



ZAMBIA ENVIRONMENTAL  
MANAGEMENT AGENCY



THE REPUBLIC OF ZAMBIA

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# Conservation Plan for Lukanga Swamp and Upper Kafue Basin

## Progress Report No. 5

April 2021

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# CONSERVATION PLAN FOR LUKANGA SWAMP AND UPPER KAFUE BASIN

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## Progress Report No. 5

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## ACRONYMS

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|                                                          |                                                                                |
|----------------------------------------------------------|--------------------------------------------------------------------------------|
| AAS – Atomic absorption spectroscopy                     | ICP-OES – Inductively Coupled Plasma Optical Emission Spectroscopy             |
| BOD – Biochemical oxygen demand                          | IUCN – International Union for Conservation of Nature                          |
| CBO – Community based Organisation                       | KNP – Kafue National Park                                                      |
| CFMG – Community Forest Management Groups                | LDCF – Least Developed Countries Fund                                          |
| CNPPA – Commission on National Parks and Protected Areas | LSCMP – Lukanga Swamp Management Plan                                          |
| COD – Chemical oxygen demand                             | MA – Ministry of Agriculture                                                   |
| CRB – Community Resource Board                           | MFL – Ministry of Fisheries and Livestock                                      |
| CSA – Climate-smart agriculture                          | MLNR – Ministry of Lands and Natural Resources                                 |
| DDCC – District Development and Coordination Committee   | MUMA – Multiple-Use Management Area                                            |
| DNPW – Department of National Parks and Wildlife         | MUMAMB – MUMA Management Board                                                 |
| DoF – Department of Fisheries                            | NGO – Non-Governmental Organisation                                            |
| EbA – Ecosystem-based Adaptation                         | NHCC – National Heritage Conservation Commission                               |
| EQA – Environmental Quality Assessment                   | NOAA – National Oceanic Atmospheric Administration                             |
| ERL – “Effects Range-Low”                                | SQG – sediment quality guideline                                               |
| ERM – “Effects Range-Medium”                             | VAG – Village Action Group                                                     |
| ES – Ecosystem Services                                  | WARMA – Water Resources Management Authority                                   |
| FAO – Food and Agriculture Organization                  | WB – World Bank                                                                |
| FCRB – Fisheries’ Community Resource Board               | WHO – World Health Organization                                                |
| FMA – Fisheries Management Area                          | WWF – World Wildlife Fund for Nature                                           |
| FMC – Fisheries Management Committee                     | ZEMA – Zambia Environmental Management Agency                                  |
| GEF – Global Environment Facility                        | ZMERIP – Zambia Mining and Environmental Remediation and Improvement Programme |
| GHG – Greenhouse Gas                                     | ZS – Zambian Standard                                                          |
| GMA – Game Management Area                               |                                                                                |
| IBA – Important Bird Area                                |                                                                                |
| IC – Ion Chromatography                                  |                                                                                |
| ICP-MS – Inductively Coupled Plasma – Mass Spectrometry  |                                                                                |



## **Executive summary**

*This document is Progress Report No. 5 of the consultancy for the development of a Conservation Plan for Lukanga Swamp and Upper Kafue Basin, conducted by Nemus – Gestão e Requalificação Ambiental, Lda., for Zambia Environmental Management Agency.*

*The main purpose of the consultancy is to develop a Conservation Plan for the Lukanga Swamp considering all the impacts that may arise from its catchment and the Upper Kafue Basin.*

*The Conservation Plan's development comprises six phases:*

- Phase 1: Planning;*
- Phase 2: Scoping and data collection*
- Phase 3: Characterisation and assessment;*
- Phase 4: Development of tools and recommendations for management (Integration);*
- Phase 5: Presentation and dissemination of results;*
- Phase 6: Final presentation and capacity building.*

*Progress Report No. 5 (D6) is the second of three reports to be submitted in Phase 4 and aims to present Part II of the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, comprising the Action Plan, including:*

- Background; Conservation Plan's vision and objectives revisited;*
- Wetland conservation approach – principles that guide the proposed conservation and management strategies; proposal of the creation of a managed area like the 2010 Lukanga Management Plan proposed model of a Multiple-Use Management Area;*
- Conservation Plan zonation – protection and land use zonation of the Lukanga Swamp critical conservation and management area; use restrictions applicable to each zone;*
- Strategies for Lukanga Swamp watershed – focusing on the following types of actions and recommendations: conservation and management strategies; research and monitoring; capacity building; socioeconomic development; climate change resilience;*



- *Strategies concerning the Upper Kafue Basin – a holistic view of water governance, considering all uses present upstream of the Lukanga Swamp; activities that should be restricted and regulated in the Upper Kafue Basin;*
- *Environmental monitoring plan – surface water, groundwater, soil, sediment, habitat and biodiversity/species monitoring activities proposed (parameters, sampling stations and frequency, data collection and analysis methods and criteria); monitoring plan revision;*
- *Implementation and follow up – schedule, institutional arrangement, monitoring and evaluation (including follow up indicators and reporting).*

*Progress Report No. 5 (D6) also presents, as an appendix, the Capacity Building Action Plan – guidelines for the training and awareness-raising actions and/or resources to be developed towards the conclusion of the Conservation Plan.*

*The Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, integrating, reviewing and updating Parts I (presented in Progress Report No. 4 – D5) and II according to comments from ZEMA and other relevant stakeholders, will be the object of the Draft Report (D7), scheduled for May 2021.*

*Regarding the overall objective of the Conservation Plan for Lukanga Swamp – generate both qualitative and quantitative data and tools to support the participatory management of the area –, a relevant amount of data has already been compiled and collected; also, its analysis allowed the selection or development of tools (e.g., Environmental Cost-Benefit Analysis, Co\$ting Nature, the Lukanga Conservation Plan website, including a “Participation form” for the reception of inputs) that will support the participatory management of the area.*

*The body of information collected and analysed, as well as these tools, allowed the assessment of different conservation scenarios and the definition of the strategies here proposed to maximize the benefits provided by the swamp and thus improve the quality of life of the populations that depend upon these resources while protecting existing natural ecosystems.*



## Foreword

The Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, developed by Nemus for ZEMA is structured as follows:

### Part I

1. Introduction
2. Conservation planning framework
3. Description – Upper Kafue, Lukanga Swamp and its catchment baseline
4. Evaluation
5. Objectives
6. Assessment – Future scenarios and decision-making framework

### Part II

7. Action Plan
  8. Conclusion
  9. References
- Appendixes

Progress Report No. 4 (D5) presented Part I of the Draft Conservation Plan.

Progress Report No. 5 (D6) presents Part II of the Draft Conservation Plan and mainly aims at proposing the Action Plan (chapter 7).

The Draft Report (D7) will present the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin; integrating, reviewing and updating Parts I and II, taking into account comments from ZEMA and other relevant stakeholders, as well as stakeholder consultation actions conducted thus far.

These three reports are the deliverables expected in Phase 4 of the development of the Plan: “development of tools and recommendations for management (integration)”. The first (Progress Report No. 4 or D5) presented the selected tools (e.g., Environmental Cost-Benefit Analysis, Co\$ting Nature) for the assessment of future scenarios and decision-making, as well as their results. Co\$ting Nature (version 3), a tool/model provided by King's College London and AmbioTEK CIC (Mulligan, 2018) was selected, because:

- it was created as a testbed for the development and implementation of conservation strategies focused on improving ecosystem services;
- it incorporates detailed spatial datasets at 1-square km and 1-hectare resolution for the entire World, spatial models for biophysical and socioeconomic processes along with scenarios for climate and land use;



- it maps 13 ecosystem services and then combines them with different analyses (current pressure, future threats, biodiversity and delphic conservation priority) to produce an assessment of priority areas for conservation;
- it values and examines the impacts – in terms of change in ecosystem services – and implications for beneficiaries (global and local);
- it calculates a baseline for ecosystem service provision and allows a series of interventions or scenarios of change (user priorities for conservation and ecosystem services; different economic valuation matrix per ecosystem service; various land-use change scenarios, including different settings for deforestation) to understand their impact on ecosystem service delivery.

These tools supported the recommendation of conservation and management strategies and are the main component of the decision-making framework.





## Introduction

This document presents Part II of the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, conducted by Nemus – Gestão e Requalificação Ambiental, Lda., for Zambia Environmental Management Agency (ZEMA).

