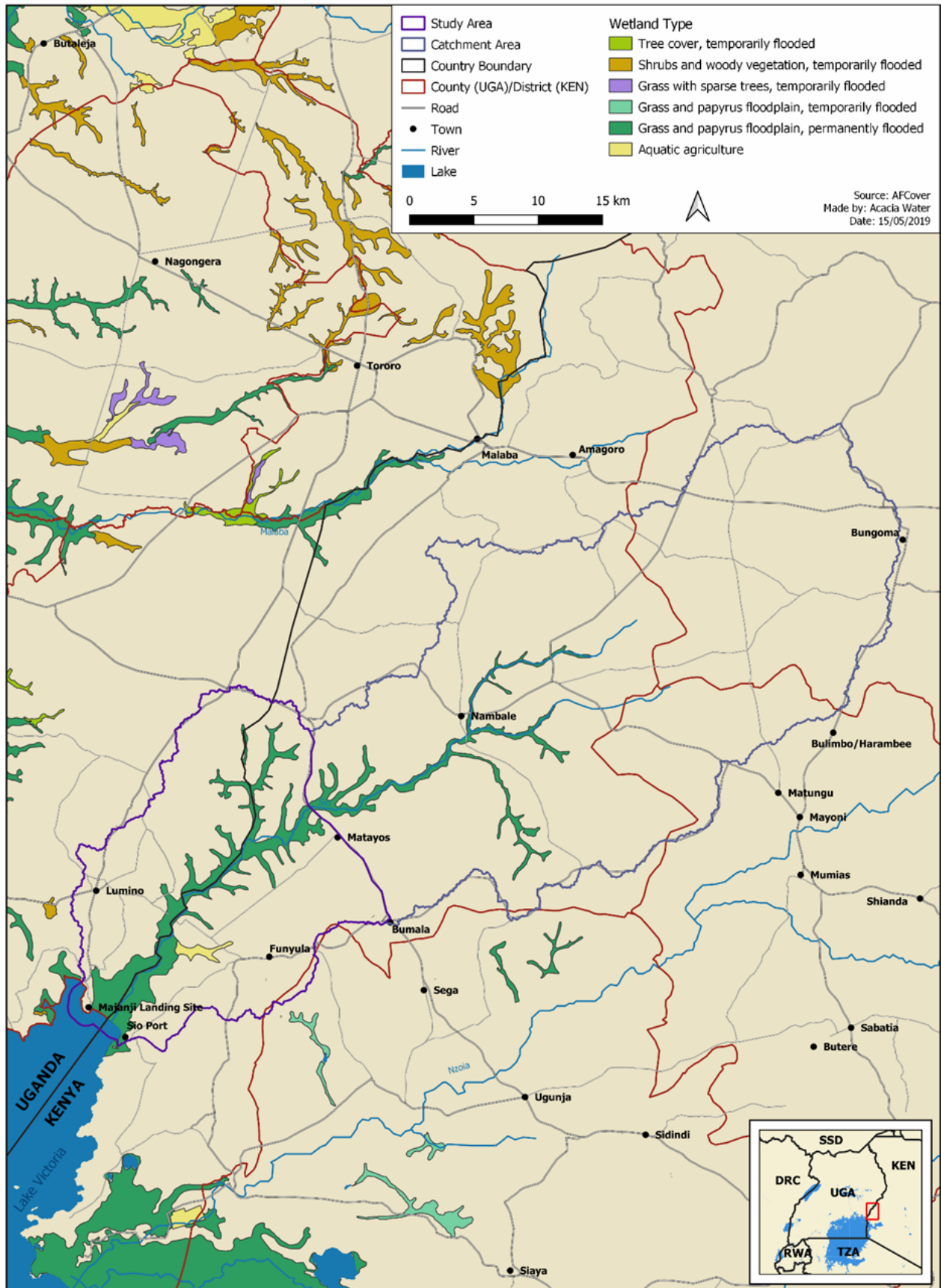
A7. Sio Siteko – Vegetation greenness (NDVI)

### SIO - SITEKO WETLANDS



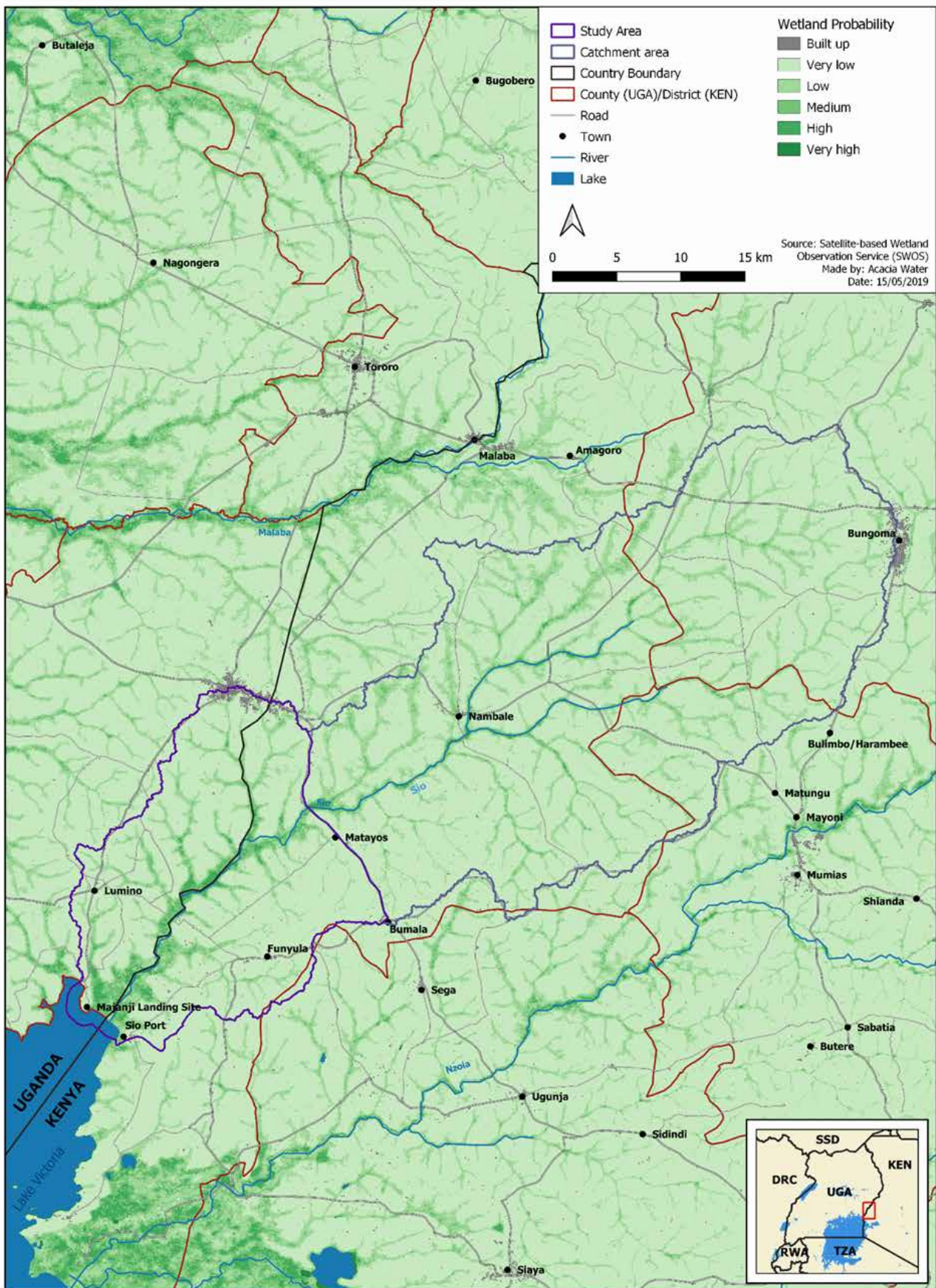
A8. Sio Siteko – Wetland types

**SIO - SITEKO WETLANDS**



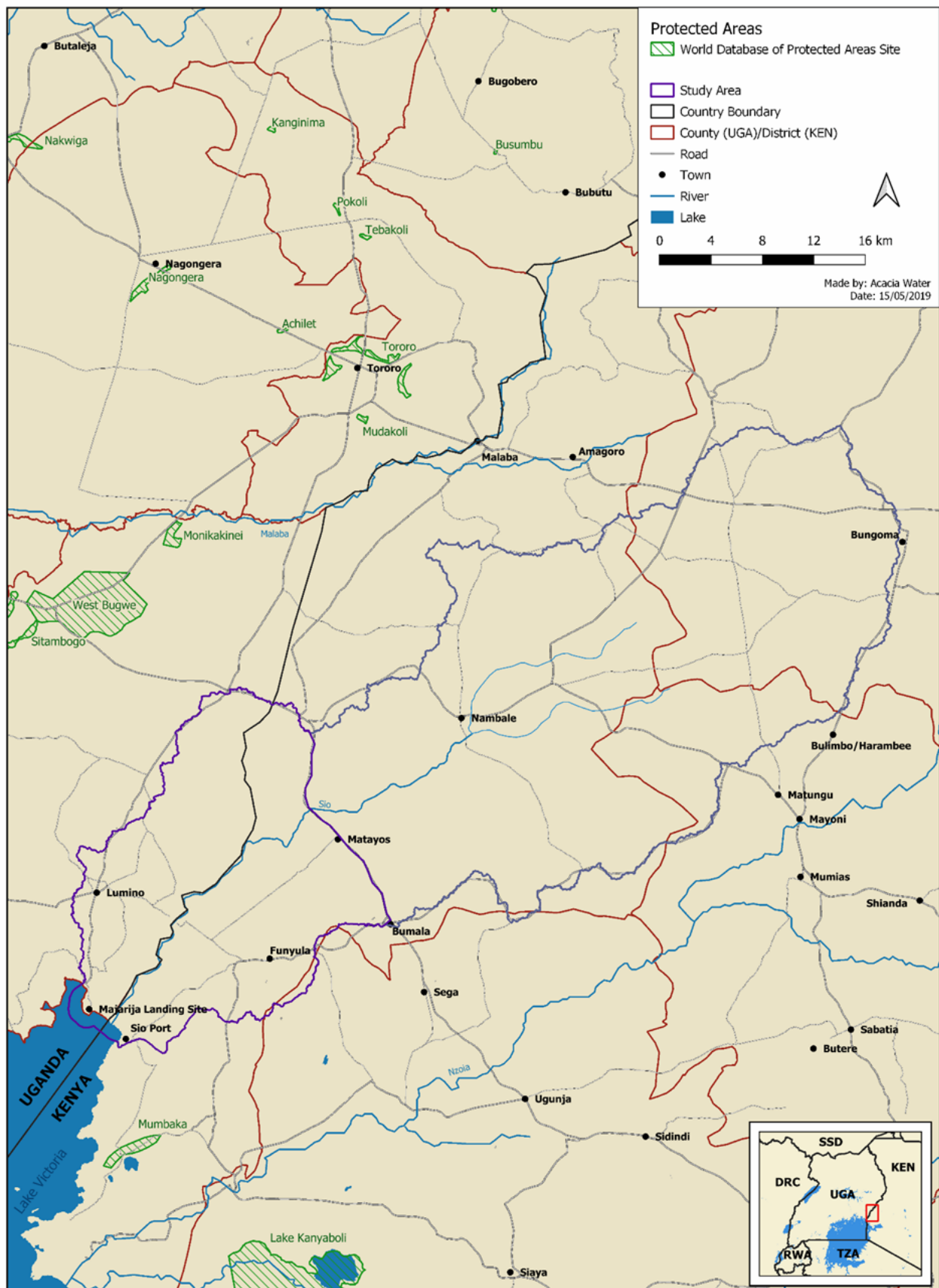
A9. Sio Siteko – Probability of wetland cover

### SIO - SITEKO WETLANDS



A10. Sio Siteko – Protected areas

### SIO - SITEKO WETLANDS





## Appendix B1 - Field notes waypoints

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC ( $\mu\text{S}/\text{cm}$ )	T ( $^{\circ}\text{C}$ )	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
711	0.24132	33.99199	1157	Lake	Lake Victoria at Majarija Landing Site	108	28	0	60		
712	0.23909	33.99734	1137	Lake	Lake Victoria	107	27.9		36		
713	0.23961	33.99961	1136	Lake	Lake Victoria						
714	0.23819	34.00095	1136	Lake	Lake Victoria						
716	0.23419	34.00766	1135	River	River Sio outlet	133	27.3	0	49		
717	0.24097	33.99746		River	River Zoa	150	27.6				
718	0.24255	33.99857		River	River Zoa	150		0	95		
719	0.24876	33.99117	1157	Borehole	Maduwa village	893	27	30	0	DWD583 82	8/1/2016
720	0.24694	33.99164	1145	Borehole		6700	30.9	45	0	DWD614 06	5/20/2017
721	0.28433	34.01054		Borehole							
722	0.28669	34.0127									
723	0.32254	34.02223		Borehole							

Borehole depth	Activities	Vegetation	Animals	Comments
	fishing	Water hyacinth	weaver birds, kingfisher, monitor lizard, tilapia, Nile perch, silverfish, catfish	Fishing boats, fishing with nets, hooks and baskets. In the lake fishermen catch Tilapia, Nile perch and Silverfish (nets). In the river they catch catfish, lungfish and mudfish (hooks, traps). Water hyacinth was floating in the lake in groups near an outlet of a stream. Drinking water is obtained from a borehole in the area.
	fishing			Fishing using woven reeds to block an entire stream into the river, which catches all fish moving from river to lake, and vice versa (bad method).
	fishing			
	fishing	reed, papyrus, Acacia	many types of birds in flooded trees	Flooded Acacia trees. People used to mine sand here, but after heavy rains in 2000 this area became inundated and thus part of the lake.
	fishing, sand mining	water hyacinth (blooming), reed, papyrus	labeu (sp?), monitor lizard, bush buck (in area), hippos (in area)	The river (10-12 m wide) is completely vegetated (floating vegetation) and is not passable by boat. When the rains come, the extra water flushes the floating vegetation into the lake and the water is free. The river stops flowing freely around November. <i>Silvinia molesta</i> (invasive species) is not observed here. Hippos are in the wetland during the day and come out to the lake at night (sighted one month ago).
				woven reed fishing method seen here, there are also long nets under the water. The water is visibly more turbid. River Zoa is frequently studied by professors from Kenya
		papyrus	water birds, crocodiles (not observed, rare)	The River is ~10 m wide, 1.5 m deep here. On the east bank there is burned papyrus. After heavy rains, even the papyrus is flooded. There have never been trees here, only papyrus.
50 m	agriculture	agriculture		The water is hard (needs a lot of soap), but is available all year round. When the borehole breaks down, repair costs are often higher than the funds available to the O and M committee. All users pitch in to the fund for maintenance. Before there were boreholes here, people used water from the lake. Livestock roams freely near the borehole.
				The borehole was salty from the day it was placed. The cuttings from the well show stones with very dark minerals (gabbro?), quartzites, iron conglomerates (concreties?), overlaid by red clayey soil. The borehole is not used.
				Along road, but not sampled. Another borehole was spotted close by. Earlier along the road some eucalypt stands (100-200 trees) were observed.
				Along road, not sampled. Along the same stretch some small-scale pine plantations were observed. One was in between the road and a large hill.

