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Nile Basin Monitoring Guideline

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ABBREVIATIONS

BOD	Biological Oxygen Demand
BWP	Basin Wide Program
CBD	Convention on Biological Diversity
CMS	Convention on Migratory Species
cfu	Colony forming unit
CISCA	Citizen Science in Africa
GHG	Green House Gas
mS/m	Millisiemens per meter
MEA	Multilateral Environmental Agreement
METT	Management Effectiveness Tracking Tool
NBI	Nile Basin Initiative
Nile-SEC	Nile Basin Initiative Secretariat
PES	Present Ecological State
TBA	Tropical Biology Association
TDS	Total Dissolved Solids
SoB	State of Basin
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wide Fund for Nature

1. INTRODUCTION

1.1 Purpose of monitoring Nile basin wetlands

Wetlands in the Nile Basin are of great importance both economically and environmentally. Many of these wetlands have been degraded or lost due to economic activities, urban developments and poor wetland management. In recent years however, a movement has started to stop this trend and find a balance between wetland use and wetland protection. It has required the mobilization of state and non-state actors for a collective and coordinated collaboration to drive the complex process of securing the transboundary wetlands and wetlands of regional significance in the Nile Basin. To achieve this, the riparian countries, through the Nile Basin Initiative, have created a common framework for the coordinated management of these wetlands.

Recently, baseline studies of various aspects related to the wetlands in the Nile Basin have been concluded, which can now serve as a reference point for wetland management (See Nile Basin Wetlands Inventory). It highlights the most important aspects of the Nile Basin wetlands that requires detailed attention. It is mostly concerned with the biophysical characteristics and governance aspects of the wetlands. Now that baseline information is known, observations can be made on a regular basis through a monitoring program to capture any changes that may occur, which creates a mechanism for pro-active remedial action to be launched where and when required. To compare the status quo with the baseline, it is required to conduct monitoring and assessments of targeted data over a certain time period.

Monitoring is the systematic observation and recording of current and changing conditions, while assessment is the use of that data to evaluate the conditions, which ultimately supports decision-making and planning processes. Well-designed and executed wetland monitoring and assessment programs are a critical tool to better manage and protect wetland resources. Monitoring can thus inform wetland management strategy and in this way strengthen the capacity of riparian states to manage their wetlands more effectively.

The implementation of a monitoring program will require the participation and commitment of a wide range of actors on local, national and regional scale. It must be emphasised that monitoring does not automatically require sophisticated technology or high investment and can be carried out at different levels of intensity. There are many different monitoring techniques available and each country should select the technique(s) most appropriate to its priorities and available resources. This monitoring guideline aims to assist with this process by providing appropriate methods and procedures that are replicable to monitor, compile, and analyze basin wide wetland data that can be translated into a mechanism that supports educated decision making. It should also provide a means to determine the effectiveness of already implemented measures and whether or not changes should be made.

The main purpose of this monitoring guideline is to assist riparian countries to communicate the environmental status of wetlands in the Nile basin to decision makers and other relevant stakeholders. In this way results can be leveraged to drive wetland policy, management, and investment.

1.2 Nile Basin Transboundary Wetlands Policy Framework

The Wetland monitoring guideline can be seen as a supplementary tool that enhances the management of the Nile basin wetlands through the various policies and management frameworks related to wetlands that are already in place.

Nile Basin Sustainability Framework

Approved by Nile Council of Ministers (Nile-COM) in 2011, the Nile Basin Sustainability Framework (NBSF) lays down NBI's approach to developing guiding principles for water resource management and development across the Nile Basin countries.

While it is not a legal framework, the NBSF which is a suite of policies, strategies, and guidance documents – functions as a guide to national policy and planning process development and seeks to build consensus. It is intended that it will contribute to the gradual alignment of the Basin's body of (national) water policies to meet international good practice and help to demonstrate to national governments and international financiers of water infrastructure that the NBI has a systematic approach for dealing with issues of sustainable development within the Basin.

The NBSF is therefore supporting the enabling environment for trans-boundary investment projects, and will promote integration of shared benefits, participation, and environmental concerns that ensure investment projects have long-term benefits.

Without the NBSF, there would be no consistent guidance for the sustainable development of new investments and no coherent guidance for the achievement of cooperation in sustainable water management and development.

Environmental and Social Policy

The Environmental and Social Policy addresses key environmental and social issues and challenges; provides guiding principles; introduces policy interventions; specifies targets and priority outcomes. The Policy also describes implementation arrangements; fosters cooperation as well as multiple-level partnerships, ultimately increasing the benefits and value of the Nile water resources towards sustainable development.

Wetland Management Strategy (WMS)

The Wetland Management Strategy (WMS) presents operational definitions and different classifications of wetlands, describing Nile Basin wetlands and their significance, highlighting Nile Basin wetlands functions and values, and justifying the applicability of the worldwide accepted principles (wetlands as ecotones, wise use, and equitable wetland resources use) within the Nile Basin context. The strategy also defines strategic outcomes together with their corresponding priority outputs and lays down the respective implementation plan.