The Plan, aiming to consider all the impacts that may arise from Lukanga's catchment and Upper Kafue Basin, is developed with the support of the World Bank (WB), under the Zambia Mining and Environmental Remediation and Improvement Programme (ZMERIP).

The focus of the Conservation Plan is Lukanga Swamp, located within the Central Province, in the east bank of the Kafue River and developing in a shallow circular depression of a generally flat area, extending over parts of the Kapiri Mposhi, Chibombo and Mpongwe Districts (Ramsar, 2005).

Lukanga Swamp is one of Zambia's key wetlands, whose ecological value is demonstrated by its classification since 2005 as both a Ramsar site (No. 1580), by the Ramsar Convention on Wetlands, and as an Important Bird Area (ZM020), by BirdLife International (BirdWatch Zambia, 2019). It is also economically important, given that it is estimated that about 60,000 people live in, or close to, the wetland and that products derived from fishing, hunting, and agriculture, support a hinterland population of some 6.1 million people (Ramsar Sites Information Service, 2005 in McCartney *et al.*, 2011).

"Lukanga Swamps Ramsar Site" (coordinates: 14°24'S 27°37'E – Ramsar, 2005; Figure 1) is the core of the wider conservation area included in the Conservation Plan (plan area "A"). The plan areas also include a 10 km conservation buffer of the Ramsar site for increased protection of the key biodiversity and conservation areas (Lukanga Swamp critical conservation and management area or plan area "B").

Complementary areas, to take into account the sources of impacts on Lukanga Swamp and its catchment, include Lukanga Swamp watershed (plan area "C") and Kafue River Basin upstream (plan area "D"), all represented in Figure 1 and Maps 1 and 2 (Appendix 1).

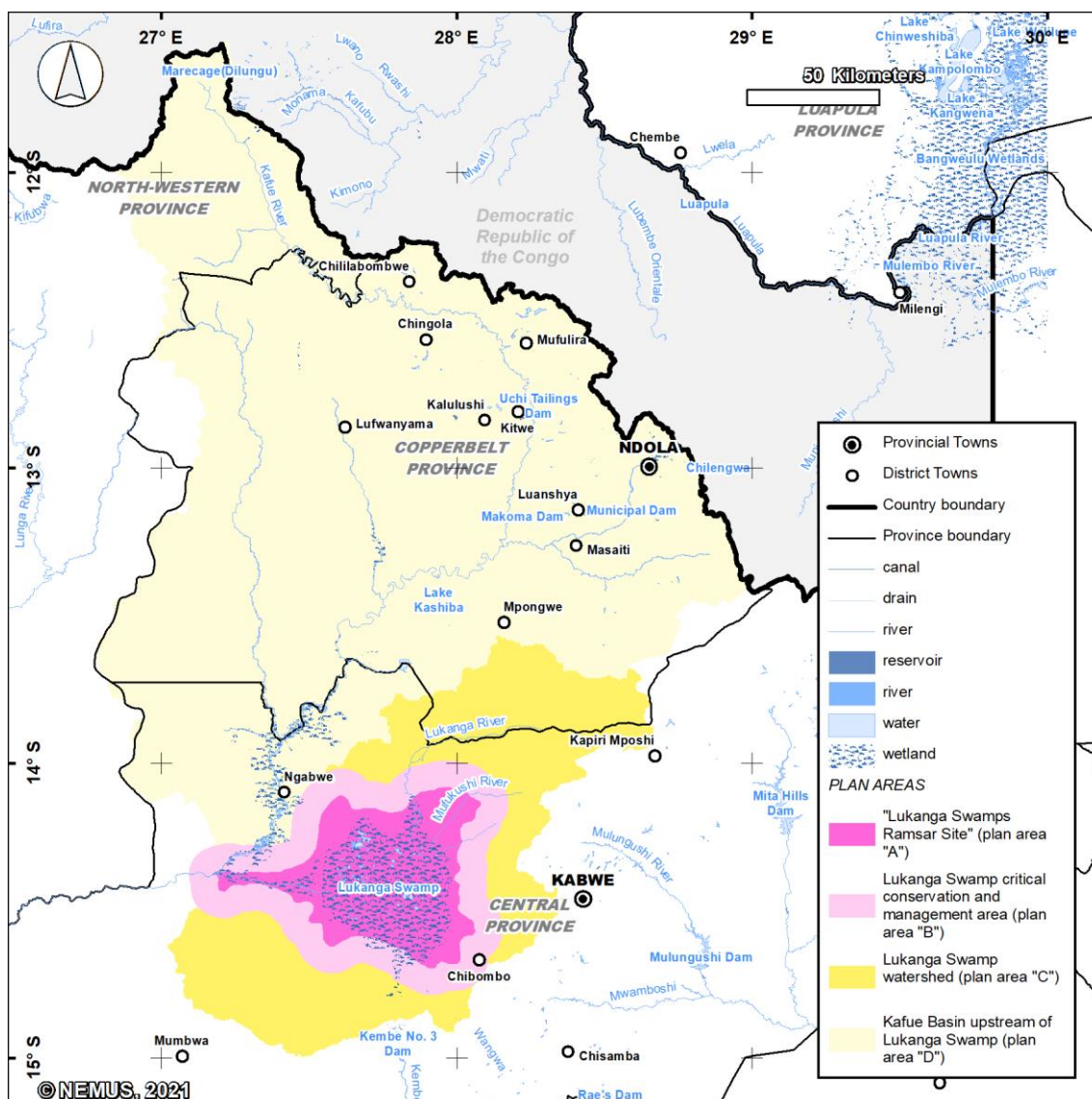


Figure 1 – Conservation Plan areas' administrative and hydrographic frameworks

This document is organised according to the following structure:

- Introduction;
- Action Plan (Chapter 7);
- Conclusion (Chapter 8);
- References (Chapter 9);
- Appendixes – maps (Appendix 1) and the Capacity Building Action Plan (guidelines for the training and awareness-raising actions and/or resources to be developed towards the conclusion of the Conservation Plan – Appendix 2).



## 7. Action Plan

### 7.1. Background; Conservation Plan's vision and objectives revisited

The action plan defines the road map for implementing the Conservation Plan for Lukanga Swamp and Upper Kafue Basin, based on the assumptions and assessments of Part I of the draft plan: conservation planning framework, baseline, evaluation, objectives and assessment of future scenarios.

It starts with the proposed **approach to wetland conservation**, described in subchapter 7.2, building upon this Plan's vision and objectives, as well as on the 2010 Lukanga Swamp Catchment Management Plan (Chabwela *et al.*, 2010).

*A sustainable, integrated and participated planning of Lukanga Swamp, its catchment and Kafue river basin upstream that addresses human well-being while sustaining and enhancing the Ecosystem Services (ES) provided by the wetland is the Plan's vision, established in the conservation planning framework (Part I, chapter 2).*

The overall objectives/goals of the Conservation Plan (derived from Part I, chapter 5) are:

- conservation of existing values and halt degradation (by knowing better, monitoring and regulating their use) to ensure long term maintenance of biodiversity and ecosystem benefits/services as well as human well-being (including food security and poverty alleviation); poverty in the Lukanga Swamp's catchment is exceptionally high (~79% of the population) and manifests through inadequate food reserves, high illiteracy rates, low cash incomes and a high dependence on the natural resource base (MLNR, 2021, "Building the resilience of local communities in Zambia through the introduction of Ecosystem-based Adaptation into priority ecosystems, including wetlands and forests" draft project document);
- restoration of degraded wetland, prioritizing those values which play significant roles in the conservation of biological diversity and ecosystem benefits/services and reversing the degradation trend.

Besides presenting the principles that guided the definition of the conservation strategy and the development of the present action plan, the proposed approach envisages the **zonation of Lukanga Swamp critical conservation and management area**, which is presented in subchapter 7.3.



Taking into account all the above, as well as the trade-offs between different options that resulted from the assessment of future scenarios presented in Part I (chapter 6) of the Draft Conservation Plan, actions and recommendations applicable to the different plan areas are proposed in subchapters 7.4 (**Strategies for Lukanga Swamp watershed**, including the ones to be applied specifically to the Ramsar site or the critical conservation and management area) and 7.5 (**Strategies concerning the Upper Kafue Basin**). These include culturally appropriate gender and social-inclusive best-practice recommendations and are intended to follow an iterative process of discussion with relevant stakeholders, to ensure the appropriate engagement of sectoral and local knowledge.