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC ( $\mu\text{S}/\text{cm}$ )	T ( $^{\circ}\text{C}$ )	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
724	0.30505	34.05103	1146	River	River Sio crossing point	169	30	5	60		
725	0.3089	34.04704									
726	0.33646	34.01648	1171	Surface water		886		1			
727	0.33849	34.02244		Rock							
728	0.34012	34.0374	1159	Floodplain							
734	0.33946	34.03178	1169	Borehole	Kateruhana West	726	27.3	25	0		
735	0.3347	34.03306	1179	Borehole	Kateruhana East	1986	26.3	15	0		
736	0.34786	34.05581		Borehole							
737	0.34997	34.05962		Floodplain	Masinya wetland						
738	0.35557	34.07523	1160	Floodplain							
739	0.36037	34.08068		Borehole							

Borehole depth	Activities	Vegetation	Animals	Comments
	transportation, sand mining, grazing (cows and goats)	reeds and (acacia) shrubs, no papyrus	(orange) butterfly	Relatively busy river crossing point for families, relatives, business/shopping. Visible river bank erosion and degradation, with sand mining in progress upstream. River bank erosion is likely caused by sand mining and/or overgrazing. The path between the road passable by cars and the crossing point has culverts every 5 m, and is used by pedestrians, bikes, and motor bikes. At the end of the road, a truck with cassava was being offloaded to carry over the river for the market in Kenya.
				Cows from WP 724 to here
	agriculture, grazing, plantation (eucalypt)	reeds and acacia shrub, no papyrus		This location had stagnant water, the flow was blocked downstream. The presence of a biofilm indicates groundwater influence. The higher EC may be due to evaporation and/or groundwater seepage. Waste was visible along the stream, likely carried with runoff. There is a eucalyptus plantation nearby.
				laterite cover
	agriculture (rice and other), plantations, grazing (cows)	reeds along the road		The middle of a wide valley which is dry (no water flowing, and no clear channel). This is a wetland area (waterlogged), but completely encroached by smallholder farming, with cattle grazing and eucalypt plantations. In the rainy season, this area floods unless the locals dig a channel to concentrate the flow.
20 m	grazing and agriculture (rice, maize and beans in the wetland area, cabbage and skuma (sp??) in the higher areas)			Soil in the higher areas is barren (perhaps due to bad agricultural practice), which led people to move agricultural activity to the wetland area. They do so despite the fact that NEMA has chastised them for this. Before the agriculture, acacia shrub covered this area. The water from the borehole is 'sour' and 'hard'.
	agriculture, charcoal production, pine plantation			This borehole is not used (too 'sour'). Near the village there is intercropping (coffee, cassava, maize). Metamorphic sandstone observed.
	agriculture (rice and yams), grazing (cows), eucalypt plantation		birds, butterflies	This is the middle of a large floodplain without a clear channel. There are eight culverts in a row under the road, suggesting high flows during wet season. Some burning was in progress in the fields, likely burning crop residue. A local observed that there is no (surface) water now at the end of the dry season, but in the wet season all water passes quickly by. Ten years ago, there was no activity within the wetland, but there was water flowing all year round.
	agriculture (maize, yams), grazing			Compared to the previous valley locations, this one is narrow. There is no clear river channel, and there are no big culverts. Smallholder agriculture with some small-scale irrigation.
				Along road, not sampled.

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC (µS/cm)	T (°C)	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
740	0.35982	34.0919	1154	Surface water	Lugudu wetland	578		1			
741	0.36024	34.09666		Borehole						DWD22653	2008
742	0.35265	34.09784		Floodplain							
743	0.35161	34.09813	1152	River	River Sio	154	27.8	0	225		
744	0.37758	34.09159		Rock							
745	0.38093	34.08925		Rock							
746	0.38333	34.08661		Rock							
747	0.3863	34.08051		Rock							
748	0.39797	34.07178		Spring							
749	0.27025	34.0853		Dam							
750	0.25794	34.06684		Sign							
751	0.23488	34.03697		Sign							
752	0.2251	34.02175		Hospital	Sio Port Hospital						
753	0.22366	34.0157		Lake	Sio Port beach	145		1			

Borehole depth	Activities	Vegetation	Animals	Comments
	agriculture (rice), grazing (cows and goats), burning (crop residue)	reeds, papyrus, Phoenix reclinata	frog, butterfly, birds	Wide valley with 7-8 clusters of 1-3 culverts (95 cm diameter). Water was sampled from a stagnant (irrigation) channel adjacent to rice fields. The rice fields are surrounded by reeds. This wetland (in contrast to the previous valley observations) still has papyrus. There is less encroachment than previous sites. Phoenix reclinata is a wetland species used for many purposes: chairs, hats, beds, mats, etc.
				Pump doesn't work, unclear how long (only children nearby). The chain of the pump appears to be intact. Cows observed returning from the river, presumably to drink.
	agriculture (marijuana), grazing (cows)	reed, papyrus, acacia shrubs		This location is in a side-channel in the Sio floodplain that is currently dry. There is a woven reed fish trap blocking the channel already. The fenced marijuana field is the single field observed in use here, there is another fenced off field that is barren.
	grazing	reed, papyrus, acacia shrub, phoenix reclinata	bird of prey, frog	The river channel is ~8 wide here, with steep banks 3-4 m high. The river was visibly turbid and flowing at ~0.5 m/s. The phoenix palms were mature and scattered. The wood of this plant is very strong and not affected by termites.
				laterite cap - iron concretion, like rock
				laterite cap - iron concretion, like rock
				laterite cap - iron concretion, like rock
				laterite cap - iron concretion, like rock
				Dam for irrigation water. Construction started 3 years ago, according to the guide it is no yet in use. Possibly part of the Lower Sio Irrigation Project (sign observed earlier on the road from Busia)
				Sign for World Bank project: boreholes for drought mitigation. Nearby is a sign for a bio-toilet project for a school
				Sign for Budongi (spelling?) water project
				Hospital in Sio Port. Potential site for high water use and/or contamination
	transport, fishing, arrival point sand mining, papyrus harvesting	reeds, papyrus, some eucalypts	birds, fish (tilapia, lungfish, Nile perch, mudfish, catfish), crocodiles (not seen), snakes (not seen), hippos (not seen, but sighting 1 month ago)	The Sio Port area has a lot of activity. Sand harvesters take sand from the mouth of the river, not from upstream. The sand is used for construction, and the demand is higher today than it was 10 years ago (attributed to high population growth rate). During the rainy season, a lot of sand is carried with the river. The river carries more sand now than previously. Sand is worth about 3000 Kenyan shillings per lorry, though lorry size is unclear. Fishermen use nets, but also hooks. Traps are said not to be used. Fish include tilapia and nil perch from he lake and catfish and lungfish from he river. A very large (1.5 m) lungfish is expected to bring up 2500 Kenyan shillings. During the rains there are more fish, but there is less fish available now than in the past (attributed to high population growth rate and poor fishing methods).

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC (µS/cm)	T (°C)	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
761	0.25703	34.04357		Rock							
762	0.26337	34.04945		Pond							
763	0.28489	34.06409	1147	River	Wahunga Stream	567	25.7	0	48		
764	0.29733	34.06622	1174	Borehole	Nyakwaka girls' secondary	1416	26.8	40	0		2016
765	0.30168	34.05621									
766	0.30418	34.05232	1143	River	River Sio	148	27.8	2	85		

Borehole depth	Activities	Vegetation	Animals	Comments
				Chemicals are prohibited and therefore said no to be used. A lot of transport of people (100 Kenyan shillings pp) and goods such as wood (100 per bushel), charcoal (1000 per bag of 1.2x0.5x0.3 m <sup>3</sup> ), and subsistence crops are transported from Uganda to Kenya. Wood, charcoal and crops are not transported the other way. There used to be a lot of wood on the Kenyan side, but not anymore. The local community takes water from out in the middle of the lake. Near the shore the water is too dirty.
				laterite cap - iron concretion, like rock
				Pond with water along the road (should be fed by runoff) with a water level measurement structure in the middle.
	agriculture (sugarcane, beans, potatoes, maize, cassava), grazing (cows, goats), washing near the river	some reeds	butterflies, small birds	The stream is 0.5-1 m wide and has a flow of ~0.5-1 L/s. The water flows all year round, and in the rainy season the flooding reaches 50 m to either side of the stream channel. The bridge over the stream has a surface area of 10 m <sup>2</sup> open to allow flow of water. There is an indication that the stream is (partly) fed by groundwater (biofilm). 10 years ago, there was no farming here. The encroachment is attributed to high population growth rate in combination with scarce land, and the very fertile land in the wetlands. Very soon, there will be irrigated rice here. This may be part of the same scheme as the dam in waypoint 749 (check map?).
				Solar-powered borehole, in combination with a water tower with a capacity of 5000 L, depth unknown. The borehole provides water to the secondary school (300 students) and the surrounding community (170 households). During school days, the pump is continuously working to provide enough water, but the water tastes salty. The water level goes down in the dry season (observation based on pressure.) Sometimes the pump is turned on but only little or no water comes out. The county government placed the well 2-3 years ago. There is another borehole nearby, which is also salty. There are 'many' latrines and pit toilets in the area.
				Rainwater harvesting in small village
	sand mining, transportation, watering/grazing (cattle and goats)	some reeds, mainly mimosa puniculata, no papyrus	birds (weaver), NO fish	There is active sand mining here, with river bank erosion. The sand is poorly sorted fine to coarse sand that is well-rounded, containing some chunks of clay. There are 18 boats available for transportation, of which none were in use. There are no fish in the river. Fishermen use chemicals in the dry season, several times a year, which make the fish come to the surface (stunned?). This chemical, although illegal, is still in use (so there must be some fish left or they must come back?).

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC ( $\mu\text{S}/\text{cm}$ )	T ( $^{\circ}\text{C}$ )	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
768	0.318	34.06142	1148	Groundwater	Sugarcane plantation	353	24.6	0	0		
769	0.31365	34.06418	1163	Borehole		407	26.2	30	0		2015
770	0.3127	34.07377		Borehole							
771	0.31247	34.0764		Pond							
772	0.31129	34.08095		Borehole							
773	0.3064	34.09526		Dam							
774	0.32658	34.12147		River							
775	0.36036	34.13184	1157	River	River Sio	139	28	1	85		
776	0.35885	34.13755	1169	Village							
777	0.3613	34.13915		Floodplain							
778	0.35717	34.14727		Borehole							

Borehole depth	Activities	Vegetation	Animals	Comments
	agriculture (sugarcane in wetlands, maize, sorghum and others just outside), grazing (cows)	scattered eucalypts, mimosa shrubs, very few reeds and no papyrus		This wide floodplain floods every year, with floods lasting 2-3 months. This is usually March until May and is not the case this year (rains are late), but was the case last year. Sugarcane has been planted in the wetlands in larger plots than commonly observed in the region. The plots belong to local individuals, and the expectation is that in the next few years much larger areas will be under sugarcane cultivation. This species of sugarcane can survive the flooding, takes 18 months to mature, and is used to produce sugar. The sugar factory is located in Busibwabo. Before the sugarcane was here, the entire floodplain was covered by mimosa shrub. The water sample was taken from an open well in the floodplain. Laterites are found on the slopes next to the wetland. These are mined for foundations and locally known as dressing stones.
				There is chlorine next to the pump, of which one drop should be added to each jerry can (20L). However, despite many filled jerry cans no one was observed to do so. The pumping rate is about 20L in 70 s. Livestock roam freely near the pump.
				Solar powered borehole along the road, not sampled.
				Pond, people with jerrycans around presumably to collect water
				Mechanized borehole along route, not sampled
				Dam and reservoir, with a borehole nearby on the SE side of the road
				Flowing river
	sand harvesting, fishing (hook), transport, waterhole (cows), washing	agriculture, grazing, salt making		River bank (10-12 m wide) with steep banks (3-4 m tall). There is sand harvesting (all between the bridge of WP 782 and Sio Port) and visible river bank degradation. Unlike previous sites there are laterite rocks in the river bed.
				Salt making occurs at many places in the district, but this village is especially known for this. The traditional salt is known to be better for people with bone diseases/issues than 'normal' salt. However, they need a good market for the salt.
	reed harvesting (for salt), agriculture on slopes floodplain	reeds, papyrus		The wetland here appears intact, with reeds and papyrus and no visible encroachment. The agriculture and eucalypt plantations are located on the slopes just outside the wetland. The salt-making process starts by gathering reeds, which are then cut into small pieces and laid in the sun to dry (2 days with warm sunny weather). The reeds are then burned. Water is added to the ashes, making the salts dissolve and the ashes float. Water is extracted from the bottom, and then boiled to extract the salts. A sample bag of salt costs 20 Kenyan shillings.
				Electric borehole along the road, not sampled

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC ( $\mu\text{S}/\text{cm}$ )	T ( $^{\circ}\text{C}$ )	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
779	0.3575	34.15525	1195	Pond							
780	0.35726	34.1553		Well							
781	0.36485	34.16522	1194	Water kiosk							
782	0.38339	34.14599	1165	River	River Sio bridge	138	27.4	1	75		
782	0.40099	34.10249	1157	River	River Buyosi	358	27.9	0	190		
783	0.40261	34.10778		Borehole							
784	0.4139	34.11327		Quarry							
785	0.42523	34.11879	1177	Spring							
786	0.4252	34.11919		Fish pond							

Borehole depth	Activities	Vegetation	Animals	Comments
				This pond was made by a local man, which is meant to supply water for livestock and washing. It fills with water during the rainy season, and provides water for two months (Dec - Jan/Feb). It is too shallow to provide water for longer. Malaria is not an issue here.
				Shallow well (depth unknown) that dried up about 1 year ago. The three years before, the production was not consistent (on and off).
				Water kiosk selling a jerrycan of water for 5 shillings. The water comes from the River Sio and is treated. This location/road is considered to be the boundary of Sio Siteko
	water intake, grazing	some reeds, shrubs		Bridge over the River Sio. During flooding periods, the river level is 4 m higher than currently, this means the river channel is filled and water spills over onto the floodplain. The Water Resources Authority (WRA) measures water levels quarterly, with incidental extra measurements. Dropping water levels during dry seasons are attributed to human activities in the catchment. There is a pumping station on the northern side of the river, providing water to the villages in the area. The pumping station was built in the early 60s. Inside, pump 1 (30691 h) and pump 2 (20575) are pumping 171 m <sup>3</sup> /hour. The meter shows a total of 1473000 m <sup>3</sup> (who knows since when this volume has been pumped).
	agriculture (rice, arrowroot, kale), grazing, firewood collection (from reeds/shrubs)	scattered reeds, eucalypts and palms, single patch of papyrus	many frogs, wetland birds, fish (eel, tilapia, mudfish, lungfish)	The River Buyosi is about 1.5-2 m wide, flowing slowly (1 - 10 L/s). The stream runs dry in the dry season (Dec - Feb/Mar), and starts again after the rains. In wet season, floods fill the valley and extend 1 km wide. 10 years ago, this area was all wetland, with papyrus and more palms. Now, most is agriculture and there are only a few palms left. Water is taken from both the river and a borehole, but many wells are dry in this area (attributed to over-extraction). Arrowroot brings a good price at the market
				Borehole (shallow) in use.
				Small quarry mining murrum stones. These are the iron rich stones we have called laterites.
				The spring was installed in 2000. At that time, it ran continuously. Nowadays, the spring is usually dry from Dec until the rains (Mar/Apr). It dries again from June to August. The flow is also lower than it used to be, ~20 min to fill a jerry can instead of 2 min previously. Many more springs in the area no longer run continuously and have a lower flow than in earlier years. Based on photos from the scoping mission, it appears this spring was active on 15 Jan 2019.
	grazing (cows), agriculture (vegetables)			This depression used to be a fish pond but is now dry. Nearby, the owner has planted large oil palms from Haiti that provide cooking oil. There is also a stand of giant bamboo (~25 cm thick after 1-2 years), which is only used for shade and not harvested.

Waypoint	Lat	Lon	Elevation (m)	Type	Name	EC ( $\mu\text{S}/\text{cm}$ )	T ( $^{\circ}\text{C}$ )	NO3 (mg/l)	Turbidity (NTU)	Borehole number	Borehole placement
787	0.42538	34.12023		River	Mabale Stream	342	28.8	8	140		
788	0.4492	34.11223		Sewage Pond							

Borehole depth	Activities	Vegetation	Animals	Comments
	agriculture (maize, kale, arrowroot, and possibly sugarcane and rice), grazing (cows)	papyrus (some burnt), reeds, palms, lily pads, touch-me-not (real name?)	birds (ma-nga-nga and others), butterflies	The stream (1.5 m wide) is very green in color. There is insufficient water treatment upstream in Busia, and water quality is getting worse. This is even changing the vegetation here (papyrus is dying). There are many latrines, and not everybody uses them - some just go to the bush. This area has many smallholder farms, some patches right up to the stream. The owner was encroaching, too, but after a visit from NEMA decided to rehabilitate the wetland. He made a pond with lilies and planted the palms and bamboo (see previous waypoint)
				Sewage ponds. There is some treatment here, but the effluent is not fully treated.

## Appendix B2 - Fish species abundance, distribution and composition

### Fish species abundance (Lake Victoria, Western Kenya)

Fish species abundance in terms of ichthyomass is dominated by *Lates niloticus* constituting 60% followed by *Oreochromis niloticus* at 25%, *Haplochromines* 15%, *Clarias gariepinus* 5% and *Protopterus aethiopicus* at 2.5%. *Rastrineobola argentea* constitute less than 2.5%. However, the latter is less represented due to the methodology used, and in reality the biomass may not be that low. Others constituted *Oreochromis leucostictus* (Trewavas), *Tilapia rendallii*, *Synodontis victoriae*, *Synodontis afrofisheri*, *Schilbe intermedius*, and *Brycinus sadleri* each contributed less than 1% of the total biomass (Mwalo 1991).