All these policies and strategic frameworks related to wetlands require monitoring to ensure that proactive wetland management takes place within the Nile Basin.

2. INTEGRATED WETLANDS MONITORING FROM SELECTED MEAs

There are various multilateral environmental agreements (MEAs) to which the Nile basin countries are party to that touch upon different aspects related to wetlands, although each of the MEAs may have different focus points. The Ramsar convention for wetlands is the main convention for wetlands that obligates parties to monitor certain indicators related to wetlands, but there are also wetland aspects in other agreements such as CBD, UNFCCC, etc. that also require monitoring to take place.

This chapter aims to provide an overview of all wetland related indicators that must be complied with according to global MEAs. The table below indicates the riparian countries' participation to various conventions and agreements.

Table 1: Member states that are parties to conventions and agreements

CONVENTIONS	RAMSAR	CBD	UNFCCC	SDG	CMS
Burundi	X	X	X	X	x
DRC	X	X	X	X	x
Egypt	X	X	X	X	x
Eritrea		X	X	X	x
Ethiopia		X	X	X	x
Kenya	X	X	X	X	x
Rwanda	X	X	X	X	x
South Sudan	X	X	X	X	
Sudan	X	X	X	X	
Tanzania	X	X	X	X	x
Uganda	X	X	X	X	x

The RAMSAR Convention of 1971, which was specifically developed for the conservation and sustainable management of important wetlands, gives some indication of reporting requirements that are expected from signatories to the convention. Other conventions and agreements including the Convention on Biological Diversity (CBD), Sustainable Development Goals (SDGs), United Nations Framework Convention on Climate Change (UNFCCC) etc. all have different reporting requirements. As with the RAMSAR convention, these also give a good indication of important parameters to include in a monitoring program. From these MEAs the following reporting obligations follow:

RAMSAR (See link in annexures for latest monitoring requirements)

- Site Boundary and Area
- Principal ecological characteristics and importance of the wetland
- Physical features such as hydrology; soil type; water quality; water depth, water permanence; fluctuations in water level; tidal variations; downstream area; general climate
- Hydrological functions and values of the wetland in groundwater recharge, flood control, sediment trapping, shoreline stabilization
- Ecological features such as main habitats, vegetation types, plant and animal communities present in the Ramsar site, and the ecosystem services of the site and the benefits derived from them
- Information on particular species and why they are noteworthy
- Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects
- List national and/or international category and legal status of protected areas, including boundary relationships with the Ramsar site
- Conservation measures such as management plans etc.

- Current scientific research, including biodiversity monitoring and field research facilities
- Current communications, education and public awareness (CEPA) activities

CBD (See link in annexures for latest monitoring requirements)

This Convention calls upon countries to identify components of biological diversity important for its conservation and sustainable use. It also indicates which components countries might need to focus on when designing monitoring programs:

- Ecosystems and habitats containing high diversity, large numbers of endemic or threatened species, or wilderness; required by migratory species; of social, economic, cultural or scientific importance; or which are representative, unique or associated with key evolutionary or other biological processes;
- Species and communities which are threatened; wild relatives of domesticated or cultivated species; of medicinal, agricultural or other economic value; or social, scientific or cultural importance; or importance for research into the conservation and sustainable use of biological diversity, such as indicator species;
- Describe genomes and genes of social, scientific, or economic importance.

To identify these components, each Contracting Party to this convention is required to, as far as possible and as appropriate:

(a) Identify components of biological diversity important for its conservation and sustainable use;
(b) Monitor, through sampling and other techniques, the components of biological diversity identified pursuant to subparagraph (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;
(c) Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques;
(d) Maintain and organize, by any mechanism data, derived from identification and monitoring activities pursuant to subparagraphs (a), (b) and (c) above.

UNFCCC (See link in annexures for latest monitoring requirements)

Each Party to this Convention is required to periodically prepare a national communication to report on the following:

- GHGs: carbon dioxide, methane, nitrous oxide and precursor gases
- Measures and programs implemented that facilitate adequate adaptation to climate change
- Contribution to and participation in research and systematic observation

SDG (See link in annexures for latest monitoring requirements)

Indicators are the backbone of monitoring progress towards the SDGs at the local, national, regional and global levels. Each level of monitoring will however require different types of indicators. The "Indicators and Monitoring Framework for the Sustainable Development Goals" Report (See link below) proposes various monitoring indicators, accompanied by suggestions for Complementary National Indicators, which together track the full range of SDGs and targets in an integrated, clear, and effective manner. Each country should pick the number and range of Indicators that best suit its needs and capacity to collect and analyze data.

CMS (See link in annexures for latest monitoring requirements)

Parties are required to promote, co-operate in and support research relating to migratory species and shall endeavour to provide immediate protection for migratory species. This can be achieved through the monitoring of important migratory species, the routes they fly and the sites they visit for stopovers, mating and feeding.