The conservation of existing values demands, in turn, the establishment (through surveying) of the current state of priority values for which information is lacking. Thus, complementing the Lukanga Swamp and its catchment's knowledge base is also critical in the implementation of the Conservation Plan. So, research and monitoring are among the areas for which strategies are proposed, and monitoring activities are detailed in subchapter 7.6 (**Environmental monitoring plan**).

Finally, the road map is operationalized in subchapter 7.7 (**Implementation and follow-up**), with the proposed schedule and the institutional arrangement for the Conservation Plan's implementation, as well as the monitoring and evaluation procedures to ensure the achievement of the Plan's objectives.



## 7.2. Wetland conservation approach

As a designated Ramsar site, and under Article 3.1 of the Convention, one of the main objectives of planning around the Lukanga Swamp should be its wise use, that is, one that safeguards the “maintenance of [its] ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development” (Ramsar, 2007) – i.e., managing for the “long term maintenance of biodiversity” and for enhancing “human well-being and [alleviating] poverty” (Ramsar Handbook 1, 4th Edition).

Over the development of the present Conservation Plan, several indirect and direct threats were identified that drive change in the wetland and surrounding ecosystems, jeopardizing the conservation of biodiversity and the good functioning of the system, which in turn translates into impacts on human well-being.

Direct threats fall into the following main classes: changes in land use and cover; species removal and/or introduction; pollution and eutrophication; and changes of the hydrological regime. These are, in turn, influenced by a set of indirect threats that include: population growth; poverty and inexistence of alternative income sources; limited knowledge of the system’s functioning; limited institutional resources; and insufficient public awareness.

In this context, the strategy of a Conservation Plan should be to combine different management tools (e.g., from the creation of zones to species or habitat management) (Chatterjee *et al.*, 2008) to approach direct and indirect drivers of change and other cross-cutting issues, while arranging for structural/basal elements that are considered vital to enhance collaboration and ensure the long-term efficacy of management. Specifically, the following **principles** guided the definition of the conservation strategy and the development of the present action plan, and should be fostered throughout the lifetime of the plan:

- Wise-use and sustainability – Ramsar “wise use philosophy” “has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind” (Ramsar, n.d. *in* Mapedza *et al.*, 2012);
- Adaptive management – a clear and effective follow-up process and adaptation mechanism built-in the plan, to ensure management remains effective and relevant throughout the plan’s lifetime, acknowledging that social and ecological conditions are not static;



- Equity and transparency – in making trade-offs between wetland users (McCartney *et al.*, 2011);
- Cross-sectoral articulation and the “nexus approach”<sup>1</sup> – establishment and nurturing of horizontal and vertical links between relevant institutions, knowledge holders, managers and users, to ensure effective and continued communication, and to avoid redundant efforts;
- Public involvement, participation and accountability – effective and consequent empowerment of communities, therefore assigning responsibility and authority where these are due – the ultimate users of the area, benefiter or potentially affected by the current management strategy; local populations must be acknowledged as partial owners of the site, and their sense of responsibility towards the land and natural resources they depend on must be strengthened;
- Education and capacity building – a significant effort must be directed into supporting elements such as education, awareness raising, knowledge sharing and capacity building across the residents, managers and other stakeholders.

Regarding governing arrangements, a co-management model is advised (see section 7.7.2), as already proposed by Chabwela *et al.* (2010). The current model of open access/public resource use under the governing of ministerial departments should be substituted by a participative common property regime, where the development of operational rules and management responsibilities are shared with resource users (Kaluma & Umar, 2021; Sverdrup-Jensen & Nielsen, 1998). Despite the use of the term “property” – meaning the assignment of “property rights” to local communities in the context of resources management –, it is considered that the “Commonality Principle” of the National Wetlands Policy (MLNR, 2018) is respected. This guiding principle states that –

*«Property rights to land do not confer property rights to wetland resources sitting wholly or in part on that piece of land. They are a vital element of the national and global*

---

<sup>1</sup> «The Nexus Approach to environmental resources' management examines the interrelatedness and interdependencies of environmental resources and their transitions and fluxes across spatial scales and between compartments. Instead of just looking at individual components, the functioning, productivity, and management of a complex system are taken into consideration» (UNU-FLORES, 2019). Subsequently, the nexus approach argues that considering the interdependencies of environmental resources between parts of a cycle and across different scales can increase resource efficiency while minimizing ecological degradation and environmental risks (World Bank Group, 2018).





*ecosystems and the economy, making them a common asset for Zambians to collectively own, use and sustain. »*

– thus, referring to the possession of land and its influence on the access to wetland resources in that piece of land. In this context, by regulating access to wetland and forest resources, the introduction of property rights to communities (not individuals) safeguards their longevity and ensures the maintenance of wider ecosystem services, with benefits at much greater scales.

In practice, through the appropriate mechanisms, local user groups must be legally empowered to manage their resources, under the condition that they understand the importance of ecosystems and their services, that they understand their responsibility towards the maintenance of natural systems, and that they act collectively to conserve these for future generations.

To ensure a **bottom-up** strategy is accomplished, the role of local users must surpass that of a purely consultative entity, and become deliberative and operational, i.e., having the authority to make decisions, and have some degree of operational responsibility (Sverdrup-Jensen & Nielsen, 1998; Musumali *et al.*, 2009; Kaluma & Umar, 2021). State entities must retain regulatory responsibilities. **Top-down** control is essential to ensure local power dynamics remain just and equitable, and that regulations are being respected (Jones, 2014; Kaluma & Umar, 2021).

The present conservation strategy also recommends an integrated and scaled approach, where the focus is at the Ramsar site-level with the creation of a managed area like the originally proposed model of a multiple-use management area (see Box below) managed under Community Resource Boards (CRBs) – or other analogous community groups –, and “buffered” by several restrictions or provisions to stressors originated upstream, in the catchment and the Upper Kafue Basin.



### On establishing the Lukanga Swamp as a designated area for the conservation of biodiversity

Chabwela *et al.* (2010) proposed designating the site as a protected area under one of (IUCN's) CNPPA's original Group B categories: **category VIII, Multiple-Use Management Area (MUMA)** (Dudley, 2008) (Output 2 of Objective n.º 9 of the LSCMP). This typology aims at «managing [all] renewable resources, [i.e.] the production of wood products, water, pasture, wildlife, settlements, agriculture, mining, etc.» (Chabwela *et al.*, 2010), and is comparable with the Game Management Area (GMA) designation.

The GMA designation, in turn, is compatible with resource use, so that these areas support human settlements, hunting activities (subject to licensing), and a variety of traditional land-uses such as chitemene agriculture (Barnes *et al.*, 2011).

While the MUMA denomination is no longer in use by IUCN, two of the existing categories could potentially apply, as both are compatible with some degree of resource use: **V – Protected Landscape/Seascape**; and **VI – Sustainable Resource Use** (Dudley, 2008):

- «**Category V** is a protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.»
- «**Category VI** protected areas conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.»

Neither of these categories seems to fit the case of the Lukanga well enough, however. It does not «remain as predominantly [a] natural ecosystem», nor does it hold a particularly significant «ecological, biological, cultural and scenic value» derived from «people's interaction with nature over time». In fact, current levels of resource use, due, in part, to a growing population and a lack of effective management, threaten the continuity of the natural systems and the benefits they provide.

There are significant issues with relying on strictly protected areas and “umbrella” taxa for biodiversity conservation, as these can result in landscape-scale heterogeneity and biodiversity patterns to not be adequately covered (Gardner *et al.*, 2007). Widening conservation efforts through an ecosystem approach – incorporating human-influenced areas – better accounts for regional biodiversity patterns. These areas' distinct biodiversity patterns confer species redundancy and complementarity regionally, promoting ecological integrity at the landscape-scale (Gardner *et al.*, 2007).

Indeed, the establishment of this region as a partially protected area forms a wildlife corridor connecting the swamp with the Lunga Luswishi GMA, leading to Kafue National Park. This designation must acknowledge the role of human communities within the system and wider





landscape, enabling their continued but sustainable use of natural resources, and conservation efforts must focus on systems and communities rather than on particular species and their conservation status.