### Fish species distribution and composition

The composition and distribution in the satellite lakes in the Western part of Lake Victoria (Kenya) shows a total of 28 species belonging to some ten families. The Haplochromine cichlids they still lead in species number and biodiversity. Fishes of the genera *Barbus* are the second in terms of biodiversity. The species are not however, equally distributed in the satellite lakes. Some have highest diversity in *Barbus* species while others have highest diversity in *Haplochromines*. Most satellite lakes are found to harbour *Oreochromis esculentus*, a native cichlid that is now thought to be commercially extinct in Lake Victoria. The native non-cichlids like the mormyrids, *Clarias alluaudi*, *Protopterus aethiopicus* and *Ctenopoma murei* are found in the satellite lakes.

Some 25 species belonging to five families are present in the dams and ponds in the western part of Lake Victoria (Kenya). The families found include *Cyprinidae*, *Cichlidae*, *Clariidae*, *Mastacembalidae* and *Protopteridae*. *Cyprinidae* dominated in the total number of species within a family. *Clarias gariepinus*, *Oreochromis niloticus* and *Barbus apleurogramm* are the most widely distributed, occurring in all the dams/ponds. The endemic tilapiines, *Oreochromis esculentus* and *O. variabilis* are found mainly in the dams/ponds.

### Trends

The decline of the native fish species in Lake Victoria has been attributed to predation by the introduced Nile perch, use of wrong and destructive fishing gears especially around the river mouths and to some extent destruction of spawning and nursery grounds through human encroachment (Ogutu-Ohwayo et al. 1991; Ochumba et al. 1991). Until the end of 1970s more than 80% of the demersal fish biomass of Lake Victoria consisted of haplochromine cichlids (Kudhongania & Cordone, 1974). Since the upsurge of *Lates niloticus* in the 1980s, the haplochromine stock and its fishery declined in the major parts of the Lake Victoria, particularly in the sub-littoral (6-20 m) and deepwater (>20 m) (Witte et al., 1992). Besides haplochromine cichlids, about 10 other genera, belonging to several families, contributed to the fisheries. Since the beginning of the century, the two indigenous tilapiine cichlids, *Oreochromis esculentus* and *O. variabilis* had been the most important target species (Fryer & Iles, 1972; Lowe-McConnell, 1987). These two species no longer occur in the lake in appreciable quantities. In addition to these cichlids, some native non-cichlid species of the family Mormyridae, Cyprinidae and Clariidae are threatened with extinction. Results from various findings revealed that these species now extinct or are threatened in Lake Victoria, occur in substantial numbers in the satellite lakes and dams within the Lake Victoria basin (Katunzi et al 2010; Masai et al 2001; TAFIRI 2014; TAFIRI 2013).

Further the results in the Western Kenya revealed that the haplochromines now occur in almost all parts of the lake and have increased in biomass. The second species rich in diversity after the haplochromines is *Barbus* with eight species recorded in the lake and in the dams within L. Victoria basin. They were however more abundant in the dams than the main lake. The introduced, *Oreochromis niloticus* is the dominant among the tilapiines in the main lake. *Tilapia rendalli* and *T. zillii* no longer occur in great quantities in both the main lake and the dams. The native non-cichlids rarely encountered in the lake and in the dams currently include *Bagrus docmac*, *Mormyrus kannume*, and *Mastercembelus frenatus*. *Lates niloticus* still remains the most dominant species, followed by *Rastrineobola argentea* and *O. niloticus*.

TABLE 12. FISH SPECIES IN LAKE VICTORIA, SATELLITE LAKES AND DAMS/PONDS (WESTERN KENYA)

Lake Victoria	Satellite Lakes	Dams/Ponds
<b>Cichlidae</b> <i>Oreochromis niloticus</i> <i>O. leucostictus</i> <i>Tilapia zillii</i> <i>Tilapia rendalli</i> <i>Xystichromis</i> sp. <i>Yssichromis laparogramma</i> <i>Y. uniformis</i> <i>Astatotilapia</i> sp. <i>Paralabidochromis kribensis</i> <i>P. chilotes</i> <i>P. plagiodon</i> <i>Paralabidochromis</i> sp. <i>Ptychromis</i> sp. Other Haplochromines  <b>Mochokidae</b> <i>Synodontis afrofishcheri</i> <i>S. victoriae</i> <b>Schilbeidae</b> <i>Schilbe intermedius</i>  <b>Clariidae</b> <i>Clarias gariepinus</i>  <b>Propteridae</b> <i>Protopterus aethiopicus</i>  <b>Cyprinidae</b> <i>Rastrineobola argentea</i> <i>Barbus profundus</i> <i>Barbus kersteni</i> <i>Barbus trispilopleura</i> <i>Barbus jacksonii</i> <i>Barbu altianalis</i> <i>Barbus neumayeri</i> <i>Barbus apleurogramma</i>  <i>Barbus cercops</i> <b>Characidae</b> <i>Brycinus sadleri</i> <i>B. jacksonii</i> <b>Centropomidae</b> <i>Lates niloticus</i> <b>Mormyridae</b> <i>Mormyrus kannume</i>  <b>Gnathonemus longibarbis</b> <b>Marcusenius victoriae</b>  <b>Bagridae</b> <i>Bagrus docmac</i> <b>mastercembalidae</b> <i>Mastercembelus frenatus</i>	<b>Anabatidae</b>  <b>Ctenopoma murei</b> <b>Cyprinidae</b> <i>Barbus apleurogramma</i> - <i>Barbus paludinosus</i> <i>Barbus karstenii</i> <i>Barbus neumayeri</i> <b>Barbus altianalis</b>  <b>Cichlidae</b> <i>Oreochromis niloticus</i> <i>Oreochromis esculentus</i> <i>Oreochromis variabilis</i> <b>Oreochromis leucostictus</b>  <i>Haplochromine</i> spp. <i>Astatoreochromis alluadi</i> <i>Astatotilapia nubilus</i> <i>Xystichromis phytophagous</i> <i>Xystichromis</i> sp. <i>Lipochromis maxillaris</i> <i>Pseudocrenilabrus multicolor</i>  <b>Clariidae</b> <i>Clarias gariepinus</i>  <i>Clarias alluadi</i> <b>Protopteridae</b> <i>Protopterus aethiopicus</i>  <b>Centropomidae</b> <i>Lates niloticus</i>  <b>Mormyridae</b> <i>Mormyrus kannume</i>  <b>Gnathonemus lonibarbis</b>  <i>Marcusenius victoriae</i>  <b>Mochokidae</b> <i>Synodontis afrofishcheri</i>  <b>Centropomidae</b> <i>lates niloticus</i>  Characidae  <i>Brycinus sadleri</i>  <i>Brycinus jacksonii</i>	<b>Cyprinidae</b> <i>Barbus apleurogramma</i> <i>Barbus paludinosus</i> <i>Barbus kerstenii</i> <i>Barbus neumayeri</i> <i>Barbus cercops</i> <i>Barbus trispilopleura</i> <i>Barbus jacksonii</i> <i>Barbus</i> sp.  <b>Labeo victorianus</b>  <b>Cichlidae</b> <i>Oreochromis niloticus</i> <i>Oreochromis esculentus</i> <i>Oreochromis variabilis</i> <b>Oreochromis leucostictus</b>  <i>Tilapia rendalli</i>  <i>Haplochromine</i> spp. <i>Astatotilapia nubilus</i> <i>Xystichromis phytophagous</i> <i>Pseudocrenilabrus multicolor</i>  <b>Clariidae</b>  <i>Clarias gariepinus</i>  <i>Clarias liocephalus</i> <b>Protopteridae</b> <i>Protopterus aethiopicus</i>  Mastacembelidae <i>Mastacembelus frenatus</i>



Plate 1: *Protopterus aethiopicus* (Kamongo).



Plate 2: *Protopterus aethiopicus*.



Plate 3: *Clarias gariepinus* and some Nile Perch (Mbuta/Sangara).



Plate 4: Empty boats at Sio landing site (Busia, Kenya).



Plate 5: Tilapia and other fish species.



Plate 6: *Clarias gariepinus*.



Plate 7: Nile Tilapia (small size) *Oreochromis niloticus* (Linnaeus 1758).



Plate 8: Nile Tilapia (large size) *Oreochromis niloticus* (Linnaeus 1758).

## Appendix B3 - Aquaculture and its impact on lake and wetland ecosystems

Fish farming has the potential to improve livelihoods in the Lake Victoria Basin. However, proper management and regulation is needed to achieve optimal results for farmers, while ensuring that environmental effects and conflicts with other activities and lake users are minimized.

On the Kenyan side of Lake Victoria, cage culture dates back to about 2005, when Dominion group of companies (US) started trials around the Yala Swamp at the mouth of the River Nzoia. In 2007, a project funded by the European Union (EU) initiated cage fish culture in small water bodies within the Lake Victoria Basin (Munguti, Kim et al., 2014a). By 2008, cage culture trials on the beaches of Lake Victoria (e.g. Dunga) were undertaken by the Fisheries Cooperative Societies under the Beach Management Unit (BMUs) (Munguti, Kim et al., 2014b). These trials consisted of small cages measuring 3.4 to 8 m<sup>3</sup> and used Nile tilapia *Oreochromis niloticus* (L.) and indigenous Victoria tilapia (*Oreochromis esculentus* (Graham)). The BMU trials on the beaches were aborted prematurely due to the destruction of the cages by water hyacinth, the use of low-quality netting material being damaged on the rocky substratum and a lack of robust information on cage culture. However, there was a resurgence of interest in cage culture in the lake in 2013, especially at Dunga and Anyanga beaches in Kisumu and Siaya counties, respectively. Since then, cages have spread across the five riparian counties along the Kenya side of Lake Victoria with about 43 fisheries businesses installing over 3,000 cages and stocking them with >3 million individual tilapia (Njiru et al 2018).

Cage operators are expected to clean cage nets to reduce clogging and fouling and to engage in proper management practices to enhance water quality and performance of fish (Shoko et al. 2014). Lack of strict adherence to this code of contact has resulted in fish kills, low dissolved oxygen (DO) levels and the spread of disease (Njiru et al. 2018). Water quality surveys using standard methods (APHA 2005), DO ranged between 2.24 and 2.58 mg/L in the water column around the cages, while inside the cages levels were as low as 0.64 mg/L (KMFRI 2016). Low DO within the cages has been attributed to poor water circulation across the walls of the cages as a result of nets becoming clogged by algae, decomposing remains of feed and reduction of water movement caused by the presence of fish in cages. Also, the condition in the cages are not suitable for fish that are known to thrive best at DO levels >3 mg/L (Aura et al. 2017).

Ammonia around the cages ranged between 0.14 and 0.2 mg/L. Increase in ammonia near the cages was attributed to the protein in uneaten food and fish waste that had been broken down into ammonia and nitrite. Recorded fish kills equivalent to about US\$ 4,300 occurred in the cages in Lake Victoria in 2016; this was attributed to low DO concentrations, although a combined effect, involving ammonia and oxygen was reported to be possible (Njiru et al 2018).

Scientist in Kenya also found that, intensification of intensively managed biological production, such as aquaculture, results to infectious diseases. In Kenya, cage establishments reported diseases and parasites occurring in their fish. The unhealthy conditions observed were mainly fin rot, which was attributed to high stocking density, poor water quality, and bad management practices. Studies conducted in Anyanga and Nyenye-Got beaches (Siaya, Kenya) in 155 and 600 cages found that poor water circulation across the walls of the cages due to clogging by algae and the remains of feeds (KMFRI 2016) caused a number of fish kills. The economic loss of these fish kills amounted to US\$ 4,300 and US\$ 570,000 at Anyanga and Nyenye beaches, respectively. It was also found that, fish kills were not restricted to cage fish, but also affected the wild fish and other aquatic biota (KMFRI 2016) across the whole of Goye Bay. This could have been due to normal annual stratification, which creates vertical mixing that lifts a layer of water with low DO concentrations to the surface (Guya 2013).

Furthermore, an environmental impact assessment (EIA) involving stakeholders may also help to alleviate some of these challenges. Governments and cage farmers need to be more pro-active in engaging local communities. For example, farmers could form discussion groups and management committees that would monitor and evaluate the systems and provide strong links to other stakeholders.

Addressing issues relating to the quality of seed and feed, stocking densities, the size, sex and biology of fish, fish tolerance to various aspects of water quality and the siting of fish cages within the water body are critical to the successful development and implementation of aquaculture in Lake Victoria. Training to provide evidence-based guidance on good practice should be provided to cage operators and extension officers in relation to cage design, construction and maintenance, seed production and handling, optimum stocking

densities, fish disease and control, monitoring of fish growth performance, harvesting and post-harvest techniques, economic performances and environmental assessment and management. There is also a need for research institutions in collaboration with other stakeholders to develop tailor made training curricula.

Support for the sustainable development of aquaculture should also be sought from the private sector and Non-Governmental Organizations (NGOs). In East Africa, bodies like the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) and Farm Africa could be instrumental in ensuring the success of aquaculture in the region.

## SPECIES LIST SIO SITEKO

Birds of Sio Siteko (source Sio-Siteko CWMP 2009 , Avian birds Database, NU opportunistic records)