Indicators of State of Basin Reporting

Monitoring the status of the Nile basin wetlands should also form part of NBI's State of the Basin (SoB) monitoring and reporting. The SoB report is a NBI initiative that aims to provide accurate and reliable information on aspects of the Nile River basin for informed management of and policy decisions regarding the Nile River basin. Various aspects are reported on in a 5-year interval. The following main themes are addressed in the SoB:

- Population growth
- Infrastructure development
- Water demand/availability
- Land use change
- Biodiversity loss
- Pollution/water quality
- Governance

When developing a monitoring program, it is recommended that these themes should also form part of it. Varying data sources in the different countries, as well as the opportunities and limitations of the riparian countries' capacities and data sharing protocols, should be considered. In this regard, data for different parameters can be collected on different spatial scales, depending on the nature of the parameters. As countries are already embarked in efforts of monitoring wetlands (individually) for their MEA obligations, the accumulation of data for the entire basin, for monitoring the state of the Nile Basin wetlands, then becomes an accessible basin-wide effort

Utilising public domain datasets for data gathering, where available, is recommended as these are mostly freely available. Some parameters may require specific data gathering for which detailed on-ground knowledge will be required. Ground truthing will have to be conducted in such cases where access is possible, to ensure that open source datasets reflect real on-site values. Where significant computing power is required to run data analyses, it is recommended to outsource the works, until sufficient in-house capacity is available.

In order for monitoring to be effective and to function correctly, data needs to be collected and processed regularly at scheduled intervals (e.g., 5-year intervals in line with the State of the Basin Report) to allow comparing the results at different timesteps. This monitoring guideline was specifically developed to assist countries with developing a monitoring program that coincides with NBI's SoB reporting. It is however also recommended that any monitoring program being developed should be considered to coincide with other compulsory reporting structures to assist countries with reaching any other reporting responsibilities coming from being signatories to various treaties, conventions and any other agreements. These require a certain responsibility toward reporting on targets that are to be reached under each specific agreement.

Some of the most important reporting requirements are listed below:

- RAMSAR - require triennial national reports to be submitted to the Conference of the Contracting Parties
- CBD – require national reports to be submitted every 4 years
- UNFCCC – require biannual update reports
- CMS – require annual reporting at the Conference of the Contracting Parties
- SoB – report updated every five years

3. STATE OF THE BASIN REPORTING INDICATORS TO BE MONITORED

The table below provides a summary of information related to the specific indicators to be monitored based on the indicator themes that are found to be reported on in the State of Basin (SoB) Report.

Table 2: Summary of indicators to be monitored

Indicator Theme	Indicators	Purpose	Data Source	Verification
Population Growth	Population numbers	To derive growth trends that indicate basic human needs such as water demand and development requirements.	Government database. Public domain datasets.	Census data.
Infrastructure Development	Number and size of irrigation schemes. Number of flow diversions/canals. Number of new dams and their operation schemes. Hydropower developments and mode of operation (peak or base).	To provide strategic insight into when and where these developments should take place and the possible impacts it will have	Government datasets. Development plans.	
Water Demand/ Availability	Surface water levels and flows. Ground water levels and flows. Water demand (demand/capita/day). Rainfall. Evaporation. Flood events.	Provides insight into water availability and subsequent scope for where development is possible.	Public domain datasets. Population numbers.	Ground truth by field gathered data.
Land use change	Wetland Extent. Forest cover. Agricultural development. Extractives	Change in extent/cover from with possible reasons/impacts from which subsequent management protocols can be derived.	Google Earth © coverage. Sentinel-2 satellite images. Global Forest Watch.	Ground truth by field gathered data. Aerial photography.
Biodiversity loss	Endangered/threatened/vulnerable species. Flagship/keystone/umbrella species. Alien/invasive species.	To indicate critical biodiversity loss and develop appropriate management protocols that limit the loss.	IUCN. Public domain datasets. Field gathered data.	Ground truth by field gathered data
Pollution/water quality	Physical and chemical indicators	Act as early warning triggers to alert investigation into possible reasons	Field gathered data and lab testing.	

		for poor water quality results.		
	Benthos macroinvertebrates	Examination of key groups of benthic macro-invertebrates indicates water quality.	Field gathered data.	
Governance	**Legal component** Number of laws. Number of regulations. Number of white papers. Legal protection status. Area covered by protected areas. Management status (RAMSAR listed). **Knowledge component** Number of Key Biodiversity Areas. Number of E-flow assessments. Number of policies. Number of publications. Number of studies.	Indicates how wetlands are being mainstreamed within governance structures.	Government database. Knowledge Portals. Science Journals. Treaties and Conventions.	

4. DESCRIPTION OF KEY INDICATORS FOR BASIN WIDE WETLAND MONITORING

4.1 Population growth

The population in the Nile Basin is ever increasing and can be considered the main reason that gives rise to a plethora of issues given the increase in demand for resources. Most of the indicators being discussed in this guideline comes as a result of population growth. These issues have to be finely monitored and managed to sustain the natural capital that is sustaining the livelihoods of the people.

Population figures, especially population density surrounding wetland areas can be gathered from census data. This information can be very useful to obtain growth trends and derive aspects such as water demand and subsequent water related infrastructure requirements. It assists with decision making related to sustaining livelihoods and how this impact upon wetland management.