In this context, the following subchapter (7.3) proposes a zonation of Lukanga Swamp critical conservation and management area (LSCCMA or plan area “B”), including the use restrictions applicable to each zone.

Other regulatory, restorative, conservation and/or management actions and recommendations applicable to this area or the whole Lukanga Swamp watershed (plan area “C”) are proposed in subchapter 7.4 (Strategies for Lukanga Swamp watershed).



### 7.3. Conservation Plan zonation

The original ecological zonation of the Lukanga site identified areas of importance for different resources, aiming at facilitating the «appropriate, controlled and sustainable land use of the area» (Chabwela *et al.*, 2010).

These resources included: hydrology and water resources; fisheries; birds; mammals and reptiles; vegetation communities; and human settlements. The zoning system was composed of wildlife areas, grazing areas, agricultural areas, bird areas, conservation areas and fish breeding areas.

The present zonation translates the original data presented in Chabwela *et al.* (2010), together with the newly compiled information – diagnostic and identification of threats and risks – geographically, allowing the distinction between different parts of the territory with different sensibilities and drivers.

This zonation must be tailored to the territory's characteristics, both biophysical and social, and its objectives are twofold, (i) to preserve biodiversity and to (ii) enhance the well-being of local populations (Part I, chapter 5 – Objectives). As such, and keeping in mind the site is not a protected area in a strict sense (subchapter 7.2), in allowing the protection of specific ecological values, this zonation is expected to not only preserve local communities' livelihoods but also empower their daily and long-term decision-making in terms of sustainability.

The protection and land use zonation of the Lukanga Swamp critical management and conservation area was produced in three phases:

- (1) Production of a map of environmental constraints composed of the **areas of conservation interest** (Map 3A, Appendix 1), whose specificities will define the objectives and appropriate uses of the zones; this map includes:
  - areas designated for the protection of biodiversity and habitats (either by national legislation or international agreements); Ramsar sites; Important Bird Areas; Game Management Areas; National Forests and Local Forests;
  - Fish breeding areas (Chabwela *et al.*, 2010);
  - Very high and high ecological value habitats (class 4 of 5) (cf., Part I, chapter 4);
  - Most suitable habitats for important biological communities, and for endangered or critically endangered animal species;



- (2) Production of a map of social constraints, showcasing the different **resource uses** and **human pressures** (Map 3B, Appendix 1) across the area (fishing, grazing, forest resource extraction, and cultivation; human population density; and Kariba weed sightings dating to 2019);
- (3) Crossing of the spatial information produced in (1) and (2) for the obtention of zones with distinct conservation and management objectives (Map 4, Appendix 1).

As a management tool, the zonation of a site requires a clear definition of the permitted, restricted and prohibited uses and activities for each zone, that minimize risks and protect the integrity of biological diversity and ecological functions.

The Lukanga Swamp Critical Conservation and Management Area was divided into three (3) protection categories, each further subdivided according to the territory's particularities and intended uses (Map 4, Appendix 1):

- **Total Protection Areas**; these are dominated by habitats of moderate to high ecological relevance, in a more favourable status, and that are known to support important ecological values and services; these are also the areas with the lowest levels of anthropogenic pressure and highest levels of habitat suitability for important wildlife, such as grassland ungulates and wetland avifauna;
  - located in the north-western quadrant of the LSCCMA, the TP area covers the Itundo plain, and reaches down to the Lukanga river outlet, and east to the Lukanga river inlet; some islands are not covered by this typology;
  - an effort was made to design a continuous area, to promote the ecological continuum;
- **Partial Protection Areas**; these are areas without – or with very few – human settlements, but which serve important ecosystem services and/or direct uses such as being grazing grounds or fishing areas; as the name indicates, these are also largely aimed at protecting natural values, however, the wise use of these same resources is allowed; these serve as a buffer between TPs and areas of stronger human influence;
  - Fisheries management area: central circular pan covered by the permanent swamp and its lakes, together with the downstream arm of the Lukanga River; these are further divided into fishing concession



zones, themselves further divided into no-take, partially no-take and open zones;

- Grazing management areas: seasonally inundated plains that surround the swamp (open areas) and rivers and streams (riparian protection areas);
- **Complementary Protection Areas**; these are areas essentially covered by semi-natural and artificial land covers (settlements, cropland, etc.), and therefore lacking the original natural values warranting conservation; management here focuses on empowering sustainable practices and implementing restorative actions; forested land is also included in this category;
  - Community forests;
  - Mosaic of settlements and cropland (low population density);
  - Mosaic of settlements and cropland (moderate population density);
  - Settlements (high population density).

In addition, to safeguard the successful implementation of this zonation system, a number of general measures must be taken:

- Demarcation of the zonation in the field – wildlife reserves and areas with restricted uses need to be adequately marked on-site;
- Installation of informative panels in the boundaries of the areas, or in the more frequently used entry points, to increase awareness; topics like restricted and prohibited practices and their impacts, occurring species – namely, endangered ones – do's and don'ts, should be included;
- Dissemination of informative material, such as maps and guidelines, and development of awareness raising campaigns across the site.

The following sections specify briefly the appropriate uses and the permanently or temporarily prohibited uses for the different zones.



### 7.3.1. Total protection areas

The TP areas are located in the north-western quadrant of the plan area, covering the Itundo plain, and reaching down to the Lukanga river outlet, and east to the same river's inlet (Figure 2). These are covered by grassland, grassland termitaria and some forest, of moderate to high ecological relevance, in favourable conservation statuses.