Order	Family	Species (Engl.)	Species (Lat.)	Status
Anseriformes	Anatidae	White-faced Whistling-Duck	<i>Dendrocygna viduata</i>	
Anseriformes	Anatidae	Fulvous Whistling-Duck	<i>Dendrocygna bicolor</i>	
Anseriformes	Anatidae	White-backed Duck	<i>Thalassornis leuconotus</i>	
Anseriformes	Anatidae	Knob-billed Duck	<i>Sarkidiornis melanotos</i>	
Anseriformes	Anatidae	Egyptian Goose	<i>Alopochen aegyptiaca</i>	
Anseriformes	Anatidae	Spur-winged Goose	<i>Plectropterus gambensis</i>	
Anseriformes	Anatidae	African Pygmy-Goose	<i>Nettapus auritus</i>	
Anseriformes	Anatidae	Garganey	<i>Spatula querquedula</i>	
Anseriformes	Anatidae	Hottentot Teal	<i>Spatula hottentota</i>	
Anseriformes	Anatidae	Eurasian Wigeon	<i>Mareca penelope</i>	RA
Anseriformes	Anatidae	African Black Duck	<i>Anas sparsa</i>	
Anseriformes	Anatidae	Yellow-billed Duck	<i>Anas undulata</i>	
Anseriformes	Anatidae	Red-billed Duck	<i>Anas erythrorhyncha</i>	
Anseriformes	Anatidae	Northern Pintail	<i>Anas acuta</i>	
Anseriformes	Anatidae	Green-winged Teal	<i>Anas crecca</i>	
Anseriformes	Anatidae	Southern Pochard	<i>Netta erythrophthalma</i>	
Anseriformes	Anatidae	Tufted Duck	<i>Aythya fuligula</i>	RA
Galliformes	Numididae	Helmeted Guineafowl	<i>Numida meleagris</i>	
Galliformes	Numididae	Crested Guineafowl	<i>Guttera pucherani</i>	
Galliformes	Phasianidae	Blue Quail	<i>Synoicus adansonii</i>	
Galliformes	Phasianidae	Common Quail	<i>Coturnix coturnix</i>	
Galliformes	Phasianidae	Harlequin Quail	<i>Coturnix delegorguei</i>	
Galliformes	Phasianidae	Scaly Francolin	<i>Pternistis squamatus</i>	
Podicipediformes	Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	
Columbiformes	Columbidae	Speckled Pigeon	<i>Columba guinea</i>	
Columbiformes	Columbidae	Lemon Dove	<i>Columba larvata</i>	
Columbiformes	Columbidae	Mourning Collared-Dove	<i>Streptopelia decipiens</i>	
Columbiformes	Columbidae	Red-eyed Dove	<i>Streptopelia semitorquata</i>	
Columbiformes	Columbidae	Ring-necked Dove	<i>Streptopelia capicola</i>	
Columbiformes	Columbidae	Laughing Dove	<i>Streptopelia senegalensis</i>	
Columbiformes	Columbidae	Emerald-spotted Wood-Dove	<i>Turtur chalcospilos</i>	
Columbiformes	Columbidae	Blue-spotted Wood-Dove	<i>Turtur afer</i>	
Columbiformes	Columbidae	Tambourine Dove	<i>Turtur tympanistria</i>	
Columbiformes	Columbidae	Namaqua Dove	<i>Oena capensis</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Columbiformes	Columbidae	African Green-Pigeon	<i>Treron calvus</i>	
Otidiformes	Otididae	Black-bellied Bustard	<i>Lissotis melanogaster</i>	
Musophagiformes	Musophagidae	Great Blue Turaco	<i>Corythaeola cristata</i>	
Musophagiformes	Musophagidae	White-crested Turaco	<i>Tauraco leucolophus</i>	
Musophagiformes	Musophagidae	Ross's Turaco	<i>Musophaga rossae</i>	
Musophagiformes	Musophagidae	Eastern Plantain-eater	<i>Crinifer zonurus</i>	
Cuculiformes	Cuculidae	Senegal Coucal	<i>Centropus senegalensis</i>	
Cuculiformes	Cuculidae	Blue-headed Coucal	<i>Centropus monachus</i>	
Cuculiformes	Cuculidae	White-browed Coucal	<i>Centropus superciliosus</i>	
Cuculiformes	Cuculidae	Black Coucal	<i>Centropus grillii</i>	
Cuculiformes	Cuculidae	Blue Malkoha	<i>Ceuthmochares aereus</i>	
Cuculiformes	Cuculidae	Great Spotted Cuckoo	<i>Clamator glandarius</i>	
Cuculiformes	Cuculidae	Levaillant's Cuckoo	<i>Clamator levaillantii</i>	
Cuculiformes	Cuculidae	Pied Cuckoo	<i>Clamator jacobinus</i>	
Cuculiformes	Cuculidae	Dideric Cuckoo	<i>Chrysococcyx caprius</i>	
Cuculiformes	Cuculidae	Klaas's Cuckoo	<i>Chrysococcyx klaas</i>	
Cuculiformes	Cuculidae	African Emerald Cuckoo	<i>Chrysococcyx cupreus</i>	
Cuculiformes	Cuculidae	Black Cuckoo	<i>Cuculus clamosus</i>	
Cuculiformes	Cuculidae	Red-chested Cuckoo	<i>Cuculus solitarius</i>	
Cuculiformes	Cuculidae	African Cuckoo	<i>Cuculus gularis</i>	
Cuculiformes	Cuculidae	Madagascar Cuckoo	<i>Cuculus rochii</i>	RA
Cuculiformes	Cuculidae	Common Cuckoo	<i>Cuculus canorus</i>	
Caprimulgiformes	Caprimulgidae	Pennant-winged Nightjar	<i>Caprimulgus vexillarius</i>	
Caprimulgiformes	Caprimulgidae	Standard-winged Nightjar	<i>Caprimulgus longipennis</i>	
Caprimulgiformes	Caprimulgidae	Eurasian Nightjar	<i>Caprimulgus europaeus</i>	
Caprimulgiformes	Caprimulgidae	Sombre Nightjar	<i>Caprimulgus fraenatus</i>	RA
Caprimulgiformes	Caprimulgidae	Swamp Nightjar	<i>Caprimulgus natalensis</i>	
Caprimulgiformes	Caprimulgidae	Plain Nightjar	<i>Caprimulgus inornatus</i>	
Caprimulgiformes	Caprimulgidae	Freckled Nightjar	<i>Caprimulgus tristigma</i>	
Caprimulgiformes	Caprimulgidae	Slender-tailed Nightjar	<i>Caprimulgus clarus</i>	
Caprimulgiformes	Apodidae	Scarce Swift	<i>Schoutedenapus myoptilus</i>	
Caprimulgiformes	Apodidae	Alpine Swift	<i>Apus melba</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Caprimulgiformes	Apodidae	Common Swift	<i>Apus apus</i>	
Caprimulgiformes	Apodidae	Nyanza Swift	<i>Apus niansae</i>	
Caprimulgiformes	Apodidae	Little Swift	<i>Apus affinis</i>	
Caprimulgiformes	Apodidae	Horus Swift	<i>Apus horus</i>	
Caprimulgiformes	Apodidae	White-rumped Swift	<i>Apus caffer</i>	
Caprimulgiformes	Apodidae	African Palm-Swift	<i>Cypsiurus parvus</i>	
Gruiformes	Sarothruridae	White-spotted Flufftail	<i>Sarothrura pulchra</i>	
Gruiformes	Sarothruridae	Buff-spotted Flufftail	<i>Sarothrura elegans</i>	
Gruiformes	Sarothruridae	Red-chested Flufftail	<i>Sarothrura rufa</i>	
Gruiformes	Rallidae	African Rail	<i>Rallus caerulescens</i>	
Gruiformes	Rallidae	Corn Crake	<i>Crex crex</i>	
Gruiformes	Rallidae	African Crake	<i>Crex egregia</i>	
Gruiformes	Rallidae	Spotted Crake	<i>Porzana porzana</i>	RA
Gruiformes	Rallidae	Lesser Moorhen	<i>Paragallinula angulata</i>	
Gruiformes	Rallidae	Eurasian Moorhen	<i>Gallinula chloropus</i>	
Gruiformes	Rallidae	Red-knobbed Coot	<i>Fulica cristata</i>	
Gruiformes	Rallidae	Allen's Gallinule	<i>Porphyrio alleni</i>	
Gruiformes	Rallidae	African Swamphen	<i>Porphyrio madagascariensis</i>	
Gruiformes	Rallidae	Striped Crake	<i>Amaurornis marginalis</i>	RA
Gruiformes	Rallidae	Black Crake	<i>Zapornia flavirostra</i>	
Gruiformes	Rallidae	Baillon's Crake	<i>Zapornia pusilla</i>	RA
Gruiformes	Gruidae	Gray Crowned-Crane	<i>Balearica regulorum</i>	EN
Charadriiformes	Burhinidae	Water Thick-knee	<i>Burhinus vermiculatus</i>	
Charadriiformes	Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	
Charadriiformes	Recurvirostridae	Pied Avocet	<i>Recurvirostra avosetta</i>	
Charadriiformes	Charadriidae	Long-toed Lapwing	<i>Vanellus crassirostris</i>	
Charadriiformes	Charadriidae	Spur-winged Lapwing	<i>Vanellus spinosus</i>	
Charadriiformes	Charadriidae	Senegal Lapwing	<i>Vanellus lugubris</i>	
Charadriiformes	Charadriidae	Wattled Lapwing	<i>Vanellus senegallus</i>	
Charadriiformes	Charadriidae	Brown-chested Lapwing	<i>Vanellus superciliosus</i>	
Charadriiformes	Charadriidae	Caspian Plover	<i>Charadrius asiaticus</i>	
Charadriiformes	Charadriidae	Kittlitz's Plover	<i>Charadrius pecuarius</i>	
Charadriiformes	Charadriidae	Common Ringed Plover	<i>Charadrius hiaticula</i>	
Charadriiformes	Charadriidae	Little Ringed Plover	<i>Charadrius dubius</i>	
Charadriiformes	Charadriidae	Three-banded Plover	<i>Charadrius tricollaris</i>	
Charadriiformes	Rostratulidae	Greater Painted-Snipe	<i>Rostratula benghalensis</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Charadriiformes	Jacaniidae	Lesser Jacana	<i>Microparra capensis</i>	
Charadriiformes	Jacaniidae	African Jacana	<i>Actophilornis africanus</i>	
Charadriiformes	Scolopacidae	Whimbrel	<i>Numenius phaeopus</i>	
Charadriiformes	Scolopacidae	Eurasian Curlew	<i>Numenius arquata</i>	NT
Charadriiformes	Scolopacidae	Black-tailed Godwit	<i>Limosa limosa</i>	NT
Charadriiformes	Scolopacidae	Ruff	<i>Calidris pugnax</i>	
Charadriiformes	Scolopacidae	Curlew Sandpiper	<i>Calidris ferruginea</i>	NT
Charadriiformes	Scolopacidae	Temminck's Stint	<i>Calidris temminckii</i>	
Charadriiformes	Scolopacidae	Little Stint	<i>Calidris minuta</i>	
Charadriiformes	Scolopacidae	Jack Snipe	<i>Lymnocyptes minimus</i>	
Charadriiformes	Scolopacidae	Great Snipe	<i>Gallinago media</i>	NT
Charadriiformes	Scolopacidae	Common Snipe	<i>Gallinago gallinago</i>	
Charadriiformes	Scolopacidae	Common Sandpiper	<i>Actitis hypoleucos</i>	
Charadriiformes	Scolopacidae	Green Sandpiper	<i>Tringa ochropus</i>	
Charadriiformes	Scolopacidae	Spotted Redshank	<i>Tringa erythropus</i>	
Charadriiformes	Scolopacidae	Common Greenshank	<i>Tringa nebularia</i>	
Charadriiformes	Scolopacidae	Marsh Sandpiper	<i>Tringa stagnatilis</i>	
Charadriiformes	Scolopacidae	Wood Sandpiper	<i>Tringa glareola</i>	
Charadriiformes	Scolopacidae	Common Redshank	<i>Tringa totanus</i>	
Charadriiformes	Turnicidae	Small Buttonquail	<i>Turnix sylvaticus</i>	
Charadriiformes	Glareolidae	Temminck's Courser	<i>Cursorius temminckii</i>	
Charadriiformes	Glareolidae	Bronze-winged Courser	<i>Rhinoptilus chalcopterus</i>	
Charadriiformes	Glareolidae	Collared Pratincole	<i>Glareola pratincola</i>	
Charadriiformes	Glareolidae	Madagascar Pratincole	<i>Glareola ocularis</i>	RA VU
Charadriiformes	Glareolidae	Rock Pratincole	<i>Glareola nuchalis</i>	
Charadriiformes	Laridae	Gray-hooded Gull	<i>Chroicocephalus cirrocephalus</i>	
Charadriiformes	Laridae	Black-headed Gull	<i>Chroicocephalus ridibundus</i>	
Charadriiformes	Laridae	Lesser Black-backed Gull	<i>Larus fuscus</i>	
Charadriiformes	Laridae	Gull-billed Tern	<i>Gelochelidon nilotica</i>	
Charadriiformes	Laridae	Caspian Tern	<i>Hydroprogne caspia</i>	RA
Charadriiformes	Laridae	White-winged Tern	<i>Chlidonias leucopterus</i>	
Charadriiformes	Laridae	African Skimmer	<i>Rynchops flavirostris</i>	NT
Ciconiiformes	Ciconiidae	African Openbill	<i>Anastomus lamelligerus</i>	
Ciconiiformes	Ciconiidae	Black Stork	<i>Ciconia nigra</i>	
Ciconiiformes	Ciconiidae	Abdim's Stork	<i>Ciconia abdimii</i>	
Ciconiiformes	Ciconiidae	Woolly-necked Stork	<i>Ciconia episcopus</i>	
Ciconiiformes	Ciconiidae	White Stork	<i>Ciconia ciconia</i>	
Ciconiiformes	Ciconiidae	Saddle-billed Stork	<i>Ephippiorhynchus senegalensis</i>	
Ciconiiformes	Ciconiidae	Marabou Stork	<i>Leptoptilos crumenifer</i>	
Ciconiiformes	Ciconiidae	Yellow-billed Stork	<i>Mycteria ibis</i>	
Suliformes	Anhingidae	African Darter	<i>Anhinga rufa</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Suliformes	Phalacrocoracidae	Long-tailed Cormorant	<i>Microcarbo africanus</i>	
Suliformes	Phalacrocoracidae	Great Cormorant	<i>Phalacrocorax carbo</i>	
Pelecaniformes	Pelecanidae	Great White Pelican	<i>Pelecanus onocrotalus</i>	
Pelecaniformes	Pelecanidae	Pink-backed Pelican	<i>Pelecanus rufescens</i>	
Pelecaniformes	Balaenicipitidae	Shoebill	<i>Balaeniceps rex</i>	VU
Pelecaniformes	Scopidae	Hamerkop	<i>Scopus umbretta</i>	
Pelecaniformes	Ardeidae	Little Bittern	<i>Ixobrychus minutus</i>	
Pelecaniformes	Ardeidae	Dwarf Bittern	<i>Ixobrychus sturmi</i>	
Pelecaniformes	Ardeidae	Gray Heron	<i>Ardea cinerea</i>	
Pelecaniformes	Ardeidae	Black-headed Heron	<i>Ardea melanocephala</i>	
Pelecaniformes	Ardeidae	Goliath Heron	<i>Ardea goliath</i>	
Pelecaniformes	Ardeidae	Purple Heron	<i>Ardea purpurea</i>	
Pelecaniformes	Ardeidae	Great Egret	<i>Ardea alba</i>	
Pelecaniformes	Ardeidae	Intermediate Egret	<i>Ardea intermedia</i>	
Pelecaniformes	Ardeidae	Little Egret	<i>Egretta garzetta</i>	
Pelecaniformes	Ardeidae	Black Heron	<i>Egretta ardesiaca</i>	
Pelecaniformes	Ardeidae	Cattle Egret	<i>Bubulcus ibis</i>	
Pelecaniformes	Ardeidae	Squacco Heron	<i>Ardeola ralloides</i>	
Pelecaniformes	Ardeidae	Madagascar Pond-Heron	<i>Ardeola idae</i>	RA, EN
Pelecaniformes	Ardeidae	Rufous-bellied Heron	<i>Ardeola rufiventris</i>	
Pelecaniformes	Ardeidae	Striated Heron	<i>Butorides striata</i>	
Pelecaniformes	Ardeidae	Black-crowned Night-Heron	<i>Nycticorax nycticorax</i>	
Pelecaniformes	Threskiornithidae	Glossy Ibis	<i>Plegadis falcinellus</i>	
Pelecaniformes	Threskiornithidae	African Sacred Ibis	<i>Threskiornis aethiopicus</i>	
Pelecaniformes	Threskiornithidae	Hadada Ibis	<i>Bostrychia hagedash</i>	
Pelecaniformes	Threskiornithidae	African Spoonbill	<i>Platalea alba</i>	
Accipitriformes	Sagittariidae	Secretarybird	<i>Sagittarius serpentarius</i>	VU
Accipitriformes	Pandionidae	Osprey	<i>Pandion haliaetus</i>	
Accipitriformes	Accipitridae	Black-winged Kite	<i>Elanus caeruleus</i>	
Accipitriformes	Accipitridae	African Harrier-Hawk	<i>Polyboroides typus</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Accipitriformes	Accipitridae	Palm-nut Vulture	<i>Gypohierax angolensis</i>	
Accipitriformes	Accipitridae	Bearded Vulture	<i>Gypaetus barbatus</i>	NT
Accipitriformes	Accipitridae	Egyptian Vulture	<i>Neophron percnopterus</i>	EN
Accipitriformes	Accipitridae	European Honey-buzzard	<i>Pernis apivorus</i>	
Accipitriformes	Accipitridae	African Cuckoo-Hawk	<i>Aviceda cuculoides</i>	
Accipitriformes	Accipitridae	White-headed Vulture	<i>Trionoceph occipitalis</i>	CE
Accipitriformes	Accipitridae	Lappet-faced Vulture	<i>Torgos tracheliotos</i>	EN
Accipitriformes	Accipitridae	Hooded Vulture	<i>Necrosyrtes monachus</i>	CE
Accipitriformes	Accipitridae	White-backed Vulture	<i>Gyps africanus</i>	CE
Accipitriformes	Accipitridae	Rüppell's Griffon	<i>Gyps rueppelli</i>	CE
Accipitriformes	Accipitridae	Bateleur	<i>Terathopius ecaudatus</i>	NT
Accipitriformes	Accipitridae	Black-chested Snake-Eagle	<i>Circaetus pectoralis</i>	
Accipitriformes	Accipitridae	Brown Snake-Eagle	<i>Circaetus cinereus</i>	
Accipitriformes	Accipitridae	Banded Snake-Eagle	<i>Circaetus cinerascens</i>	
Accipitriformes	Accipitridae	Bat Hawk	<i>Macheiramphus alcinus</i>	
Accipitriformes	Accipitridae	Martial Eagle	<i>Polemaetus bellicosus</i>	VU
Accipitriformes	Accipitridae	Long-crested Eagle	<i>Lophaetus occipitalis</i>	
Accipitriformes	Accipitridae	Wahlberg's Eagle	<i>Hieraaetus wahlbergi</i>	
Accipitriformes	Accipitridae	Ayres's Hawk-Eagle	<i>Hieraaetus ayresii</i>	
Accipitriformes	Accipitridae	Tawny Eagle	<i>Aquila rapax</i>	VU
Accipitriformes	Accipitridae	Steppe Eagle	<i>Aquila nipalensis</i>	EN
Accipitriformes	Accipitridae	African Hawk-Eagle	<i>Aquila spilogaster</i>	
Accipitriformes	Accipitridae	Lizard Buzzard	<i>Kaupifalco monogrammicus</i>	
Accipitriformes	Accipitridae	Gabar Goshawk	<i>Micronisus gabar</i>	
Accipitriformes	Accipitridae	Eurasian Marsh-Harrier	<i>Circus aeruginosus</i>	
Accipitriformes	Accipitridae	African Marsh-Harrier	<i>Circus ranivorus</i>	
Accipitriformes	Accipitridae	Pallid Harrier	<i>Circus macrourus</i>	NT
Accipitriformes	Accipitridae	Montagu's Harrier	<i>Circus pygargus</i>	
Accipitriformes	Accipitridae	African Goshawk	<i>Accipiter tachiro</i>	
Accipitriformes	Accipitridae	Shikra	<i>Accipiter badius</i>	
Accipitriformes	Accipitridae	Little Sparrowhawk	<i>Accipiter minullus</i>	
Accipitriformes	Accipitridae	Ovambo Sparrowhawk	<i>Accipiter ovampensis</i>	
Accipitriformes	Accipitridae	Rufous-breasted Sparrowhawk	<i>Accipiter rufiventris</i>	
Accipitriformes	Accipitridae	Black Goshawk	<i>Accipiter melanoleucus</i>	
Accipitriformes	Accipitridae	Black Kite	<i>Milvus migrans</i>	
Accipitriformes	Accipitridae	African Fish-Eagle	<i>Haliaeetus vocifer</i>	
Accipitriformes	Accipitridae	Common Buzzard	<i>Buteo buteo</i>	
Accipitriformes	Accipitridae	Augur Buzzard	<i>Buteo augur</i>	
Strigiformes	Tytonidae	African Grass-Owl	<i>Tyto capensis</i>	
Strigiformes	Tytonidae	Barn Owl	<i>Tyto alba</i>	
Strigiformes	Strigidae	Eurasian Scops-Owl	<i>Otus scops</i>	
Strigiformes	Strigidae	African Scops-Owl	<i>Otus senegalensis</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Strigiformes	Strigidae	Southern White-faced Owl	<i>Ptilopsis granti</i>	
Strigiformes	Strigidae	Spotted Eagle-Owl	<i>Bubo africanus</i>	
Strigiformes	Strigidae	Verreaux's Eagle-Owl	<i>Bubo lacteus</i>	
Strigiformes	Strigidae	Pearl-spotted Owlet	<i>Glaucidium perlatum</i>	
Strigiformes	Strigidae	Red-chested Owlet	<i>Glaucidium tephronotum</i>	
Strigiformes	Strigidae	African Wood-Owl	<i>Strix woodfordii</i>	
Strigiformes	Strigidae	Marsh Owl	<i>Asio capensis</i>	
Coliiformes	Coliidae	Speckled Mousebird	<i>Colius striatus</i>	
Coliiformes	Coliidae	Blue-naped Mousebird	<i>Urocolius macrourus</i>	
Trogoniformes	Trogonidae	Narina Trogon	<i>Apaloderma narina</i>	
Bucerotiformes	Upupidae	Eurasian Hoopoe	<i>Upupa epops</i>	
Bucerotiformes	Phoeniculidae	Green Woodhoopoe	<i>Phoeniculus purpureus</i>	
Bucerotiformes	Phoeniculidae	White-headed Woodhoopoe	<i>Phoeniculus bollei</i>	
Bucerotiformes	Phoeniculidae	Forest Woodhoopoe	<i>Phoeniculus castaneiceps</i>	
Bucerotiformes	Phoeniculidae	Common Scimitarbill	<i>Rhinopomastus cyanomelas</i>	
Bucerotiformes	Bucerotidae	Crowned Hornbill	<i>Lophoceros alboterminatus</i>	
Bucerotiformes	Bucerotidae	African Gray Hornbill	<i>Lophoceros nasutus</i>	
Bucerotiformes	Bucerotidae	Black-and-white-casqued Hornbill	<i>Bycanistes subcylindricus</i>	
Coraciiformes	Alcedinidae	Shining-blue Kingfisher	<i>Alcedo quadibrachys</i>	
Coraciiformes	Alcedinidae	Malachite Kingfisher	<i>Corythornis cristatus</i>	
Coraciiformes	Alcedinidae	African Pygmy-Kingfisher	<i>Ispidina picta</i>	
Coraciiformes	Alcedinidae	Gray-headed Kingfisher	<i>Halcyon leucocephala</i>	
Coraciiformes	Alcedinidae	Woodland Kingfisher	<i>Halcyon senegalensis</i>	
Coraciiformes	Alcedinidae	Striped Kingfisher	<i>Halcyon chelicuti</i>	
Coraciiformes	Alcedinidae	Giant Kingfisher	<i>Megaceryle maxima</i>	
Coraciiformes	Alcedinidae	Pied Kingfisher	<i>Ceryle rudis</i>	
Coraciiformes	Meropidae	Little Bee-eater	<i>Merops pusillus</i>	
Coraciiformes	Meropidae	Blue-breasted Bee-eater	<i>Merops variegatus</i>	
Coraciiformes	Meropidae	White-throated Bee-eater	<i>Merops albicollis</i>	
Coraciiformes	Meropidae	Blue-cheeked Bee-eater	<i>Merops persicus</i>	
Coraciiformes	Meropidae	Madagascar Bee-eater	<i>Merops superciliosus</i>	
Coraciiformes	Coraciidae	European Roller	<i>Coracias garrulus</i>	
Coraciiformes	Coraciidae	Lilac-breasted Roller	<i>Coracias caudatus</i>	
Coraciiformes	Coraciidae	Rufous-crowned Roller	<i>Coracias naevius</i>	
Coraciiformes	Coraciidae	Broad-billed Roller	<i>Eurystomus glaucurus</i>	
Piciformes	Lybiidae	Yellow-billed Barbet	<i>Trachyphonus purpuratus</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Piciformes	Lybiidae	Gray-throated Barbet	<i>Gymnobucco bonapartei</i>	
Piciformes	Lybiidae	Speckled Tinkerbird	<i>Pogoniulus scolopaceus</i>	
Piciformes	Lybiidae	Yellow-rumped Tinkerbird	<i>Pogoniulus bilineatus</i>	
Piciformes	Lybiidae	Yellow-fronted Tinkerbird	<i>Pogoniulus chrysoconus</i>	
Piciformes	Lybiidae	Yellow-spotted Barbet	<i>Buccanodon duchaillui</i>	
Piciformes	Lybiidae	Hairy-breasted Barbet	<i>Tricholaema hirsuta</i>	
Piciformes	Lybiidae	Red-fronted Barbet	<i>Tricholaema diademata</i>	
Piciformes	Lybiidae	Spot-flanked Barbet	<i>Tricholaema lacrymosa</i>	
Piciformes	Lybiidae	White-headed Barbet	<i>Lybius leucocephalus</i>	
Piciformes	Lybiidae	Double-toothed Barbet	<i>Lybius bidentatus</i>	
Piciformes	Indicatoridae	Least Honeyguide	<i>Indicator exilis</i>	
Piciformes	Indicatoridae	Greater Honeyguide	<i>Indicator indicator</i>	
Piciformes	Picidae	Eurasian Wryneck	<i>Jynx torquilla</i>	
Piciformes	Picidae	Rufous-necked Wryneck	<i>Jynx ruficollis</i>	
Piciformes	Picidae	Elliot's Woodpecker	<i>Chloropicus elliotii</i>	
Piciformes	Picidae	Speckle-breasted Woodpecker	<i>Chloropicus poecilolaemus</i>	
Piciformes	Picidae	Cardinal Woodpecker	<i>Chloropicus fuscescens</i>	
Piciformes	Picidae	Bearded Woodpecker	<i>Chloropicus namaquus</i>	
Piciformes	Picidae	Golden-crowned Woodpecker	<i>Chloropicus xantholophus</i>	
Piciformes	Picidae	Brown-backed Woodpecker	<i>Chloropicus obsoletus</i>	
Piciformes	Picidae	African Gray Woodpecker	<i>Chloropicus goertae</i>	
Piciformes	Picidae	Brown-eared Woodpecker	<i>Campethera caroli</i>	
Piciformes	Picidae	Buff-spotted Woodpecker	<i>Campethera nivosa</i>	
Piciformes	Picidae	Green-backed Woodpecker	<i>Campethera cailliautii</i>	
Piciformes	Picidae	Nubian Woodpecker	<i>Campethera nubica</i>	
Falconiformes	Falconidae	Pygmy Falcon	<i>Polihierax semitorquatus</i>	
Falconiformes	Falconidae	Lesser Kestrel	<i>Falco naumanni</i>	
Falconiformes	Falconidae	Eurasian Kestrel	<i>Falco tinnunculus</i>	
Falconiformes	Falconidae	Gray Kestrel	<i>Falco ardosiaceus</i>	
Falconiformes	Falconidae	Red-necked Falcon	<i>Falco chicquera</i>	
Falconiformes	Falconidae	Red-footed Falcon	<i>Falco vespertinus</i>	RA/ NT
Falconiformes	Falconidae	Amur Falcon	<i>Falco amurensis</i>	RA
Falconiformes	Falconidae	Eurasian Hobby	<i>Falco subbuteo</i>	
Falconiformes	Falconidae	African Hobby	<i>Falco cuvierii</i>	
Falconiformes	Falconidae	Lanner Falcon	<i>Falco biarmicus</i>	
Falconiformes	Falconidae	Peregrine Falcon	<i>Falco peregrinus</i>	
Falconiformes	Falconidae	Taita Falcon	<i>Falco fasciitucha</i>	VU
Psittaciformes	Psittaculidae	Red-headed Lovebird	<i>Agapornis pullarius</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Psittaciformes	Psittacidae	Gray Parrot	<i>Psittacus erithacus</i>	
Psittaciformes	Psittacidae	Meyer's Parrot	<i>Poicephalus meyeri</i>	
Passeriformes	Calypptomidae	African Broadbill	<i>Smithornis capensis</i>	
Passeriformes	Pittidae	African Pitta	<i>Pitta angolensis</i>	
Passeriformes	Pittidae	Green-breasted Pitta	<i>Pitta reichenowi</i>	
Passeriformes	Campephagidae	White-breasted Cuckooshrike	<i>Coracina pectoralis</i>	
Passeriformes	Campephagidae	Black Cuckooshrike	<i>Campephaga flava</i>	
Passeriformes	Campephagidae	Red-shouldered Cuckooshrike	<i>Campephaga phoenicea</i>	
Passeriformes	Campephagidae	Purple-throated Cuckooshrike	<i>Campephaga quisqualina</i>	
Passeriformes	Oriolidae	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	
Passeriformes	Oriolidae	African Golden Oriole	<i>Oriolus auratus</i>	
Passeriformes	Oriolidae	Western Black-headed Oriole	<i>Oriolus brachyrynchus</i>	
Passeriformes	Oriolidae	African Black-headed Oriole	<i>Oriolus larvatus</i>	
Passeriformes	Oriolidae	Black-tailed Oriole	<i>Oriolus percivali</i>	
Passeriformes	Platysteiridae	Brown-throated Wattle-eye	<i>Platysteira cyanea</i>	
Passeriformes	Platysteiridae	Black-throated Wattle-eye	<i>Platysteira peltata</i>	
Passeriformes	Platysteiridae	Chestnut Wattle-eye	<i>Platysteira castanea</i>	
Passeriformes	Platysteiridae	Jameson's Wattle-eye	<i>Platysteira jamesoni</i>	
Passeriformes	Platysteiridae	Chin-spot Batis	<i>Batis molitor</i>	
Passeriformes	Platysteiridae	Western Black-headed Batis	<i>Batis erlangeri</i>	
Passeriformes	Vangidae	African Shrike-flycatcher	<i>Megabyas flammulatus</i>	
Passeriformes	Vangidae	Black-and-white Shrike-flycatcher	<i>Bias musicus</i>	
Passeriformes	Malaconotidae	Brubru	<i>Nilaus afer</i>	
Passeriformes	Malaconotidae	Northern Puffback	<i>Dryoscopus gambensis</i>	
Passeriformes	Malaconotidae	Marsh Tchagra	<i>Tchagra minutus</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Malaconotidae	Black-crowned Tchagra	<i>Tchagra senegalus</i>	
Passeriformes	Malaconotidae	Brown-crowned Tchagra	<i>Tchagra australis</i>	
Passeriformes	Malaconotidae	Lühder's Bushshrike	<i>Laniarius luehderi</i>	
Passeriformes	Malaconotidae	Tropical Boubou	<i>Laniarius major</i>	
Passeriformes	Malaconotidae	Black-headed Gonolek	<i>Laniarius erythrogaster</i>	
Passeriformes	Malaconotidae	Papyrus Gonolek	<i>Laniarius mufumbiri</i>	NT
Passeriformes	Malaconotidae	Gray-green Bushshrike	<i>Telophorus bocagei</i>	
Passeriformes	Malaconotidae	Sulphur-breasted Bushshrike	<i>Telophorus sulfureopectus</i>	
Passeriformes	Malaconotidae	Gray-headed Bushshrike	<i>Malaconotus blanchoti</i>	
Passeriformes	Dicruridae	Velvet-mantled Drongo	<i>Dicrurus modestus</i>	
Passeriformes	Monarchidae	Blue-headed Crested-Flycatcher	<i>Trochocercus nitens</i>	
Passeriformes	Monarchidae	Black-headed Paradise-Flycatcher	<i>Terpsiphone rufiventer</i>	
Passeriformes	Monarchidae	African Paradise-Flycatcher	<i>Terpsiphone viridis</i>	
Passeriformes	Laniidae	Red-backed Shrike	<i>Lanius collurio</i>	
Passeriformes	Laniidae	Red-tailed Shrike	<i>Lanius phoenicuroides</i>	
Passeriformes	Laniidae	Isabelline Shrike	<i>Lanius isabellinus</i>	
Passeriformes	Laniidae	Gray-backed Fiscal	<i>Lanius excubitoroides</i>	
Passeriformes	Laniidae	Mackinnon's Shrike	<i>Lanius mackinnoni</i>	
Passeriformes	Laniidae	Northern Fiscal	<i>Lanius humeralis</i>	
Passeriformes	Corvidae	Piapiac	<i>Ptilostomus afer</i>	
Passeriformes	Corvidae	Pied Crow	<i>Corvus albus</i>	
Passeriformes	Corvidae	White-necked Raven	<i>Corvus albicollis</i>	
Passeriformes	Hylotiidae	Yellow-bellied Hyliota	<i>Hyliota flavigaster</i>	
Passeriformes	Stenostiridae	African Blue Flycatcher	<i>Elminia longicauda</i>	
Passeriformes	Stenostiridae	Dusky Crested-Flycatcher	<i>Elminia nigromitrata</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Paridae	White-shouldered Black-Tit	<i>Melaniparus guineensis</i>	
Passeriformes	Paridae	Dusky Tit	<i>Melaniparus funereus</i>	
Passeriformes	Remizidae	African Penduline-Tit	<i>Anthoscopus caroli</i>	
Passeriformes	Alaudidae	Rufous-naped Lark	<i>Mirafra africana</i>	
Passeriformes	Alaudidae	Flappet Lark	<i>Mirafra rufocinnamomea</i>	
Passeriformes	Nicatoridae	Western Nicator	<i>Nicator chloris</i>	
Passeriformes	Macrosphenidae	Green Crombec	<i>Sylvietta virens</i>	
Passeriformes	Macrosphenidae	Northern Crombec	<i>Sylvietta brachyura</i>	
Passeriformes	Macrosphenidae	Moustached Grass-Warbler	<i>Melocichla mentalis</i>	
Passeriformes	Cisticolidae	Yellow-bellied Eremomela	<i>Eremomela icteropygialis</i>	
Passeriformes	Cisticolidae	Green-backed Eremomela	<i>Eremomela canescens</i>	
Passeriformes	Cisticolidae	White-chinned Prinia	<i>Schistolais leucopogon</i>	
Passeriformes	Cisticolidae	Green-backed Camaroptera	<i>Camaroptera brachyura</i>	
Passeriformes	Cisticolidae	Buff-bellied Warbler	<i>Phyllolais pulchella</i>	
Passeriformes	Cisticolidae	Black-throated Apalis	<i>Apalis jacksoni</i>	
Passeriformes	Cisticolidae	Yellow-breasted Apalis	<i>Apalis flavida</i>	
Passeriformes	Cisticolidae	Buff-throated Apalis	<i>Apalis rufogularis</i>	
Passeriformes	Cisticolidae	Tawny-flanked Prinia	<i>Prinia subflava</i>	
Passeriformes	Cisticolidae	Gray-capped Warbler	<i>Eminia lepida</i>	
Passeriformes	Cisticolidae	Red-faced Cisticola	<i>Cisticola erythropus</i>	
Passeriformes	Cisticolidae	Singing Cisticola	<i>Cisticola cantans</i>	
Passeriformes	Cisticolidae	Whistling Cisticola	<i>Cisticola lateralis</i>	
Passeriformes	Cisticolidae	Rattling Cisticola	<i>Cisticola chiniana</i>	
Passeriformes	Cisticolidae	Winding Cisticola	<i>Cisticola marginatus</i>	
Passeriformes	Cisticolidae	Carruthers's Cisticola	<i>Cisticola carruthersi</i>	
Passeriformes	Cisticolidae	Croaking Cisticola	<i>Cisticola natalensis</i>	
Passeriformes	Cisticolidae	Siffling Cisticola	<i>Cisticola brachypterus</i>	
Passeriformes	Cisticolidae	Zitting Cisticola	<i>Cisticola juncidis</i>	
Passeriformes	Acrocephalidae	Eastern Olivaceous Warbler	<i>Iduna pallida</i>	
Passeriformes	Acrocephalidae	Upcher's Warbler	<i>Hippolais languida</i>	
Passeriformes	Acrocephalidae	Icterine Warbler	<i>Hippolais icterina</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Acrocephalidae	Sedge Warbler	<i>Acrocephalus schoenobaenus</i>	
Passeriformes	Acrocephalidae	Eurasian Reed Warbler	<i>Acrocephalus scirpaceus</i>	
Passeriformes	Acrocephalidae	Lesser Swamp Warbler	<i>Acrocephalus gracilirostris</i>	
Passeriformes	Acrocephalidae	Greater Swamp Warbler	<i>Acrocephalus rufescens</i>	
Passeriformes	Acrocephalidae	Great Reed Warbler	<i>Acrocephalus arundinaceus</i>	
Passeriformes	Locustellidae	Fan-tailed Grassbird	<i>Schoenicola brevirostris</i>	
Passeriformes	Locustellidae	River Warbler	<i>Locustella fluviatilis</i>	RA
Passeriformes	Hirundinidae	Plain Martin	<i>Riparia paludicola</i>	
Passeriformes	Hirundinidae	Bank Swallow	<i>Riparia riparia</i>	
Passeriformes	Hirundinidae	Banded Martin	<i>Riparia cincta</i>	
Passeriformes	Hirundinidae	Rock Martin	<i>Ptyonoprogne fuligula</i>	
Passeriformes	Hirundinidae	Barn Swallow	<i>Hirundo rustica</i>	
Passeriformes	Hirundinidae	Angola Swallow	<i>Hirundo angolensis</i>	
Passeriformes	Hirundinidae	Wire-tailed Swallow	<i>Hirundo smithii</i>	
Passeriformes	Hirundinidae	Montane Blue Swallow	<i>Hirundo atrocaerulea</i>	VU
Passeriformes	Hirundinidae	Red-rumped Swallow	<i>Cecropis daurica</i>	
Passeriformes	Hirundinidae	Lesser Striped Swallow	<i>Cecropis abyssinica</i>	
Passeriformes	Hirundinidae	Rufous-chested Swallow	<i>Cecropis semirufa</i>	
Passeriformes	Hirundinidae	Mosque Swallow	<i>Cecropis senegalensis</i>	
Passeriformes	Hirundinidae	Common House-Martin	<i>Delichon urbicum</i>	
Passeriformes	Hirundinidae	White-headed Sawwing	<i>Psalidoprocne albiceps</i>	
Passeriformes	Hirundinidae	Black Sawwing	<i>Psalidoprocne pristoptera</i>	
Passeriformes	Hirundinidae	Gray-rumped Swallow	<i>Pseudhirundo griseopyga</i>	
Passeriformes	Pycnonotidae	Slender-billed Greenbul	<i>Stelgidillas gracilirostris</i>	
Passeriformes	Pycnonotidae	Honeyguide Greenbul	<i>Baeopogon indicator</i>	
Passeriformes	Pycnonotidae	Yellow-throated Greenbul	<i>Atimastillas flavicollis</i>	
Passeriformes	Pycnonotidae	Red-tailed Greenbul	<i>Criniger calurus</i>	
Passeriformes	Pycnonotidae	Plain Greenbul	<i>Eurillas curvirostris</i>	
Passeriformes	Pycnonotidae	Little Greenbul	<i>Eurillas virens</i>	
Passeriformes	Pycnonotidae	Toro Olive-Greenbul	<i>Phyllastrephus hypochloris</i>	
Passeriformes	Pycnonotidae	White-throated Greenbul	<i>Phyllastrephus albigularis</i>	
Passeriformes	Pycnonotidae	Common Bulbul	<i>Pycnonotus barbatus</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Phylloscopidae	Wood Warbler	<i>Phylloscopus sibilatrix</i>	
Passeriformes	Phylloscopidae	Willow Warbler	<i>Phylloscopus trochilus</i>	
Passeriformes	Sylviidae	Eurasian Blackcap	<i>Sylvia atricapilla</i>	
Passeriformes	Sylviidae	Garden Warbler	<i>Sylvia borin</i>	
Passeriformes	Sylviidae	Barred Warbler	<i>Sylvia nisoria</i>	
Passeriformes	Sylviidae	Greater Whitethroat	<i>Sylvia communis</i>	
Passeriformes	Zosteropidae	African Yellow White-eye	<i>Zosterops senegalensis</i>	
Passeriformes	Leiothrichidae	Black-lored Babbler	<i>Turdoides sharpei</i>	
Passeriformes	Leiothrichidae	Brown Babbler	<i>Turdoides plebejus</i>	
Passeriformes	Buphagidae	Red-billed Oxpecker	<i>Buphagus erythrorhynchus</i>	
Passeriformes	Sturnidae	Wattled Starling	<i>Creatophora cinerea</i>	
Passeriformes	Sturnidae	Violet-backed Starling	<i>Cinnyricinclus leucogaster</i>	
Passeriformes	Sturnidae	Rüppell's Starling	<i>Lamprotornis purpuroptera</i>	
Passeriformes	Sturnidae	Splendid Starling	<i>Lamprotornis splendidus</i>	
Passeriformes	Sturnidae	Purple Starling	<i>Lamprotornis purpureus</i>	
Passeriformes	Turdidae	Rufous Flycatcher-Thrush	<i>Neocossyphus fraseri</i>	
Passeriformes	Turdidae	Abyssinian Thrush	<i>Turdus abyssinicus</i>	
Passeriformes	Turdidae	African Thrush	<i>Turdus pelios</i>	
Passeriformes	Muscicapidae	African Dusky Flycatcher	<i>Muscicapa adusta</i>	
Passeriformes	Muscicapidae	Spotted Flycatcher	<i>Muscicapa striata</i>	
Passeriformes	Muscicapidae	Swamp Flycatcher	<i>Muscicapa aquatica</i>	
Passeriformes	Muscicapidae	Sooty Flycatcher	<i>Bradornis fuliginosus</i>	
Passeriformes	Muscicapidae	Pale Flycatcher	<i>Agricola pallidus</i>	
Passeriformes	Muscicapidae	Gray Tit-Flycatcher	<i>Fraseria plumbea</i>	
Passeriformes	Muscicapidae	Ashy Flycatcher	<i>Fraseria caerulescens</i>	
Passeriformes	Muscicapidae	Silverbird	<i>Melaenornis semipartitus</i>	
Passeriformes	Muscicapidae	Northern Black-Flycatcher	<i>Melaenornis edolioides</i>	
Passeriformes	Muscicapidae	Fire-crested Alethe	<i>Alethe castanea</i>	
Passeriformes	Muscicapidae	Brown-backed Scrub-Robin	<i>Cercotrichas hartlaubi</i>	
Passeriformes	Muscicapidae	Red-backed Scrub-Robin	<i>Cercotrichas leucophrys</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Muscicapidae	Blue-shouldered Robin-Chat	<i>Cossypha cyanocampter</i>	
Passeriformes	Muscicapidae	Gray-winged Robin-Chat	<i>Cossypha polioptera</i>	
Passeriformes	Muscicapidae	White-browed Robin-Chat	<i>Cossypha heuglini</i>	
Passeriformes	Muscicapidae	Brown-chested Alethe	<i>Chamaetylas poliocephala</i>	
Passeriformes	Muscicapidae	Common Nightingale	<i>Luscinia megarhynchos</i>	
Passeriformes	Muscicapidae	Semicollared Flycatcher	<i>Ficedula semitorquata</i>	
Passeriformes	Muscicapidae	Common Redstart	<i>Phoenicurus phoenicurus</i>	
Passeriformes	Muscicapidae	Rufous-tailed Rock-Thrush	<i>Monticola saxatilis</i>	
Passeriformes	Muscicapidae	Whinchat	<i>Saxicola rubetra</i>	
Passeriformes	Muscicapidae	Mocking Cliff-Chat	<i>Thamnolaea cinnamomeiventris</i>	
Passeriformes	Muscicapidae	Sooty Chat	<i>Myrmecocichla nigra</i>	
Passeriformes	Muscicapidae	Northern Wheatear	<i>Oenanthe oenanthe</i>	
Passeriformes	Muscicapidae	Isabelline Wheatear	<i>Oenanthe isabellina</i>	
Passeriformes	Muscicapidae	Pied Wheatear	<i>Oenanthe pleschanka</i>	
Passeriformes	Nectariniidae	Gray-headed Sunbird	<i>Deleornis axillaris</i>	
Passeriformes	Nectariniidae	Little Green Sunbird	<i>Anthreptes seimundi</i>	
Passeriformes	Nectariniidae	Green Sunbird	<i>Anthreptes rectirostris</i>	
Passeriformes	Nectariniidae	Collared Sunbird	<i>Hedydipna collaris</i>	
Passeriformes	Nectariniidae	Green-headed Sunbird	<i>Cyanomitra verticalis</i>	
Passeriformes	Nectariniidae	Olive Sunbird	<i>Cyanomitra olivacea</i>	
Passeriformes	Nectariniidae	Green-throated Sunbird	<i>Chalcomitra rubescens</i>	
Passeriformes	Nectariniidae	Scarlet-chested Sunbird	<i>Chalcomitra senegalensis</i>	
Passeriformes	Nectariniidae	Bronze Sunbird	<i>Nectarinia kilimensis</i>	
Passeriformes	Nectariniidae	Golden-winged Sunbird	<i>Drepanorhynchus reichenowi</i>	
Passeriformes	Nectariniidae	Olive-bellied Sunbird	<i>Cinnyris chloropygius</i>	
Passeriformes	Nectariniidae	Northern Double-collared Sunbird	<i>Cinnyris reichenowi</i>	
Passeriformes	Nectariniidae	Mariqua Sunbird	<i>Cinnyris mariquensis</i>	
Passeriformes	Nectariniidae	Red-chested Sunbird	<i>Cinnyris erythrocerus</i>	
Passeriformes	Nectariniidae	Orange-tufted Sunbird	<i>Cinnyris bouvieri</i>	
Passeriformes	Nectariniidae	Superb Sunbird	<i>Cinnyris superbus</i>	
Passeriformes	Nectariniidae	Variable Sunbird	<i>Cinnyris venustus</i>	
Passeriformes	Nectariniidae	Copper Sunbird	<i>Cinnyris cupreus</i>	
Passeriformes	Ploceidae	Red-headed Malimbe	<i>Malimbus rubricollis</i>	
Passeriformes	Ploceidae	Red-headed Weaver	<i>Anaplectes rubriceps</i>	
Passeriformes	Ploceidae	Baglafaecht Weaver	<i>Ploceus baglafaecht</i>	
Passeriformes	Ploceidae	Little Weaver	<i>Ploceus luteolus</i>	
Passeriformes	Ploceidae	Slender-billed Weaver	<i>Ploceus pelzelni</i>	