4.2 Infrastructure development

Examples of infrastructure developments that are related to impacts on wetlands and that will provide useful management data when monitored, may include:

- Number and size of irrigation schemes
- Number of flow diversions/canals
- Number of new dams and their operation schemes
- Hydropower developments and mode of operation (peak or base)

All of the above-mentioned infrastructure developments may have a major effect on the hydrologic conditions within the wetland system, especially related to water demand/availability. Through monitoring, information gathered can provide strategic insight and direct how, when and where these developments should take place.

4.3 Water demand/availability

Water flows are crucial to sustain wetlands. However, as population growth increase, the demand for water will also increase to sustain crops, cattle etc. Water related infrastructure such as dams, flow diversions (canals) and irrigation schemes can all cause drawdown/decrease water availability which, depending on the type and size, can have dramatic effects on wetlands. Monitoring water demand against water availability is therefore a crucial requirement to ensure that harm to wetlands and other surface waters does not occur. Monitoring can consist of various types of data collection:

- Surface and ground water levels and flows
- Water demand (demand/capita/day)
- Rainfall and flood events
- Evaporation and droughts

The Monitoring and Forecasting Drought Bulletin is a bi-weekly bulletin which aims at serving end-users in drought management by providing data and information as well as locations of drought hazards. This report has been automatically generated by the Flood and Drought Data Portal (See link in annexures). It contains drought indices suitable for hydrological and meteorological drought that are based on climate information for the 10 major sub-basins of the Nile Basin. All of the above-mentioned parameters will provide insight into water availability and when combined with population growth and infrastructure development, can be used to set up a high-level water balance. This can be used to get an indication of where water shortages may be

experienced and thereby assist with decision making on the extent of developments and where it should be taking place.

4.4 Land use change related to wetlands

Land use change related to wetlands is an indication of how land surrounding wetlands are used through human activities, subsequently transforming the natural landscape and thereby emphasizing the functional role of wetlands for economic activities. Wetlands may be impacted upon directly by land uses located within the wetland or indirectly by land uses located in the wetland's upslope catchment. Each land use tends to have particular ecological impacts associated with it and can therefore also be strongly related to biodiversity loss (See Section 3.5).

By estimating the extent of specific land uses in a wetland and its catchment, inferences can be drawn about the magnitude of impacts on the ecological condition of the wetland. Land use change monitoring therefore gives a good indication of wetland integrity in that it provides data on the loss, gain or conversion of land, built-up area growth and surface water change. Various tools exist both commercially and in the public domain that can be used to monitor land use change.

One way in which land use change can be monitored, is through the use of land cover datasets that are typically based on observations from satellite mounted sensors, commonly called, remote sensing. Data can consist of a combination of commercial data or public domain data, but should be verified through field gathered data/ground truthing. Remote sensing can be used to monitor a number of different indicators of land use change, which may include:

- Wetland extent
- Forest area/deforestation
- Agricultural development.
- Extractives (papyrus, grasses etc.)

Carrying out multi-temporal analyses on these types of indicators gives an indication of how and to what extent changes occur over time. Accuracy and scale will be dependent on how much detailed and reliable information is available for the specific areas being monitored.

As the size of the study area gets bigger, monitoring land use change by means of field gathered data only, can become a very costly and time-consuming exercise. Given the size and extent of the Nile Basin, remote sensing via satellite imagery is an excellent tool to study land use change because images can cover large geographic extents and have a high temporal coverage. Remote sensing can also provide data in areas that are usually inaccessible. There are also some disadvantages associated with remote sensing, which include the following:

- The inability of many sensors to obtain data and information through cloud cover
- Distinct phenomena can be confused if they look the same to the sensor
- The resolution of the satellite imagery may be too coarse for detailed mapping and for distinguishing small contrasting areas
- Very high-resolution satellite imagery is very expensive.

Despite these disadvantages, remotely sensed satellite data have been used to identify changes in a variety of aquatic and terrestrial environments including coastal, agriculture, forested, and urban areas (Berlanga and Ruiz 2002).