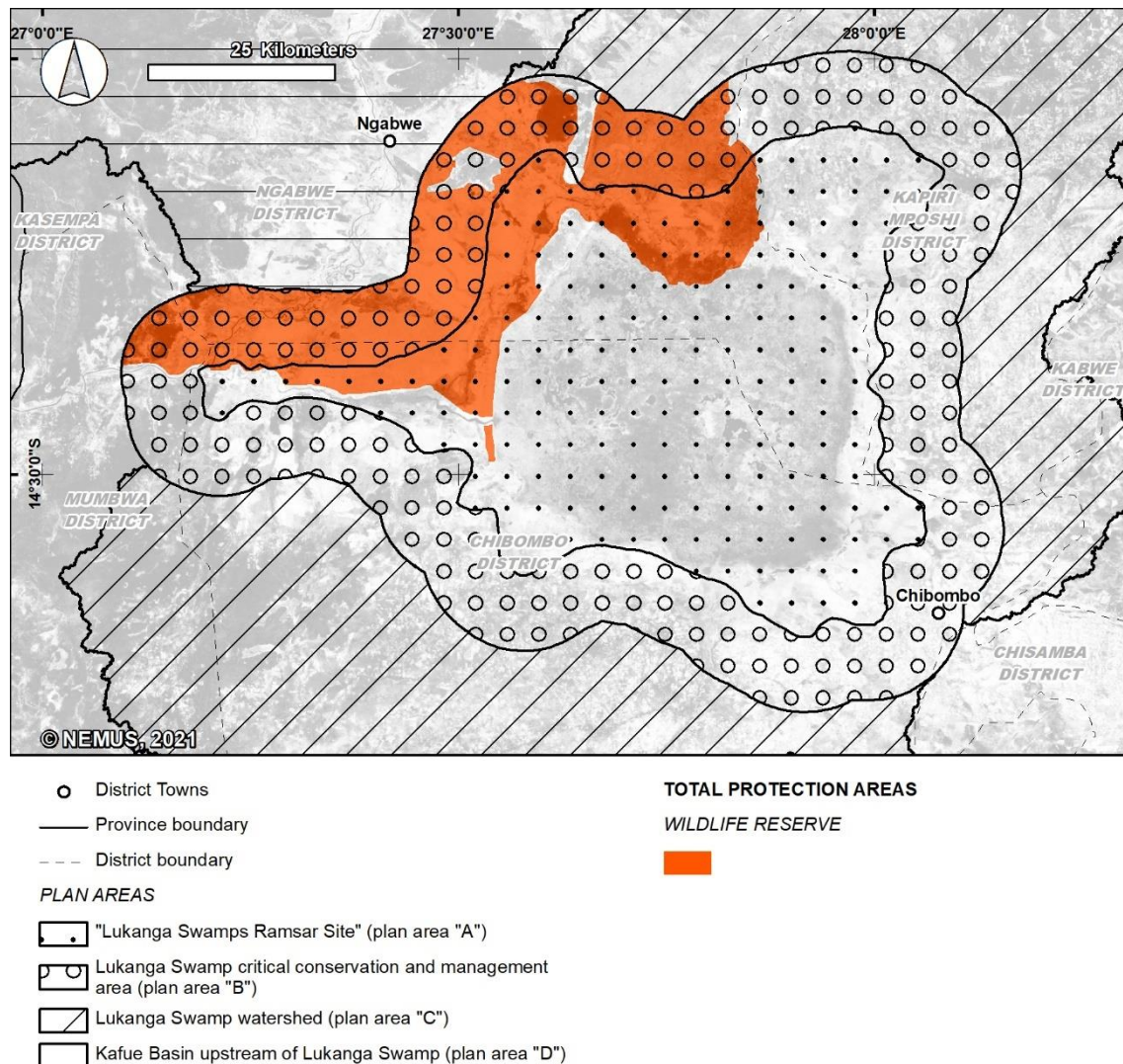


Figure 2 – Total protection areas: wildlife reserve

The TP areas are composed of zones with higher biodiversity, and with very high value communities of fauna and flora (fish assemblages, zooplankton, phytoplankton/benthos, macroinvertebrates, wild ungulates and waterbirds), in low human density areas, with



limited direct use value. The majority of this territory is well characterized by its seasonal biophysical dynamics.

These areas provide services essential to biodiversity conservation, such as habitat or refuge for wildlife, high productivity (the edaphic grassland, for instance), and breeding habitat for different groups; they loosely correspond to the original plan's "wildlife", "seasonal fish breeding" and "intensive bird" areas.

Specifically, in addition to being the permanent habitat, a regular stop or the wintering site for water birds (meeting IBA criterion A4), the edaphic grassland/ termitaria mosaic, in particular, holds the only potentially suitable breeding areas for the wattled crane, *Bugeranus carunculatus* (Gmelin, 1789) ("vulnerable", and one of the species that meets IBA criterion A1 and Ramsar criterion 2).

The open forest areas are suitable habitat for the martial (*Polemaetus bellicosus* [Daudin, 1800]) and steppe (*Aquila nipalensis* Hodgson, 1833) eagles ("vulnerable" and "endangered", respectively). These are also likely to provide adequate nesting habitat for critically endangered vultures (*Gyps africanus* Salvadori, 1865, white-backed vulture; and *Trigonoceps occipitalis* [Burchell, 1824], white-headed vulture). However, it is not clear whether they occur; the unavailability of their preferred prey suggests they are not present (Larocque, 2019). Provisions are nonetheless given for mitigating potential negative impacts on these species, which are vulnerable to poisoning and poaching.

The Lukanga wetland complex is also believed to play an important role as the breeding site for several fish species of the Kafue river system, as these migrate horizontally towards the floodplain to reproduce.

Finally, the grassland habitats provide important habitat for grazers, including the remaining antelopes in the area, such as the puku (*Kobus vardonii* [Livingstone, 1857]) or the red lechwe (*Kobus leche* subsp. *leche* Gray, 1850); while the forest/savanna/grassland mosaic with scattered water bodies is ideal for the ground pangolin (*Smutsia temmickii* [Smuts, 1832]), and for the yellow-backed duiker (*Cephalophus silvicultor* [Afzelius, 1815]), who prefers to keep to forest edges.

As such, and taking into account the conservation objectives, this zone has as its **primary objective** the protection of habitats, species and biological communities. The establishment of this region as a reserve creates a wildlife corridor leading to the KNP through the Lunga Luswishi GMA.





Those activities that are compatible with the maintenance of the systems' ecological character, and those that enhance their conservation status (e.g., habitat rehabilitation) are allowed. These uses should largely be non-consumptive, and related to visiting and monitoring or research-related activities, while consumptive uses are restricted (Table 1).

Any activity or intervention which implicates the significant, immediate or future, obvious or presumed, degradation of the ecological values is not allowed.

Activities that entail the capture of living organisms for scientific purposes are subjected to previous authorization, as long as this removal does not significantly impact population and community dynamics, and that it builds the knowledge about these systems, their biological communities, and how to better protect and manage them. These activities can be temporarily/seasonally restricted, in order to safeguard periods of heightened sensibility for different species such as nesting, breeding, migratory movements, flowering, among others.

**Table 1 – Use restrictions in the total protection area (i.e., wildlife reserve)**

| Uses/ activities |                                                                                                                                                                                 |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prohibited       | <ul style="list-style-type: none"> <li>Constructing any structures that disrupt the hydrological regime</li> </ul>                                                              |
|                  | <ul style="list-style-type: none"> <li>Settling in undisturbed areas (here, undisturbed includes areas that have been burnt or grazed in the past)</li> </ul>                   |
|                  | <ul style="list-style-type: none"> <li>Eliminating natural cover for agricultural purposes</li> </ul>                                                                           |
|                  | <ul style="list-style-type: none"> <li>Hunting and trading wild ungulates (like the puku, the red lechwe or the yellow-backed duiker, among others)</li> </ul>                  |
|                  | <ul style="list-style-type: none"> <li>Hunting and trading the ground pangolin</li> </ul>                                                                                       |
|                  | <ul style="list-style-type: none"> <li>Hunting and trading bats, especially the African straw-coloured fruit bat</li> </ul>                                                     |
|                  | <ul style="list-style-type: none"> <li>Hunting and trading waterbirds (juveniles and adults) or collecting their eggs</li> </ul>                                                |
|                  | <ul style="list-style-type: none"> <li>Hunting and trading vultures (juveniles and adults) or collecting their eggs</li> </ul>                                                  |
|                  | <ul style="list-style-type: none"> <li>Using diclofenac and other toxic drugs (for veterinary or any other purposes), to prevent unintentional poisoning of vultures</li> </ul> |
|                  | <ul style="list-style-type: none"> <li>Fishing</li> </ul>                                                                                                                       |
|                  | <ul style="list-style-type: none"> <li>Fish farming</li> </ul>                                                                                                                  |
|                  | <ul style="list-style-type: none"> <li>Engaging in non-traditional pastoralist systems</li> </ul>                                                                               |
|                  | <ul style="list-style-type: none"> <li>Burning/ igniting fires for the purpose of hunting</li> </ul>                                                                            |
|                  | <ul style="list-style-type: none"> <li>Logging</li> </ul>                                                                                                                       |





| Uses/ activities |                                                                                                                                                                                                                                                                                                   |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Restricted       | <ul style="list-style-type: none"> <li>Grazing along the flood line should be minimized, since some bird species nest there, like the slaty egret</li> </ul>                                                                                                                                      |
|                  | <ul style="list-style-type: none"> <li>Livestock stocking density should be limited</li> </ul>                                                                                                                                                                                                    |
|                  | <ul style="list-style-type: none"> <li>Late dry season fires are not allowed, to prevent disturbing breeding seasons and to prevent damaging nests (ideally, august onward); this is the most consensual period regarding breeding seasons for fauna that reproduces in these habitats</li> </ul> |

This area provides an opportunity for the development of wildlife-based tourism. If, and when, this is developed, the use of this area must only serve visitation/observation: the installation of accommodation structures should not be allowed.



### 7.3.2. Partial protection areas

The partial protection areas include the central pan and a band that goes around it, with varying width, cropped by the complementary protection areas (Figure 3).