Order	Family	Species (Engl.)	Species (Lat.)	Status
Passeriformes	Ploceidae	Black-necked Weaver	<i>Ploceus nigricollis</i>	
Passeriformes	Ploceidae	Spectacled Weaver	<i>Ploceus ocularis</i>	
Passeriformes	Ploceidae	Holub's Golden-Weaver	<i>Ploceus xanthops</i>	
Passeriformes	Ploceidae	Orange Weaver	<i>Ploceus auranfius</i>	
Passeriformes	Ploceidae	Northern Brown-throated Weaver	<i>Ploceus castanops</i>	
Passeriformes	Ploceidae	Lesser Masked-Weaver	<i>Ploceus intermedius</i>	
Passeriformes	Ploceidae	Vieillot's Weaver	<i>Ploceus nigerrimus</i>	
Passeriformes	Ploceidae	Village Weaver	<i>Ploceus cucullatus</i>	
Passeriformes	Ploceidae	Golden-backed Weaver	<i>Ploceus jacksoni</i>	
Passeriformes	Ploceidae	Compact Weaver	<i>Pachyphantes superciliosus</i>	
Passeriformes	Ploceidae	Cardinal Quelea	<i>Quelea cardinalis</i>	
Passeriformes	Ploceidae	Red-headed Quelea	<i>Quelea erythroptus</i>	
Passeriformes	Ploceidae	Red-billed Quelea	<i>Quelea quelea</i>	
Passeriformes	Ploceidae	Black-winged Bishop	<i>Euplectes hordeaceus</i>	
Passeriformes	Ploceidae	Black Bishop	<i>Euplectes gierowii</i>	
Passeriformes	Ploceidae	White-winged Widowbird	<i>Euplectes albonotatus</i>	
Passeriformes	Ploceidae	Yellow-mantled Widowbird	<i>Euplectes macroura</i>	
Passeriformes	Ploceidae	Fan-tailed Widowbird	<i>Euplectes axillaris</i>	
Passeriformes	Ploceidae	Marsh Widowbird	<i>Euplectes hartlaubi</i>	
Passeriformes	Ploceidae	Grosbeak Weaver	<i>Amblyospiza albifrons</i>	
Passeriformes	Estrildidae	Gray-headed Nigrita	<i>Nigrita canicapillus</i>	
Passeriformes	Estrildidae	Fawn-breasted Waxbill	<i>Estrilda paludicola</i>	
Passeriformes	Estrildidae	Common Waxbill	<i>Estrilda astrild</i>	
Passeriformes	Estrildidae	Black-crowned Waxbill	<i>Estrilda nonnula</i>	
Passeriformes	Estrildidae	Black-bellied Seedcracker	<i>Pyrenestes ostrinus</i>	
Passeriformes	Estrildidae	Red-cheeked Cordonbleu	<i>Uraeginthus bengalus</i>	
Passeriformes	Estrildidae	Brown Twinspot	<i>Clytospiza monteiri</i>	
Passeriformes	Estrildidae	Red-billed Firefinch	<i>Lagonosticta senegala</i>	
Passeriformes	Estrildidae	Bar-breasted Firefinch	<i>Lagonosticta rufopicta</i>	
Passeriformes	Estrildidae	African Firefinch	<i>Lagonosticta rubricata</i>	
Passeriformes	Estrildidae	Zebra Waxbill	<i>Sporaeginthus subflavus</i>	
Passeriformes	Estrildidae	Bronze Mannikin	<i>Spermestes cucullata</i>	
Passeriformes	Estrildidae	Black-and-white Mannikin	<i>Spermestes bicolor</i>	
Passeriformes	Viduidae	Pin-tailed Whydah	<i>Vidua macroura</i>	
Passeriformes	Viduidae	Village Indigobird	<i>Vidua chalybeata</i>	
Passeriformes	Passeridae	Northern Gray-headed Sparrow	<i>Passer griseus</i>	
Passeriformes	Motacillidae	Gray Wagtail	<i>Motacilla cinerea</i>	
Passeriformes	Motacillidae	Western Yellow Wagtail	<i>Motacilla flava</i>	
Passeriformes	Motacillidae	African Pied Wagtail	<i>Motacilla aguimp</i>	
Passeriformes	Motacillidae	White Wagtail	<i>Motacilla alba</i>	