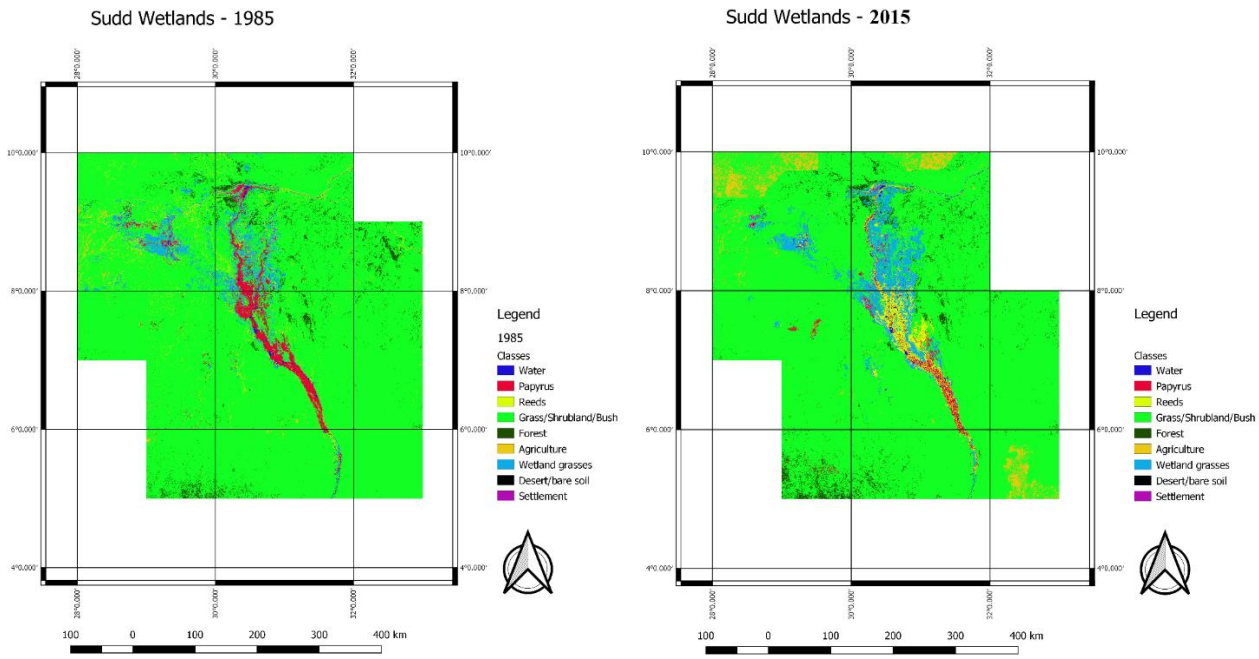

Figure 1: Remote sensing used to analyse change in land cover of the Sudd wetland (1985-2015).

Wetland integrity tool

Since prevention of deterioration is a better option than wetland restoration, it stands to reason that proactive and well-informed management is desirable. As such the knowledge and quantification of wetland integrity, a surrogate for, and directly related to health, is vital for the facilitation of wetland management.

Several tools have been designed to calculate wetland integrity, but is mostly governed by the availability and quality of relevant data. Accessibility is a pertinent problem in the Nile Basin and therefore satellite data can become a useful component to monitor land use.

The Nile Basin Biodiversity Assessment Report (See link in Annexures), which formed part of the baseline studies, outlines an approach to define and assess wetland integrity using available land use data, and takes the first step towards its quantification. The outputs, if used correctly, should make a notable contribution towards strategic adaptive management of wetlands within the Nile River Basin.

The land use categories were derived from satellite data and are accurate enough to be meaningful and useful for the calculation of wetland integrity and health. Land use data can be improved in resolution so that wetland integrity scores are more realistic. This can be done by manually checking satellite data or by field verification/ground truthing.

The measure of a wetland's internal integrity is no doubt useful for management if change is monitored over time. The weakness with the approach proposed (based on land use categories with assigned ecological function values) is that data with low resolution will provide unrealistic assessments. The very notable advantage however, if data resolution is sufficient (or improved upon), is that large wetlands can be meaningfully assessed in short amounts of time and at low expense. The approach outlined in the biodiversity assessment report (See link in Annexures) was designed in relation to available land use categories. These are not cast in stone i.e. the details of the approach may be altered to cater for additional or better data and still provide meaningful assessments. In addition, the approach may be vastly improved if field verification were to be incorporated into assessments. Other metrics, such as ecological sensitivity or biodiversity characteristics may also be incorporated into the assessment of wetland integrity, but the proposed design would have to be updated and altered to include such additional data sources/types.

Citizen Science

Another option for monitoring land use change and associated biodiversity loss, is to implement a citizen science approach. Citizen science refers to research in which local volunteers and/or stakeholders play a prominent role as participants in gathering data (Silvertown et al., 2013). It combines environmental research with environmental education and observation. With this approach, scientific information which would otherwise be too complex for non-specialists to understand, is simplified, thereby empowering a wide range of locals to participate in local environmental research programs. It thus empowers the public with skills and knowledge that enables them to understand environmental issues without depending on specialists.

Citizen science have already been successfully applied in various parts of the world. It can take on different forms with different degrees of participation. Across Africa, citizen science is now producing such a large body of data, that there is a growing need for the training of African scientists to analyse and interpret this data to generate useful outputs that can be used to inform policy and management practices.

Some examples of key benefits of a citizen science program include the following:

- Biodiversity driver – Promotes sustainable use of biodiversity
- Economic driver – Promotes alternative approaches to achieving income that does not degrade natural resources
- Cultural Driver – Promotes traditional ecological knowledge (remedies and medicine)
- Technological Driver – Narrows the digital divide and reduces technological inequality
- Social Driver – Raises awareness of the value of biodiversity and how to conserve and use it sustainably
- Policy Driver – Contributes towards various stages of the policy-making cycle.

A case can thus be made for citizen science as being an important element of environmental education that could be used to engage all citizens, regardless of their socio-economic and demographic characteristics. It allows a move beyond awareness training that can be used to enable people at local level to make informed decisions on wetland issues and facilitate changing the ways in which wetlands are used.