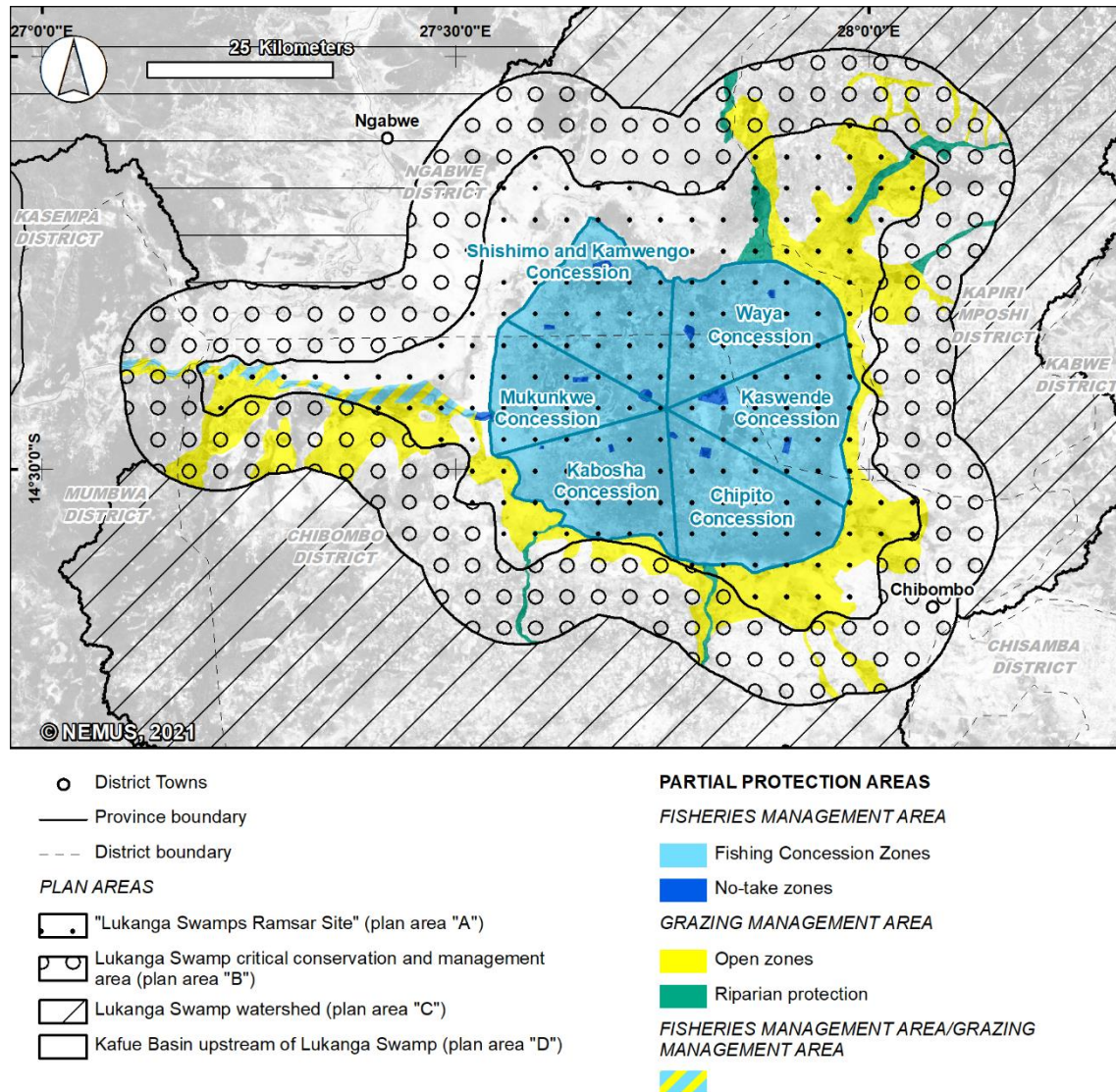


Figure 3 – Partial protection areas

This typology comprises two (2) main sub-types with distinct hydrological regimes, and, hence, ecological characters, and of moderate to very high ecological relevance:

- the swamp and lakes;
- floodplain grasslands and termitaria.



Grassland and termitaria zones which are more significantly fragmented than those of the TP area, normally contacting with anthropic land uses, were included in this category. Compared to the Itundo Plain, these areas are less suitable for wildlife.

Rivers and riparian vegetation provide shelter and breeding habitat for fish, raw material and food for local populations, while also contributing to the filtration and purification of the water, where there is a healthy vegetation.

These zones are also subjected to a seasonal hydrology dynamic. Both the Mufukushi and Lukanga rivers' surface flows are interrupted during the dry season, upstream of the swamp, and their courses become instead a series of open water patches with varying degrees of vegetation cover.

The banks are usually colonized by a fringe of emergent macrophytes, which can overgrow the entire stream if it is sufficiently shallow and slow-flowing. Upstream of the swamp, the dominant species is *Phragmites mauritianus* Kunth. while, downstream, emergent macrophyte stands are dominated by *Cyperus papyrus* L. and/or *Typha capensis* (Rohrb.) N. E. Br.

Ichthyofaunal communities are similar to those of the swamp, as these are closely linked, more so during the wet season. According to Chabwela *et al.* (2010), inflowing streams to the swamp are important breeding areas for fish species. Among the ichthyofauna potentially inhabiting these areas, the yellow-belly bream (*Serranochromis robustus* [Gunther, 1864]; "critically endangered") stands-out, followed by the many spines climbing perch (*Ctenopoma multispine* Peters, 1844) and the greenhead tilapia (*Oreochromis macrochir* [Boulenger, 1912]) (both "vulnerable").

Resident and migrant waterbirds use the rivers and streams, however, given the higher degree of human disturbance, and the availability of better habitat in the proximity, most are expected to prefer the swamp and the Lukanga river's outflow.

Insectivore shrews and bats use streams and rivers for foraging, while otters, mongooses and civets predate on crustaceans, fish and herpetofauna. The African clawless otter, *Aonyx capensis* (Schinz, 1821) ("near threatened") could be present in the area, given its resilience and ability to colonize altered habitats.

The swamp itself is characterized by its high productivity, its water storage ability, its role as nursery/breeding habitat for fish and bird species, habitat for wildlife, carbon sink,



nutrient trap and pump, while also providing local communities with raw material and food. Its lakes are also important fish breeding areas.

As such, and taking into account the conservation objectives, this zone has as its **primary objectives** the maintenance of water quality/ecological conditions, of vegetation health, and of fish populations. Here, the wise use of these resources is allowed, in the measure it does not compromise these objectives.

Depending on their characteristics and intended uses, the following sub-divisions were produced:

- **Fisheries management area:** the swamp and lakes, further divided into:
  - Fishing concession zones (for each fishing village), in turn divided into:
    - no-take zones;
    - partially no-take zones;
    - open zones;
    - *of these three categories, only no-take-zones were produced (corresponding to the fish breeding areas in Chabwela et al. [2010], these are wildlife reserves in essence, for the protection of fish populations); not enough information is available at the moment to produce partially no-take and open zones; these should be delineated in the first stages of the Plan's implementation; for more details, refer to the conservation and management strategies for the swamp's fisheries (section 7.4.4.2);*
- **Grazing management areas:** floodplain grasslands and termitaria, further divided into:
  - Riparian protection areas; these include rivers, streams, and a proportion of the floodplain around them;
  - Open areas;
- **Fisheries and grazing management area:** Lukanga river downstream of the swamp – this area is a combination of a riparian protection area, as it follows the river, and a fishing concession zones.

The outer PP areas (termitaria, grassland and rivers) function as buffers to the TP areas and the central swamp against the encroachment by anthropic pressures.



As with the TP zone, all the activities that are compatible with the maintenance of the systems' ecological character, and those that enhance their conservation status (e.g., habitat rehabilitation) are allowed. Visiting, monitoring or research-related activities (including those that involve the capture of living organisms for scientific purposes) are allowed under the same basis as for the TP zone. Some consumptive uses are prohibited, while the majority is only restricted or regulated (Table 2).

In addition to the zonation, regulatory mechanisms and restorative actions are proposed, in the subchapters that follow.