<b>Order</b>	<b>Family</b>	<b>Species (Engl.)</b>	<b>Species (Lat.)</b>	<b>Status</b>
Passeriformes	Motacillidae	African Pipit	<i>Anthus cinnamomeus</i>	
Passeriformes	Motacillidae	Plain-backed Pipit	<i>Anthus leucophrys</i>	
Passeriformes	Motacillidae	Tree Pipit	<i>Anthus trivialis</i>	
Passeriformes	Motacillidae	Red-throated Pipit	<i>Anthus cervinus</i>	
Passeriformes	Motacillidae	Yellow-throated Longclaw	<i>Macronyx croceus</i>	
Passeriformes	Fringillidae	Yellow-fronted Canary	<i>Crithagra mozambica</i>	
Passeriformes	Fringillidae	Western Citril	<i>Crithagra frontalis</i>	
Passeriformes	Fringillidae	Papyrus Canary	<i>Crithagra koliensis</i>	
Passeriformes	Fringillidae	Black-throated Canary	<i>Crithagra atrogularis</i>	
Passeriformes	Fringillidae	White-bellied Canary	<i>Crithagra dorsostriata</i>	
Passeriformes	Fringillidae	Brimstone Canary	<i>Crithagra sulphurata</i>	

**Bird Species list for Sio-Siteko Wetland (source Sio-Siteko CWMP 2009 , Avian birds Database, NU opportunistic records)**