4.5 Biodiversity loss

Biodiversity refers to the diversity of species of plants and animals and their habitats. Loss of biodiversity and pressures on ecosystem services are global challenges and mostly comes as a result of land use change. Land use change surrounding wetlands is generally associated with a decline in species diversity which can have major impacts on ecosystems. Apart from monitoring land use change (as described in section 3.4 above), there are also other measures available to monitor pressures on wetland ecosystems and biodiversity. The Convention on Biological Diversity (CBD) requires contracting parties (of which all riparian countries are part):

- To identify and monitor, through sampling and other techniques, the components of biological diversity identified (ecosystems and habitats, species and communities, and significant genetic resources)
- To identify and monitor the processes likely to have significant adverse impacts on the conservation of biological diversity
- To collect and maintain the data in good order.

The Convention works especially closely with five global non-governmental organizations (NGOs) which have been associated with the treaty. The five International Organisation Partners (IOPs) of the CBD are:

- BirdLife International (formerly ICBP)
- IUCN – International Union for Conservation of Nature
- International Water Management Institute (IWMI)
- Wetlands International (formerly IWRB, the Asian Wetlands Bureau, and Wetlands for the Americas)
- WWF International

The IOPs provide invaluable support for the work of the Convention at global, regional, national, and local levels, chiefly by providing expert technical advice, field level implementation assistance, and financial support, both from their headquarters units and from their national and regional offices and affiliates and from their expert networks. Monitoring the change in number and population size of species of concern as well as invasive and nuisance species are very useful to deduce the following important factors:

- It gives an indication of what is available (inventory)
- It indicates any changes that may have occurred and the possible drivers of that change
- It shows the effectiveness of management actions and whether any changes are necessary
- It may be used as an early warning system (incline of invasive species)
- Can assist countries with reporting responsibilities as monitoring is often an explicit requirement within international treaties and conventions e.g. Convention on Biological Diversity (CBD).

The table below indicates the main threats to and impacts on the biodiversity of the wetland groups found in the Nile Basin and the key species that should be monitored as a measure to manage these threats.

Table 3: Main threats and impacts on biodiversity of wetland groups in Nile Basin

Wetland Group	Main threats and impacts
Lake Victoria	Changes to the integrity of the wetland through draining, agriculture, hydropower and introducing of the Nile Perch hinders the wetland from coping with the subsequent pollution and climate change. Over exploitation and habitat degradation by alien plants and fish are main impacts.
Mara	Overgrazing and changes to the flow of the river upstream impacts on Mara and on downstream users.
Kagera	Kagera: Agriculture has the most important impact on the biodiversity through loss of habitat and pollution of the water and the removal of vegetation.
Sio	Changes in the flow and volume of the water through hydropower, canal construction and over abstraction has the greatest impact on biodiversity.
Nzoia	Changes in water quality through hydropower, pollution from draining for agriculture, mining and chemical pollution from agriculture, industrial waste.
Yala	Greatest impact on biodiversity is the change in water quality through hydropower, mining, rice farming and diversion of the Yala River.
Nyando	Greatest impact on biodiversity is the change in water quality and flow through farming, industrial and sewage discharge and Owen Falls Dam.
Sudd	Greatest impact on biodiversity is the change in water quantity and flow by anthropogenic activities, oil exploration, *Eichhornia crassipes* and the proposed completion of the Jonglei Canal.
Semliki	Greatest impact on biodiversity is the change in land use surrounding the wetland resulting in water pollution from agro-chemicals, industrialization and urbanization and increase in siltation of Lake Albert.
Kyoga	The greatest impact on biodiversity is through the decrease in water quality and quantity caused by an increase in anthropogenic activities and the lake's clay has high retention properties thereby retaining water pollution.
Bahr el Ghazal	Anthropogenic activities such as fishing and agriculture increases the effects of climate change on the wetland thus impacting on biodiversity.
Mashar Marshes	Should any water from this system be stored or extracted upstream of the Machar Marshes, the area of the seasonally flooded marshes will be reduced and impact on livestock and wildlife. It is one of the most important wetlands in the basin.
Lake Tana	Anthropogenic activities and hydropower have greatest impact on biodiversity.
Dinder	Reduction of quality of wildlife forage through anthropogenic activities, especially overgrazing, reduces the biodiversity and functioning of the Dinder ecosystem.
Nile Delta	Construction of Aswan High Dam prevents annual flooding and migration of fish and disappearance of *Cyperus papyrus* swamps.

Parameters that can be monitored to indicate biodiversity loss may include:

- Number of endangered/threatened/vulnerable species (See link in annexures for IUCN species data lists for specific species).
- Number of flagship/keystone/umbrella species (See link to Biodiversity Report in Annexures)
- Number of alien/invasive species (See link to Biodiversity Report in Annexures)
- Overall taxon richness
- Overall habitat diversity (numbers or extent of diversity types)

The tables below give examples of flagship, threatened and alien species per sub-basin that can be monitored.