**Table 2 – Use restrictions in the partial protection areas**

| Uses/ activities                                                                                                                     | Fishing management areas |                                        |                                   | Grazing management areas          |            |
|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------|-----------------------------------|-----------------------------------|------------|
|                                                                                                                                      | No-take                  | Partially no-take                      | Open                              | Riparian protection areas         | Open areas |
| • Fishing                                                                                                                            | Prohibited               | Restricted to resident licence holders | Restricted to any licence holders | Restricted to any licence holders | n.a.       |
| • Constructing any structures that disrupt the hydrological regime                                                                   | Prohibited               | Prohibited                             | Prohibited                        | Prohibited                        | Prohibited |
| • Settling in undisturbed areas (here, undisturbed includes areas that have been burnt or grazed in the past)                        | Prohibited               | Prohibited                             | Prohibited                        | Prohibited                        | Prohibited |
| • Eliminating natural cover for agricultural purposes                                                                                | Prohibited               | Prohibited                             | Prohibited                        | Prohibited                        | Prohibited |
| • Pouring any polluting substances into the water; this includes chemical fertilizers, pesticides, petrol, domestic wastewater, etc. | Prohibited               | Prohibited                             | Prohibited                        | Prohibited                        | Prohibited |
| • Littering                                                                                                                          | Prohibited               | Prohibited                             | Prohibited                        | Prohibited                        | Prohibited |



| Uses/ activities                                                                                                                               | Fishing management areas                                                                         |                                                                                                  |                                                                                                  | Grazing management areas                                              |                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|
|                                                                                                                                                | No-take                                                                                          | Partially no-take                                                                                | Open                                                                                             | Riparian protection areas                                             | Open areas                                                    |
| Knowingly transporting and/or introducing individuals of Nile tilapia, Kariba weed, redclaw crayfish, giant sensitive plant and water hyacinth | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                            | Prohibited                                                    |
| Collecting macroinvertebrates                                                                                                                  | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                            | Prohibited                                                    |
| Fish farming                                                                                                                                   | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                            | To assess                                                     |
| Non-traditional systems of pastoralism (i.e., other than low-density transhumance)                                                             | n.a.                                                                                             | n.a.                                                                                             | n.a.                                                                                             | Prohibited                                                            | Allowed in agreement with local regulations (section 7.4.4.3) |
| Igniting fires for hunting purposes                                                                                                            | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                                                       | Prohibited                                                            | Prohibited                                                    |
| Harvesting reeds and <i>Papyrus</i> spp.                                                                                                       | Allowed in agreement with local regulations (for the maintenance of channels and ponds for fish) | Allowed in agreement with local regulations (for the maintenance of channels and ponds for fish) | Allowed in agreement with local regulations (for the maintenance of channels and ponds for fish) | Prohibited during the summer (growing season; from November to April) | n.a.                                                          |



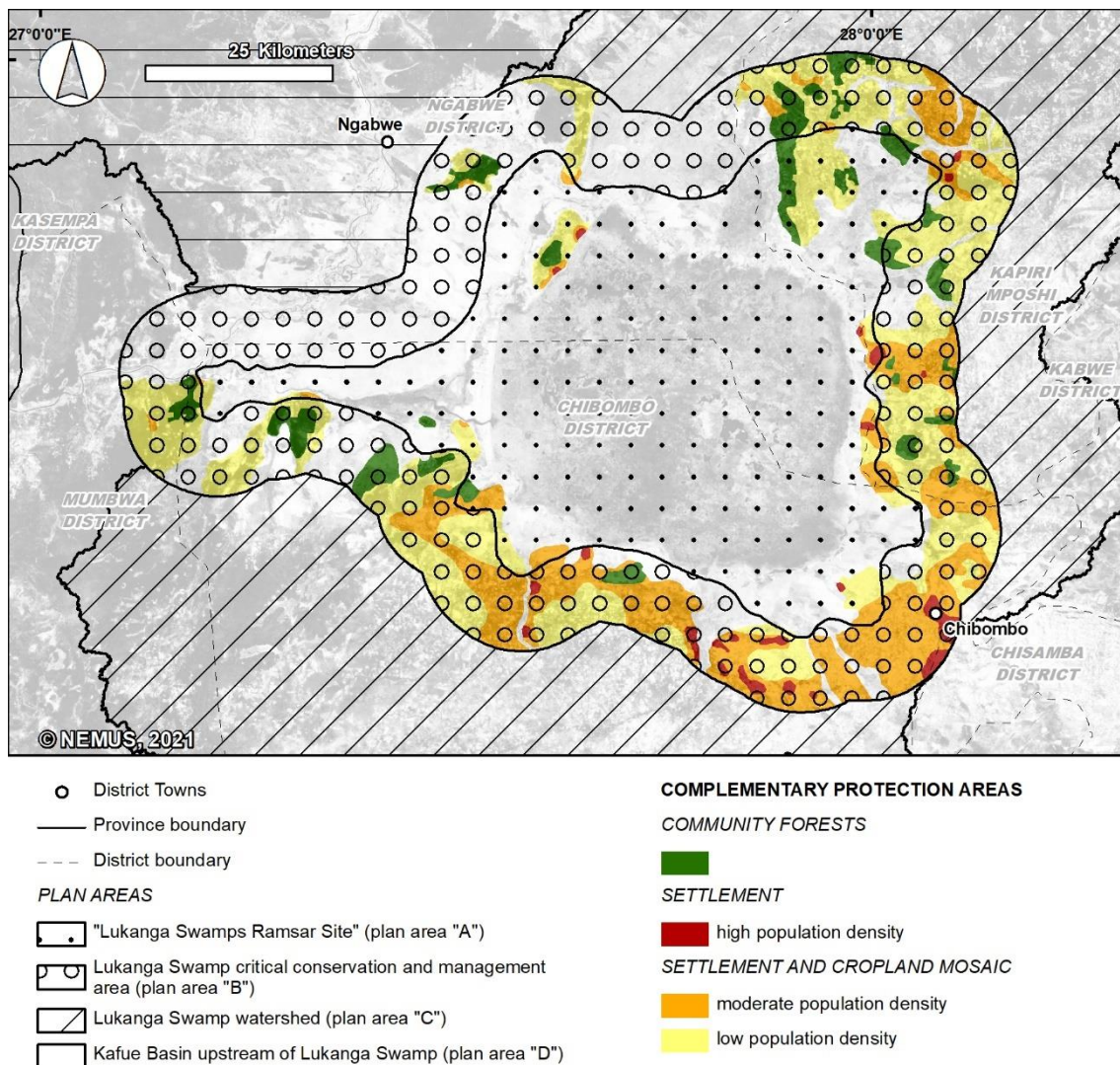


| Uses/ activities                             | Fishing management areas                                                     |                                                                       |                                                                       | Grazing management areas  |                                                               |
|----------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------|---------------------------------------------------------------|
|                                              | No-take                                                                      | Partially no-take                                                     | Open                                                                  | Riparian protection areas | Open areas                                                    |
| Burning/igniting fires within the reedbed is | <u>prohibited</u> during the summer (growing season; from November to April) | prohibited during the summer (growing season; from November to April) | prohibited during the summer (growing season; from November to April) | Prohibited                | Allowed in agreement with local regulations (section 7.4.4.4) |
| Reed, grass and sedge harvesting activities  | To assess                                                                    | To assess                                                             | To assess                                                             | Restricted                | n.a.                                                          |



### 7.3.3. Complementary protection areas

The complementary protection areas include the remainder of the area within the 10 km buffer around the Ramsar site, to the south and east of it, and also the islands of higher ground that are already settled in (Figure 4).



**Figure 4 – Complementary protection areas**

These are areas essentially covered by semi-natural and artificial land covers (settlements, cropland, etc.), and therefore lacking the original natural values warranting conservation. Some forested patches still occur, but mostly in an unfavourable conservation status due possibly to sustained harvesting, grazing, logging and burning. These are also significantly fragmented.



Based on the population densities and the land cover, the following sub-divisions were produced:

- Community forests (section 7.4.4.5);
- Mosaic of settlements and cropland with low human density;
- Mosaic of settlements and cropland with moderate human density;
- Mosaic of settlements and cropland with high human density (corresponding mostly to settlements).

In addition to the zonation, taking into account the conservation objectives, these zones have as their primary management objectives to **foster sustainable practices** and **implement restorative actions**. As such, most of the management measures concerning these areas are the regulatory mechanisms and restorative actions proposed in the subchapter that follows. Some uses are still restricted (Table 3).