<b>Species</b>	<b>Family</b>	<b>Habit</b>	<b>Conservation status (IUCN)</b>	<b>Uses</b>
<i>Abrus canescens</i>	Fabaceae	Herb		
<i>Abrus precatorius</i>	Fabaceae	Herb		Medicine
<i>Abutilon mauritianum</i>	Malvaceae	Shrub		
<i>Acacia polyacantha</i>	Fabaceae	Tree		Firewood
<i>Acanthus pubescens</i>	Acanthaceae	Shrub		
<i>Achyranthes aspera</i>	Amaranthaceae	Herb		
<i>Acmella calirhiza</i>	Asteraceae	Herb		
<i>Acmella oleracea</i>	Asteraceae	Herb		
<i>Adenostemma perottetii</i>	Asteraceae	Herb		
<i>Aerva lanata</i>	Amaranthaceae	Shrub		Medicine
<i>Aeschynomene elaphroxylon</i>	Fabaceae	Tree	LC	Floaters
<i>Aeschynomene indica</i>	Fabaceae	Herb	LC	
<i>Aeschynomene sp.</i>	Fabaceae	Herb		
<i>Aframomum angustifolium</i>	Zingiberaceae	Herb	LC	Food
<i>Ageratum conyzoides</i>	Asteraceae	Herb		
<i>Allophylus africanus</i>	Sapindaceae	Tree	LC	Firewood
<i>Allophylus latifolius</i>	Sapindaceae	Shrub		Firewood
<i>Alysicarpus glumaceus</i>	Fabaceae	Herb		
<i>Amaranthus hybridus</i>	Amaranthaceae	Herb		
<i>Antidesma venosum</i>	Euphorbiaceae	Tree	LC	Firewood
<i>Asystasia gangetica</i>	Acanthaceae	Herb		
<i>Azima tetraacantha</i>	Salvadoraceae	Tree		
<i>Basilicum polystachyon</i>	Lamiaceae	Herb		
<i>Bersama abyssinica</i>	Melanthaceae	Tree		Firewood
<i>Bidens pilosa</i>	Asteraceae	Herb		Medicine
<i>Blighia unijugata</i>	Sapindaceae	Tree		Timber
<i>Brachiaria brizantha</i>	Poaceae	Herb		
<i>Brachiaria decumbens</i>	Poaceae	Herb		
<i>Brachiaria sp.</i>	Poaceae	Herb		

<i>Bridelia micrantha</i>	Euphorbiaceae	Tree	LC	Firewood
<i>Bulbostylis</i> sp.	Cyperaceae	Herb		
<i>Capparis erythrocarpos</i>	Capparaceae	Shrub		
<i>Capsicum frutescens</i>	Solanaceae	Shrub		Food, Medicine
<i>Cardiospermum halicacabum</i>	Sapindaceae	Herb		Medicine
<i>Centella</i> sp.	Apiaceae	Herb		Medicine
<i>Chamaecrista mimosoides</i>	Fabaceae	Herb		
<i>Chloris gayana</i>	Poaceae	Herb		Fodder
<i>Chloris pycnothrix</i>	Poaceae	Herb		
<i>Cissampelos mucronata</i>	Menispermaceae	Herb		Medicine
<i>Cissus quadrangularis</i>	Vitaceae	Herb		
<i>Cissus rotundifolia</i>	Vitaceae	Herb		
<i>Clitoria ternatea</i>	Fabaceae	Herb		
<i>Coccinia grandis</i>	Cucurbitaceae	Herb		
<i>Commelina africana</i>	Commelinaceae	Herb	LC	Medicine
<i>Commelina benghalensis</i>	Commelinaceae	Herb	LC	Medicine
<i>Conyza</i> sp.	Asteraceae	Herb		
<i>Conyza sumatrensis</i>	Asteraceae	Herb		
<i>Crassocephalum crepidioides</i>	Asteraceae	Herb		
<i>Crassocephalum vitellinum</i>	Asteraceae	Herb		
<i>Crotalaria</i> sp. 1	Fabaceae	Herb		
<i>Crotalaria</i> sp. 2	Fabaceae	Herb		
<i>Crotalaria spinosa</i>	Fabaceae	Herb		
<i>Cyclosorus striatus</i>	Thelypteridaceae	Herb		
<i>Cynium tubulosum</i>	Scrophulariaceae	Herb		
<i>Cynodon dactylon</i>	Poaceae	Herb		
<i>Cyperus articulatus</i>	Cyperaceae	Herb	LC	
<i>Cyperus cyperoides</i>	Cyperaceae	Herb	LC	
<i>Cyperus difformis</i>	Cyperaceae	Herb	LC	
<i>Cyperus dives</i>	Cyperaceae	Herb	LC	
<i>Cyperus dubius</i>	Cyperaceae	Herb	LC	
<i>Cyperus latifolius</i>	Cyperaceae	Herb	LC	

<i>Cyperus nitidus</i>	Cyperaceae	Herb	LC	
<i>Cyperus papyrus</i>	Cyperaceae	Herb	LC	Crafts, Thatching
<i>Cyperus rotundus</i>	Cyperaceae	Herb	LC	
<i>Cyperus</i> sp. 1	Cyperaceae	Herb		
<i>Cyperus</i> sp. 2	Cyperaceae	Herb		
<i>Cyperus</i> sp. 3	Cyperaceae	Herb		
<i>Cyphostemma adenocaulis</i>	Vitaceae	Herb		Medicine
<i>Cyphostemma serpens</i>	Vitaceae	Herb		
<i>Desmodium ramossissimum</i>	Fabaceae	Herb		
<i>Desmodium salicifolium</i>	Fabaceae	Herb	LC	
<i>Digitaria ciliaris</i>	Poaceae	Herb		
<i>Digitaria velutina</i>	Poaceae	Herb		
<i>Dombeya</i> sp.	Sterculiaceae	Shrub		
<i>Dracaena fragrans</i>	Dracaenaceae	Shrub	LC	Boundary marker
<i>Dyschoriste radicans</i>	Acanthaceae	Herb		
<i>Echinochloa pyramidalis</i>	Poaceae	Herb	LC	Fodder
<i>Eclipta prostrata</i>	Asteraceae	Herb	LC	
<i>Eichhornia crassipes</i>	Pontederiaceae	Herb		
<i>Eleusine indica</i>	Poaceae	Herb	LC	
<i>Emilia coccinea</i>	Asteraceae	Herb		
<i>Eragrostis exasperata</i>	Poaceae	Herb		
<i>Eragrostis mildbraedii</i>	Poaceae	Herb		
<i>Eriosema</i> sp.	Fabaceae	Herb		
<i>Erythrina abyssinica</i>	Fabaceae	Tree	LC	Spiritual value
<i>Erythrococca bongensis</i>	Euphorbiaceae	Shrub	LC	Medicine
<i>Ethulia conyzoides</i>	Asteraceae	Herb	LC	
<i>Euphorbia candelabrum</i>	Euphorbiaceae	Tree	LC	
<i>Euphorbia hirta</i>	Euphorbiaceae	Herb		
<i>Euphorbia indica</i>	Euphorbiaceae	Herb		
<i>Flueggea virosa</i>	Euphorbiaceae	Shrub	LC	Firewood
<i>Fuirena umbellata</i>	Cyperaceae	Herb	LC	
<i>Gomphocarpus physocarpus</i>	Apocynaceae	Herb		
<i>Grewia mollis</i>	Tiliaceae	Tree		Firewood
<i>Grewia similis</i>	Tiliaceae	Tree		Firewood

<i>Grewia trichocarpa</i>	Tiliaceae	Tree		Firewood
<i>Gutenbergia petersii</i>	Asteraceae	Herb		
<i>Hibiscus diversifolius</i>	Malvaceae	Shrub		
<i>Hibiscus</i> sp.	Malvaceae	Herb		
<i>Hoshundia opposita</i>	Lamiaceae	Shrub		Medicine
<i>Hygrophila schullii</i>	Acanthaceae	Herb	LC	
<i>Hyparrhenia rufa</i>	Poaceae	Herb		
<i>Hyptis lanceolata</i>	Lamiaceae	Herb		
<i>Indigofera arrecta</i>	Fabaceae	Shrub		Medicine
<i>Ipomoea cairica</i>	Convolvulaceae	Herb	LC	
<i>Ipomoea rubens</i>	Convolvulaceae	Herb		
<i>Justicia exigua</i>	Acanthaceae	Herb		
<i>Justicia flava</i>	Acanthaceae	Herb		
<i>Kigelia africana</i>	Bignoniaceae	Tree	LC	Firewood
<i>Kosteletzkya begoniifolia</i>	Malvaceae	Herb		Medicine
<i>Kyllinga odorata</i>	Cyperaceae	Herb		
<i>Kyllinga</i> sp. 1	Cyperaceae	Herb		
<i>Kyllinga</i> sp. 2	Cyperaceae	Herb		
<i>Lantana camara</i>	Verbenaceae	Shrub		
<i>Lantana trifolia</i>	Verbenaceae	Shrub		
<i>Laportea</i> sp.	Urticaceae	Herb		
<i>Leersia hexandra</i>	Poaceae	Herb	LC	
<i>Leonotis nepetifolia</i>	Lamiaceae	Herb		
<i>Lepistemon hirta</i>	Convolvulaceae	Herb		
<i>Leucas martinicensis</i>	Lamiaceae	Herb		
<i>Ludwigia abyssinica</i>	Onagraceae	Herb	LC	
<i>Luffa cylindrica</i>	Cucurbitaceae	Herb		Bath sponge
<i>Macaranga</i> sp.	Euphorbiaceae	Tree		
<i>Mar khamia lutea</i>	Bignoniaceae	Tree	LC	Timber, Firewood
<i>Melanthera scandens</i>	Asteraceae	Herb		
<i>Melochia</i> sp.	Sterculiaceae	Herb		
<i>Merremia</i> sp.	Convolvulaceae	Herb		
<i>Mikania cordata</i>	Asteraceae	Herb		
<i>Mimosa pigra</i>	Fabaceae	Shrub		

<i>Mimosa pudica</i>	Fabaceae	Herb	LC	
<i>Momordica foetida</i>	Cucurbitaceae	Herb		Medicine
<i>Morella kandtiana</i>	Myricaceae	Shrub		
<i>Mukia maderaspatana</i>	Cucurbitaceae	Herb		
<i>Murdannia simplex</i>	Commelinaceae	Herb	LC	
<i>Neonotonia wightii</i>	Fabaceae	Herb	LC	
<i>Nymphaea caerulea</i>	Nymphaeaceae	Herb		
<i>Nymphaea lotus</i>	Nymphaeaceae	Herb		
<i>Ocimum basilicum</i>	Lamiaceae	Shrub		
<i>Ocimum gratissimum</i>	Lamiaceae	Shrub		Tea spice
<i>Ottelia ulvifolia</i>	Hydrocharitaceae	Herb	LC	
<i>Panicum chionachne</i>	Poaceae	Herb		
<i>Panicum maximum</i>	Poaceae	Herb		Crafts
<i>Paspalidium geminatum</i>	Poaceae	Herb	LC	
<i>Paullinia pinnata</i>	Sapindaceae	Shrub		
<i>Pennisetum unisetum</i>	Poaceae	Herb		Drinking straws
<i>Pentodon pentandrus</i>	Rubiaceae	Herb	LC	
<i>Persicaria decipiens</i>	Polygonaceae	Herb		
<i>Persicaria madagascariensis</i>	Polygonaceae	Herb		
<i>Persicaria senegalensis</i>	Polygonaceae	Herb	LC	
<i>Persicaria setosula</i>	Polygonaceae	Herb		
<i>Persicaria strigosa</i>	Polygonaceae	Herb		
<i>Phoenix reclinata</i>	Arecaceae	Tree	LC	Building poles, Food, Crafts
<i>Phragmites mauritanus</i>	Poaceae	Herb	LC	Thatching, Fencing
<i>Phyllanthus pseudo-niruri</i>	Euphorbiaceae	Herb		
<i>Physalis minima</i>	Solanaceae	Herb		Food
<i>Pluchea dioscoridis</i>	Asteraceae	Shrub		
<i>Polyscias fulva</i>	Araliaceae	Tree	LC	Firewood
<i>Psidium guajava</i>	Myrtaceae	Tree	LC	Food
<i>Rhus natalensis</i>	Anacardiaceae	Tree		Food
<i>Rhynchosia minima</i>	Fabaceae	Herb	LC	
<i>Rhynchosia resinosa</i>	Fabaceae	Herb		

<i>Ricinus communis</i>	Euphorbiaceae	Tree		
<i>Rumex steudelii</i>	Polygonaceae	Herb		
<i>Sacciolepis</i> sp.	Poaceae	Herb		
<i>Sansevieria</i> sp.	Agavaceae	Herb		
<i>Sarcostemma viminale</i>	Asclepiadaceae	Herb		
<i>Schkuhria pinnata</i>	Asteraceae	Herb		
<i>Scutia myrtina</i>	Rhamnaceae	Shrub	LC	
<i>Senna bicapsularis</i>	Fabaceae	Shrub	LC	
<i>Senna didymobotrya</i>	Fabaceae	Tree	LC	Medicine
<i>Senna obtusifolia</i>	Fabaceae	Herb	LC	
<i>Senna occidentalis</i>	Fabaceae	Herb		Medicine
<i>Senna</i> sp.	Fabaceae	Shrub		
<i>Sesbania sesban</i>	Fabaceae	Shrub		Agro-forestry
<i>Setaria sphacelata</i>	Poaceae	Herb		Fodder
<i>Shirakiopsis elliptica</i>	Euphorbiaceae	Tree		Firewood
<i>Sida arcuta</i>	Malvaceae	Herb		
<i>Sida cordifolia</i>	Malvaceae	Herb		
<i>Sida cuneifolia</i>	Malvaceae	Herb		Medicine, Brooms
<i>Sida rhombifolia</i>	Malvaceae	Herb		
<i>Sigesbeckia abyssinica</i>	Asteraceae	Herb		
<i>Smithia elliotii</i>	Fabaceae	Herb		
<i>Solanum campylacanthum</i>	Solanaceae	Shrub		Medicine
<i>Sorghum arundinaceum</i>	Poaceae	Herb		Crafts
<i>Spermaoce princeaea</i>	Rubiaceae	Herb		
<i>Sphaeranthus suaveolens</i>	Asteraceae	Herb		
<i>Sporobolus pyramidalis</i>	Poaceae	Herb		
<i>Tagetes minuta</i>	Asteraceae	Herb		Medicine
<i>Teramnus labialis</i>	Fabaceae	Herb		
<i>Thevetia peruviana</i>	Apocynaceae	Shrub		Fencing
<i>Thunbergia alata</i>	Acanthaceae	Herb		
<i>Tithonia diversifolia</i>	Asteraceae	Shrub		
<i>Tridax procumbens</i>	Asteraceae	Herb		
<i>Triumfetta macrophylla</i>	Tiliaceae	Shrub		Crafts
<i>Triumfetta rhomboidea</i>	Tiliaceae	Shrub		

<i>Tylophora sylvatica</i>	Asclepiadaceae	Herb		
<i>Typha domingensis</i>	Typhaceae	Herb		Thatching
<i>Typha latifolia</i>	Typhaceae	Herb	LC	Thatching
<i>Urena lobata</i>	Malvaceae	Shrub		
<i>Vernonia amygdalina</i>	Asteraceae	Shrub		Medicine
<i>Vernonia lasiopus</i>	Asteraceae	Shrub		
<i>Vigna reticulata</i>	Fabaceae	Herb		
<i>Waltheria indica</i>	Sterculiaceae	Herb		
<i>Wissadula rostrata</i>	Malvaceae	Shrub		
<i>Xanthium strumarium</i>	Asteraceae	Shrub		
<i>Zehneria minutiflora</i>	Cucurbitaceae	Herb		
Unknown 1	Lamiaceae	Herb		
unknown 2	Fabaceae	Shrub		

## Amphibian Species of Sio Siteko

Family	Species	Common Name	IUCN Status
Bufoiidae	<i>Schlerophrys regularis</i>	Common African Toad	Least Concern
Bufoiidae	<i>Schlerophrys vitattus</i>	Lake Victoria Toad	Data Deficient
Ranidae	<i>Amietia nutti</i>	Nutt's River Frog	Least Concern
Ranidae	<i>Amnirana albolabris</i>	White-lipped Frog	Least Concern
Dicroglossidae	<i>Hoplobatrachus occipitalis</i>	Common Bull Frog	Least Concern
Hyperoliidae	<i>Africalus quadrivittatus</i>	Banded Banana Frog	Least Concern
Hyperoliidae	<i>Hyperolius cinnamomeoventris</i>	Cinnamon Tree Frog	Least Concern
Hyperoliidae	<i>Hyperolius kivuensis</i>	Kivu Reed Frog	Least Concern
Hyperoliidae	<i>Hyperolius viridiflavus bayoni</i>	Bayon's Reed Frog	Least Concern
Hyperoliidae	<i>Hyperolius v. viridiflavus</i>	Common Reed Frog	Least Concern
Prynobatrachidae	<i>Phrynobatrachus natalensis</i>	Natal Dwarf Peddle Frog	Least Concern
Ranidae	<i>Ptychadena nilotica</i>	Nile Grass Frog	Least Concern
Ranidae	<i>Ptychadena porosissima</i>	Grassland Ridged Frog	Least Concern
Pipidae	<i>Xenopus victorianus</i>	Lake Victoria Clawed Toad	Least Concern