Table 4: Flagship species per wetland group in the Nile Basin

Flagship Species	Bahr el Ghazal	Baro/Akobo Sobat Wetlands (Machar Marshes)	Dinder	Kagera	Lake Kyoga	Lake Tana	Lake Victoria	Mara	Nile Delta	Semliki	Sio Nzoia Yala Nyando	Sudd
African Openbill	X	X	X	X	X	X	X	X	X	X	X	X
African Pygmy Goose	X	X	X	X	X	X	X	X	X	X	X	X
Basra Reed Warbler		X					X		X			X
Black Crowned Crane	X	X	X			X						X
Erismature maccoa										X		
Goldbelly Reed Frog										X		
Graham's tilapia				X	X		X	X				
Grauer's Swamp-warbler										X		
Grey Crowned Crane				X	X		X	X		X	X	
Madagascar Pond-Heron				X	X		X	X		X	X	
Nile Lechwe	X	X										X
Nile Softshell Turtle	X	X	X			X			X	X		X
Nubian Flapshell Turtle		X	X									X
Papyrus Yellow Warbler				X			X	X		X	X	
Pel's fishing owl		X	X			X	X	X		X	X	X
Pied Oystercatcher									X			
Sahelian Flapshell Turtle		X	X									X
Shoebill	X	X		X	X		X	X		X	X	X
Sitatunga	X			X	X		X	X		X		X
Victoria Tilapia				x	X		X	X				
Vundu Catfish		X	X		X		x	X	x	X	X	X
White-eared kob	x	x			x					X		X

Table 5: Alien species per wetland group in the Nile Basin

Alien Species	Bahr el Ghazal	Baro/Akobo Sobat Wetlands (Machar Marshes)	Dinder	Kagera	Lake Kyoga	Lake Tana	Lake Victoria	Mara	Nile Delta	Semliki	Sio Nzoia Yala Nyando	Sudd
Floating fern - Azolla nilotica			1	1	1		1	1	1	1		1
Water Hyacinth - Eichhornia crassipes		1		1			1		1		1	1
Red River Gum - Eucalyptus							1					
Water lettuce - Pistia stratiotes	1	1		1	1		1	1		1	1	1
Guppy - Poecilia reticulata	1			1	1		1	1		1		1

Other References

Other references related to biodiversity that can be consulted for further information includes:

- Living Planet Database
  It currently holds time-series data for over 27,000 populations of more than 4,300 mammal, bird, fish, reptile and amphibian species from around the world, which are gathered from a variety of sources such as journals, online databases and government reports. These species population trends are then aggregated to produce indices of the state of biodiversity. The population time-series data can be augmented with additional information relating to the population's taxonomy, location and ecology, which allows for the analysis of trends at different scales and for different habitats.

- Bird Life International
  It is the world's largest nature conservation partnership with the main goal of conserving birds, their habitats and global biodiversity. It has a database with country profiles of all relevant and important bird species that are unique to those specific areas.

- See citizen science under section 3.4

4.6 Pollution/water quality

Water quality is a major concern for the health of the Nile Basin wetlands. Routine monitoring and testing are vital to ensure quality and safety. The earlier a problem is detected, the sooner it can be treated and rectified. Water quality issues are mostly related to the effects of certain actions, such as rapid population growth, intensification of agriculture and deforestation. Pollution comes in the form of untreated waste such as plastic from urban areas and industries, fertilizer/pesticide run-off and sedimentation.

There are a range of different actions that cause water quality issues and they differ in extent and effect from catchment to catchment. While the water quality of certain areas in the Nile Basin may be considered to still be acceptable, some areas, especially the urban areas, may be the cause for major concern. Water quality monitoring programs should therefore be developed per catchment area.

For transboundary wetlands however, attention should be given to selecting the most appropriate water quality monitoring parameters that will align with and support international cooperation. The Nile-SEC has initiated a Basin Wide Program (BWP) for the management of water resources in the Nile Basin. A major

component of this program is water quality monitoring. It is envisaged that the Nile-SEC will lead the development of a Nile Basin Water Quality Baseline.

Routine water quality monitoring by riparian countries combined with knowledge sharing initiatives between countries will assist greatly in this endeavor, thereby building a strong database upon which educated decisions related to water quality can be made for the future management of the Nile Basin wetlands. Based on international best practice and depending on country specific targets and practices, water quality monitoring may include any of the following parameters:

- Electrical conductivity
- Dissolved oxygen
- PH
- Turbidity/TSS (total suspended solids)
- TDS (total dissolved solids)
- BOD (biological oxygen demand)
- Phosphorous
- Nitrates
- Potassium
- Magnesium
- Lead
- Copper
- Microbiology incl. E. coli & Total Coliforms

By introducing best practice/country specific thresholds, many of these parameters can be used as triggers that alert investigations/interventions into possible sources of contamination. Below are some examples with arbitrary threshold values:

- Any confirmed result outside the pH range of 6.5 – 9
- Any Dissolved Oxygen concentration < 6mg/l
- No more than 10 variation in seasonal median and 95-percentile suspended solids or turbidity values
- Electrical Conductivity exceeding 55 mS/m
- Any *E. coli* result exceeding 2 000 cfu per 100 ml

Another technique that indicates the condition of water quality is by monitoring benthic macroinvertebrates. Macroinvertebrates may include communities of flies, beetles, mayflies, caddisflies, stoneflies, dragonflies, aquatic worms, snails, leeches and numerous other organisms. These organisms are sensitive to changes in water quality e.g. as a result of pollutants and therefore forms an integral part of water quality monitoring.

Aquatic macroinvertebrate biologists analyse the data gathered from sampling macroinvertebrate communities and use it:

- To identify the impacts of pollution
- To determine the effectiveness of pollution control measures
- To show water quality trends
- To identify areas of concern

Another area of concern related to water quality is plastics pollution. Plastic production is foreseen to continue to grow, and with that the pollution to the environment (Lebreton and Andrady, 2019). The global rise in attention to the plastic pollution problem has resulted in various initiatives to clean up or even reduce plastic pollution. To track this process, monitoring of plastic pollution is required. Monitoring of plastic pollution may occur in various ways, including the use of UAVs, remote sensing, physical sampling or through

citizen science (See section 3.4). When monitoring plastic pollution, it has to be considered that plastic does not only float, but may also be suspended in the water.

Building a database with regular measurements of the above-mentioned parameters will give an indication of the potential pressures on wetland resources and their associated stressors and ecosystem receptors which could be adversely affected by degradation in water quality.

4.7 State of governance related to wetland management

Governance related to wetlands plays an essential role in terms of the way in which wetlands are being managed and how successfully management plans can be implemented. It gives an indication of the government commitment towards the protection and sustainable use of wetlands. Monitoring the institutional context surrounding wetland management provides an assessment vehicle that informs the governments and partners of the Nile basin countries of where possible gaps are, which dictates future actions that have to be prioritized.

Access to information on regulatory compliance leads to a common belief that regulatory systems are transparent. Monitoring the governance aspects related to wetland management mainly consist of two components: a legal component, which focus on all legal/enforceable documents that exist and a non-legal component, which includes all knowledge-based documents that are not legally enforceable, but still supports the governance of wetlands. Some examples of governance aspects that should be monitored are presented in the table below.

Table 6: Governance aspects to be monitored

Legal component (includes all legal/enforceable documents):	**Knowledge component (including all non-legal documents):**
Number of laws related to wetlands	Number of Key Biodiversity Areas related to wetlands
Number of regulations related to wetlands	Number of E-flow assessments related to wetlands
Number of white papers related to wetlands	Number of policies related to wetlands
Legal protection/protected area status related to wetlands	Number of publications related to wetlands
Area covered by protected areas	Number of management plans related to wetlands
Management status (RAMSAR listed)	

Monitoring of these parameters shows to what extent wetlands are being mainstreamed within governance structures and subsequently informs management and decision-making processes, supports accountability and guides organizational learning to improve wetland management.

To assist managers that are responsible for the management of wetlands, a number of tools have been developed that help to assess and respond to the effectiveness of management planning processes and their implementation. The Ramsar Site Management Effectiveness Tracking Tool (R-METT) is based on the 2007 version of the METT, which is designed to track and monitor progress towards worldwide protected area management effectiveness. The R-METT have some adaptations that are specific to the needs of the Convention and wetlands (Ramsar, 2010).

5. CONCLUSION

This monitoring guideline is based on best practice for reporting on various factors related to the sustainable management of environmental concerns. It also incorporates reporting requirements from MEAs to which the Nile Basin countries are parties. This will contribute to the efforts of NBI at basin monitoring, as conducted under the five year “State of Basin” reporting.

Monitoring must continue to better conceptualize and describe current conditions in the Nile Basin. Continued support and coordination of hydrologic and ecological monitoring and coordination among them are important components of monitoring and assessment. National monitoring programmes should be set as soon as possible that define the extent of monitoring, based on capacity and resource availability. Institutional mechanisms should be created and sustained to ensure that scientific information is available and accessible to the decision-making process.

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ANNEXURES

The following reports can be found on the pCloud link provided below:

- NBI wetland strategy
- NBI Shared Vision Program
- National Biodiversity Strategy and Action Plan
- South Sudan State-of-Environment Report
- Nile Basin State of Basin Report
- Nile Basin Wetland Inventory
- Nile Basin Biodiversity Assessment Report

pCloud Link: https://u.pcloud.link/publink/show?code=kZJNctXZLtn9TWYxflyTVrxHxF9a6YwrPUAk

Relevant Links:

- Ramsar Convention https://www.ramsar.org/
- CBD https://www.cbd.int/convention/
- CMS https://www.cms.int/
- SoB http://sob.nilebasin.org/
- IUCN https://1drv.ms/x/s!AjDz6ZcpjAAZi4ZD7bhZk-ZzGK5bIg?e=1qG5S0
- Living Planet Index https://www.livingplanetindex.org/home/index
- Global Forest Watch https://www.globalforestwatch.org/
- Bird Life International http://www.birdlife.org/
- TBA http://www.tropical-biology.org/
- METT http://assets.panda.org/downloads/mett2_final_version_july_2007.pdf
- Flood and Drought Portal https://www.flooddroughtmonitor.com/home
- SDG Indicators Report https://sustainabledevelopment.un.org/content/documents/2013150612-FINAL-SDSN-Indicator-Report1.pdf

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