## Reptilian Species of Sio-Siteko

Order	Family	Species	Common name	IUCN Status
Sauria	Scincidae	<i>Trachylepis maculilabris</i>	Speckle-lipped Mabuya	Least Concern
Sauria	Agamidae	<i>Agama finchi</i>	Malaba Rock Agama	Least Concern
Sauria	Chamaelionidae	<i>Chameleo laevigatus</i>	Smooth chameleon	Least Concern
Sauria	Varanidae	<i>Varanus niloticus</i>	Nile Monitor	Least Concern
Crocodylia	Crododylidae	<i>Crocodylus niloticus</i>	Nile Crocodile	Least Concern
Serpentes	Pythonidae	<i>Python sebae</i>	African Rock Python	Least Concern
Serpentes	Elapidae	<i>Naja melanoleuca</i>	Forest Cobra	Least Concern

## Mammal Species list for Sio-Siteko Wetland

Order	Family	Species	SS status	IUCN status	Uganda status
Artiodactyla	Bovidae	White-bellied Duiker <i>Cephalophus leucogaster</i>		LC	NA
Artiodactyla	Bovidae	Waterbuck <i>Kobus ellipsiprymnus</i>	p	LC	LC
Artiodactyla	Bovidae	Uganda Kob <i>Kobus kob</i>		NE	LC
Artiodactyla	Bovidae	Pygmy Antelope <i>Neotragus batesi</i>		LC	EN B2ab(iii)
Artiodactyla	Bovidae	Bohor Reedbuck <i>Reduna redunca</i>	p	LC	EN C1
Artiodactyla	Bovidae	Common Bush Duiker <i>Sylvicapra grimmia</i>	p	LC	LC
Artiodactyla	Bovidae	Blue Duiker <i>Cephalophus monticola</i>		LC	LC
Artiodactyla	Bovidae	Buffalo <i>Syncerus caffer</i>		LC	LC
Artiodactyla	Bovidae	Bushbuck <i>Tragelaphus scriptus</i>	p	LC	LC
Artiodactyla	Bovidae	Sitatunga <i>Tragelaphus spekei</i>	p	LC	VU B1b(i)c(i)
Artiodactyla	Bovidae	Bongo <i>Tragelaphus eurycerus</i>		NT	NA
Artiodactyla	Swidae	Red river Hog <i>Potamochoerus porcus</i>	p	LC	DD
Artiodactyla	Swidae	Giant Forest Hog <i>Hylochoerus meinertzhageni</i>		LC	EN B1ab(iii)
Artiodactyla	Hipopotamidae	Hipopotamus <i>Hipopotamus amphibius</i>	p	VU	VU B2b(iii)c (iv)
Artiodactyla	Tragulidae	Water Chevrotain <i>Hyemoschus aquaticus</i>		LC	DD
Pholidota	Manidae	Tree Pangolin <i>Manis tricupsis</i>		VU (A4d)	EN B2ab(iii, v)
Lagomorpha	Leporidae	Bunyoro Rabbit <i>Poelagus marjorita</i>		LC	VU B1ab(i,ii)
Lagomorpha	Leporidae	Cape Hare <i>Lepus capensis</i>		LC	LC
Lagomorpha	Leporidae	Savanna Hare <i>Lepus victoriae</i>		LC	LC
Lagomorpha	Canidae	Side-striped Jackal <i>Canis adustus</i>	p	LC	LC
Carnivora	Felidae	Leopard <i>Panthera pardus</i>	p	NT	VU C1+2(i)
Carnivora	Felidae	Serval <i>Leptailurus serval</i>	p	LC	NT
Carnivora	Herpestidae	Marsh Mongoose <i>Atilax paludinosus</i>	p	LC	LC
Carnivora	Herpestidae	Egyptian Mongoose <i>Herpestes ichneumon</i>	p	LC	LC
Carnivora	Herpestidae	Banded Mongoose <i>Mungos mungos</i>	P	LC	LC
Carnivora	Herpestidae	Slender Mongoose <i>Herpestes sanguineus</i>	p	LC	LC
Carnivora	Herpestidae	White-tailed Mongoose <i>Ichneumia albicauda</i>	p	LC	LC
Carnivora	Mustelidae	African Spot-necked Otter <i>Hydrictis maculicollis</i>	p	NT	EN C1
Carnivora	Mustelidae	East African Stripped Weasel <i>Poecilogale albinuca</i>		LC	NA
Carnivora	Viveridae	African Civet <i>Civettictis civetta</i>	p	LC	LC
Carnivora	Viveridae	African Palm Civet <i>Nandinia binotata</i>		LC	NA

Order	Family	Species	SS status	IUCN status	Uganda status
Carnivora	Viveridae	Rusty nosed Genet <i>Geneta tigrina</i>		LC	LC
Carnivora	Viveridae	Servaline Genet <i>geneta servalina</i>		LC	LC
Carnivora	Viveridae	Small-spotted Genet <i>Geneta genetta</i>	p	LC	LC
Carnivora	Hyenidae	Spotted Hyena <i>Crocuta crocuta</i>	p	LC	CR C1
Mega-Chiroptera	Macroglossinae	Nector bat <i>Megaloglossus woermanni</i>		LC	NA
Mega-Chiroptera	Pteropodidae	Little Epauletted Fruit bat <i>Epomophorus labiatus</i>	p	LC	LC
Mega-Chiroptera	Pteropodidae	Epomophorus minimus		LC	LC
Mega-Chiroptera	Pteropodidae	Hammerhead Fruit Bat <i>Hypsignathus monstrosus</i>		LC	LC
Mega-Chiroptera	Pteropodidae	Franquet's Fruit Bat <i>Epomops franqueti</i>		LC	LC
Mega-Chiroptera	Pteropodidae	Egyptian Fruit bat <i>Rousettus aegyptiacus</i>		LC	LC
Mega-Chiroptera	Pteropodidae	Bocage's Fruit bat <i>Rousettus angolensis</i>		LC	LC
Mega-Chiroptera	Pteropodidae	Common Dwarf Epauletted Fruit Bat <i>Micropteropus pusillus</i>		LC	LC
Mega-Chiroptera	Pteropodidae	Common Collared Fruit Bat <i>Myonycteris torquata</i>		LC	NA
Mega-Chiroptera	Embalonuridae	Tomb bat <i>Taphozous mauritanus</i>		LC	NA
Micro - Chiroptera	Hiposideridae	Aba Leaf-nosed Bat <i>Hipposideros abae</i>		LC	VU D2
Micro - Chiroptera	Hiposideridae	Cyclops Leaf-nosed Bat <i>Hipposideros cyclops</i>		LC	VU C1
Micro - Chiroptera	Hiposideridae	Sundevall's Leaf-nosed Bat <i>Hipposideros caffer</i>		LC	LC
Micro - Chiroptera	Hiposideridae	Noack's Leaf-nosed Bat <i>Hipposideros ruber</i>		LC	LC
Micro - Chiroptera	Rhinolophidae	East African Horseshoe Bat <i>Rhinolophus eloquens</i>		LC	LC
Micro - Chiroptera	Rhinolophidae	Rueppell's Horseshoe Bat <i>Rhinolophus fumigatus</i>		LC	LC
Micro - Chiroptera	Rhinolophidae	Savanna Woodland Horseshoe Bat <i>Rhinolophus simulator</i>		LC	LC
Micro - Chiroptera	Megadermatidae	Yellow winged bat <i>Lavia frons</i>		LC	LC
Micro - Chiroptera	Molosidae	Little Free-tailed bat <i>Chaerophon pumila</i>		LC	LC
Micro - Chiroptera	Molosidae	Angolan Free-tailed Bat <i>Mops condylurus</i>		LC	LC
Micro - Chiroptera	Molosidae	Trevor's Free-tailed Bat <i>Mops trevoli</i>		DD	EN B2b(iii) c(ii)
Micro - Chiroptera	Nycteridae	Bate's Slit-faced Bat <i>Nycteris arge</i>		LC	LC
Micro - Chiroptera	Nycteridae	Hairy Slit-faced Bat <i>Nycteris hispida</i>		LC	LC
Micro - Chiroptera	Nycteridae	Large-eared Slit faced Bat <i>Nycteris macrotis</i>		LC	LC

Order	Family	Species	SS status	IUCN status	Uganda status
Micro - Chiroptera	Vespertilionidae	White-winged Serotine <i>Eptesicus tenuipinnis</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Cape Serotine <i>Eptesicus capensis</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Bibundi Butterfly Bat <i>Glauconycteris egeria</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Variiegated butterfly bat <i>Glauconycteris variegata</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Banana Bat <i>Pipistrellus nanus</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Rueppell's Bat <i>Pipistrellus rueppellii</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Rufous Mouse-eared Bat <i>Myotis bocagei</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	Scoteocus albofuscus		LC	LC
Micro - Chiroptera	Vespertilionidae	Forest Brown House Bat <i>Scotophilus nux</i>		LC	LC
Micro - Chiroptera	Vespertilionidae	<i>Scotophilus leucogaster</i>		LC	LC
Micro - Chiroptera	Chrysochloridae	Stuhlmann's golden Mole <i>Chrysochloris stuhlmanni</i>		LC	NA
Insectivora	Soricidae	Long-tailed Musk Shrew <i>Crocidura dolichura</i>		LC	LC
Insectivora	Soricidae	Tiny Musk Shrew <i>Crocidura fuscomurina</i>		LC	LC
Insectivora	Soricidae	Peter's Musk Shrew <i>Crocidura gracilipes</i>		LC	NA
Insectivora	Soricidae	Hildegard's Musk Shrew <i>Crocidura hildegardeae</i>		LC	LC
Insectivora	Soricidae	Jackson's Musk Shrew <i>Crocidura jacksoni</i>		LC	LC
Insectivora	Soricidae	Musk Shrew <i>Crocidura ludia</i>		LC	LC
Insectivora	Soricidae	Greater Grey-brown Musk Shrew <i>Crocidura luna</i>		LC	LC
Insectivora	Soricidae	Dwarf Musk Shrew <i>Crocidura nanilla</i>		LC	LC
Insectivora	Soricidae	Uganda Forest Musk Shrew <i>Crocidura selina</i>		LC	LC
Insectivora	Soricidae	Musk Shrew <i>Crocidura denti</i>		LC	LC
Insectivora	Soricidae	Uganda Musk Shrew <i>Crocidura tarella</i>		LC	LC
Insectivora	Soricidae	Butiab Musk Shrew <i>Crocidura littolaris</i>		LC	LC
Insectivora	Soricidae	Greater Grey-brown Musk Shrew <i>Croociduara luna</i>		LC	LC
Insectivora	Soricidae	Dwarf Musk Shrew <i>Crocidura nanilla</i>		LC	LC
Insectivora	Soricidae	Matschie's Musk Shrew <i>Crocidura nigrofusca</i>		LC	LC
Insectivora	Soricidae	Northern Swamp Musk Shrew <i>Crocidura maurisca</i>		LC	VU D2
Insectivora	Soricidae	Olivier's Musk Shrew <i>Crocidura olivieri</i>		LC	LC

Order	Family	Species	SS status	IUCN status	Uganda status
Insectivora	Soricidae	Small-footed Musk Shrew <i>Crocidura parvipes</i>		LC	LC
Insectivora	Soricidae	Southern Woodland Musk shrew <i>Crocidura turba</i>		LC	LC
Insectivora	Soricidae	Hero Shrew <i>Scutisorex somereni</i>		LC	NA
Insectivora	Soricidae	<i>Suncus infinitesimus</i>		LC	NA
Insectivora	Soricidae	Climbing Forest Shrew <i>Sylvisorex megalura</i>		LC	LC
Insectivora	Soricidae	Least Long-tailed Forest Shrew <i>Sylvisorex granti</i>		LC	LC
Insectivora	Soricidae	Pygmy Forest Shrew <i>Sylvisorex johnstoni</i>		LC	LC
Primates	Pongidae	Common Chimpanzee <i>Pan troglodytes</i>		EN	ENA4c
Primates	Cercopithecidae	Red-tailed Monkey <i>Cercopithecus ascanius</i>		LC	LC
Primates	Cercopithecidae	Vervet Monkey <i>Cercopithecus aethiops</i>	p	LC	LC
Primates	Cercopithecidae	Blue Monkey <i>Cercopithecus mitis</i>		LC	LC
Primates	Cercopithecidae	DeBrazza's Monkey <i>Cercopithecus neglectus</i>		LC	VU D2
Primates	Cercopithecidae	Uganda Mangabey <i>Lophocebus ugandae</i>		LC	VU A2c
Primates	Cercopithecidae	Olive Baboon <i>Papio anubis</i>	p	LC	LC
Primates	Cercopithecidae	Black and White Colobus <i>Colobus guereza</i>		LC	LC
Primates	Cercopithecidae	Angola Colobus <i>Colobus angolensis</i>		LC	VU D2
Primates	Galagonidae	Spectacled Galago <i>Galago matschiei</i>		LC	DD
Proboscidea	Elephantidae	African Elephant <i>Loxodonta africana</i>		VU	CR A4a
Procavidae	Hyracoidea	Southern Tree Hyrax <i>Dendrohyrax arboreus</i>		LC	LC
Tubulidentata	Tubulidentidae	Aardvark <i>Orycteropus afer</i>		LC	LC
Rodentia	Anomaluridae	Lord Berdy's Flying Squirrel <i>Anomalurus beecrofti</i>		LC	LC
Rodentia	Anomaluridae	African Dwarf Flying Squirrel <i>Idiurus zenkeri</i>		LC	LC
Rodentia	Cricetidae	Savannah Pouched Rat <i>Cricetomys emini</i>		LC	LC
Rodentia	Cricetidae	Grey Climbing Mouse <i>Dendromus melanotis</i>		LC	LC
Rodentia	Cricetidae	Brant's Climbing Mouse <i>Dendromus mesorius</i>		LC	LC
Rodentia	Cricetidae	Chestnut Climbing Mouse <i>Dendromus mystacalis</i>		LC	LC
Rodentia	Cricetidae	Congo Forest Mouse <i>Deomys ferrugineus</i>		LC	LC
Rodentia	Cricetidae	Montane groove-toothed Rat <i>Otomys denti</i>		LC	LC

Order	Family	Species	SS status	IUCN status	Uganda status
Rodentia	Hystriidae	Crested Porcupine <i>Hystrix cristata</i>	p	LC	LC
Rodentia	Muridae	Eastern Brush-furred Rat <i>Lophuromys flavopunctatus</i>	p	LC	LC
Rodentia	Muridae	Stella Wood Mouse <i>Hylomyscus stella</i>		LC	LC
Rodentia	Rhizomyidae	Rueppell's Mole-rat <i>Tachyoryctes splendens</i>	p	LC	LC
Rodentia	Scuiridae	Cuvier's Fire-footed Squirrel <i>Funisciurus pyrrhopus</i>		LC	LC
Rodentia	Scuiridae	Red-legged Sun Squirrel <i>Heliosciurus rufobrachium</i>		LC	LC
Rodentia	Scuiridae	Alexander's Bush Squirrel <i>Paraxerus alexandri</i>		LC	LC
Rodentia	Scuiridae	Boehm's Bush Squirrel <i>Paraxerus boehmi</i>		LC	LC
Rodentia	Scuiridae	Giant Forest Squirrel <i>Protoxerus stangeri</i>		LC	LC
Rodentia	Scuiridae	Geoffrey's Ground Squirrel <i>Xerus erythropus</i>	p	LC	LC
Rodentia	Thryonomidae	Lesser Cane Rat <i>Thryonomys gregorianus</i>	p	LC	LC
Rodentia	Thryonomidae	Common Cane Rat <i>Thryonomys swinderianus</i>		LC	LC



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Development of Wetland Management Plans for three wetland landscape; 1. Sio-Siteko wetland landscape (Kenya - Uganda)  
2. Sango-Bay Minziro wetland landscape (Tanzania - Uganda) 3. Semliki Delta wetland landscape (Democratic Republic of Congo - Uganda)

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**ONE RIVER ONE PEOPLE ONE VISION**



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