**Table 3 – Use restrictions in the complementary protection areas**

| Uses/ activities                                                                                               | Community forests                                                                         | Low density                                                                               | Moderate density                                                                          | High density                                                                              |
|----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Constructing any structures that disrupt the hydrological regime (in order to maintain natural river dynamics) | Prohibited                                                                                | Prohibited                                                                                | Prohibited                                                                                | Prohibited                                                                                |
| Additional settlement/expansion of villages                                                                    | Prohibited                                                                                | Prohibited                                                                                | Restricted                                                                                | n.a.                                                                                      |
| Littering                                                                                                      | Prohibited                                                                                | Prohibited                                                                                | Prohibited                                                                                | Prohibited                                                                                |
| Using fertilisers                                                                                              | Prohibited                                                                                | Restricted                                                                                | Restricted                                                                                | Restricted                                                                                |
| Deforestation                                                                                                  | Prohibited                                                                                | Prohibited                                                                                | Restricted                                                                                | n.a.                                                                                      |
| Grazing                                                                                                        | Restricted according to the Grazing Management Plan to be developed under section 7.4.4.3 | Restricted according to the Grazing Management Plan to be developed under section 7.4.4.3 | Restricted according to the Grazing Management Plan to be developed under section 7.4.4.3 | Restricted according to the Grazing Management Plan to be developed under section 7.4.4.3 |



| Uses/ activities          | Community forests                                                     | Low density                                                                            | Moderate density                                                                       | High density                                                                           |
|---------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Harvesting reeds          | Prohibited during the summer (growing season; from November to April) | Prohibited during the summer (growing season; from November to April)                  | Prohibited during the summer (growing season; from November to April)                  | Prohibited during the summer (growing season; from November to April)                  |
| Burning                   | Prohibited                                                            | Restricted according to the Fire Management Plan to be developed under section 7.4.4.4 | Restricted according to the Fire Management Plan to be developed under section 7.4.4.4 | Restricted according to the Fire Management Plan to be developed under section 7.4.4.4 |
| Logging                   | Restricted as detailed in section 7.4.4.5                             | Restricted as detailed in section 7.4.4.5                                              | Restricted as detailed in section 7.4.4.5                                              | Restricted as detailed in section 7.4.4.5                                              |
| Chitemene/ slash-and-burn | Prohibited                                                            | Restricted                                                                             | Restricted                                                                             | Restricted                                                                             |



#### 7.4. Strategies for Lukanga Swamp watershed

Conservation and management of Lukanga watershed should aim at reducing and monitoring several factors that threaten the healthy functioning of the swamp ecosystems and their surroundings, endangering biodiversity and human populations alike.

In this context, activities such as the ones listed below should be restricted and regulated in the Lukanga swamp watershed:

- Interventions that alter water and flood levels;
- Degradation of forest and riparian habitats to ensure the maintenance of terrestrial habitats with protective functions in the catchment;
- Industrial and domestic waste discharges into the wetland and river system;
- Use of agrochemicals;
- Invasive weed introduction.

On the other hand, for the management of communal and traditionally-exploited resources (such as water, fisheries, forests and grazed grasslands) to be successful, it must be **data-driven**, **cooperative**, **adequately funded** and make use of the appropriate **incentives** to steer the behaviour of local actors, given local driving forces.

In particular, there is a need to improve the knowledge of the Lukanga system's functioning, to build capacity and raise awareness among those living in and/or managing the region, to maintain the livelihoods of the local communities through a more sustainable way, and to increase the region's climate change resilience.

Jones (2014) highlights five categories of incentives in his framework for assessing the governance of marine protected areas, which are useful in understanding the diversity of instruments available to manage ecosystems in general, namely:

- **Economic:** payments for ecosystem services (PESs); assignment of property rights; green marketing; promotion of alternative livelihoods; providing compensation for costs; reinvesting income in local infrastructure; ensuring sufficient state funding; provision of NGO and private sector funding;
- **Interpretative:** raising awareness; promoting the recognition of regulations and restrictions (i.e., ensure users know and understand these); promoting the recognition of benefits;



- **Knowledge:** promoting collective learning (integrating the traditional knowledge of local users with the scientific knowledge of experts); agreeing on approaches for addressing uncertainty (i.e., what to do in the absence of data/certainty); independent advice and arbitration;
- **Legal:** hierarchical legal obligations (international, regional, national); capacity for enforcement; penalties for deterrence; protection from incoming users; attaching conditions to property rights; cross-jurisdictional coordination; clear and consistent legal definitions; clarity concerning jurisdictional limitations; legal adjudication platforms; transparency, justice and fairness;
- **Participative:** rules for participation; establishing collaborative platforms; neutral facilitation; independent arbitration panels; decentralising responsibilities; peer enforcement; building social capital; bracing linkages; building on local customs; potential to influence higher institutional levels.

Ultimately, the set of incentives put in place for a given site must address the drivers that steer the site's condition away from strategic objectives and should be as diverse as possible. The **diversity of incentives** in the management of socio-ecological systems – in a way that mimics the functioning of natural ecosystems – provides the necessary redundancy and complementarity to ensure the system is resilient.

So, building on the Conservation Plan's zonation proposed above, the strategies for Lukanga Swamp watershed conservation, presented in the following sections, focus on providing such incentives through the following types of actions and recommendations:

- Conservation and management strategies (section 7.4.1) –
  - Water and soil management;
  - Habitat management;
  - Biodiversity/species management;
- Research and monitoring (7.4.2) –
  - Surface water and groundwater;
  - Soil;
  - Habitats;
  - Biodiversity/species;
  - Grazing;
  - Burning practices;



- Capacity building (7.4.3) –
  - Training – Fisheries management; Climate-smart agriculture; Fire management; Sustainable forest resource management;
  - Awareness-raising and education campaigns;
- Socioeconomic development (7.4.4) –
  - Agriculture;
  - Fisheries;
  - Grazing;
  - Use of fire;
  - Use of forest resources;
- Climate change resilience (7.4.5) –
  - Regional-scale;
  - Local-scale.

At the end of the Action Plan (section 7.7.3 – Follow up), the management strategies and actions proposed are summarized in Table 46 – Summary of the proposed management strategies; scales, time frames, responsibilities and follow up indicators.

#### 7.4.1. Conservation and management strategies

##### 7.4.1.1. Water and soil management

Several hydrological and biogeochemical values were identified in Part I of the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin (chapter 4 – Evaluation) and their ecological relevance and status evaluated. Table 4 identifies these values and their classification.

**Table 4 – Ecological relevance and state of hydrological and biogeochemical values**

| Natural Resource | Hydrological and biogeochemical values | Ecological Relevance | Ecological State |
|------------------|----------------------------------------|----------------------|------------------|
| Water            | Surface water quantity                 | Very High            | Medium           |
|                  | Groundwater quantity                   | High                 | Medium           |
|                  | Surface water quality                  | Very High            | Medium           |
|                  | Groundwater quality                    | High                 | Unfavourable     |
| Soil             | Soil quality                           | Very High            | Unfavourable     |





Given their ecological relevance (high or very high) and particularly their general inauspicious ecological state, a group of measures and recommendations are indicated below. Their goal is to increase the ecological state of the different values in a sustainable manner, considering:

- The Lukanga Swamp is a natural and sensitive area dependent on its catchment;
- The population living in the area will probably continue to increase (and with it the increase of the area used for the production of agricultural crops and the total number of cattle);
- The increasing effects of climate change (cf. section 7.4.5).

#### **A) Water**

Water from streams is mainly enriched in metals and in some cases in nitrates. Groundwater from analysed wells failed one or more parameters for guideline values defined by the WHO or ZS for drinking purposes. This was because of metal concentrations in all cases, because of pH values (6 out of 14 wells) and concentrations of nitrates (3 out of 14 wells). While high concentrations of nitrates are clearly explained by human activities, pH and metal concentrations may or may not be partially explained by them. The fact that most (if not all) of the wells are affected by high concentrations of metals, even in remote areas, indicates that probably there is a natural component to these concentrations. In addition, some metals may be coming from the fertilizers used.

Regarding nitrates, the three wells are in different areas of the Lukanga catchment: one southwest, one southeast and the other east from the swamp. The streams with higher contents are those from southwest. This probably means that the contamination of nitrates is related to local agriculture practices, although the inputs from farms located in the upstream areas of the small catchment is not out of the equation. For this environmental problem it is important that people living around the swamp and farms – for example those located in the East part of the catchment – change their agriculture practices, and that integrated soil fertility management becomes mainstream in the area. Measures associated with these practices are developed in section 7.4.4.1.



## **B) Soil**

Unfortunately, soil degradation is a process very common in the world. This is because soil and land in general has been managed unsustainably in many places, disregarding for example the balance between different cycles, such as the carbon cycle and the water cycle. For a long time, soils were simply taken for granted.

Unsustainable management practices lead to soil degradation that can be manifested in different multiple ways: reduction of organic matter, contamination, compaction, salinization and alkalinization, nutrient imbalance, erosion, acidification, waterlogging and/or loss of soil biodiversity.

According to the available information, there is no study focusing on the quality of soils throughout the Lukanga Swamp area. Considering the lack of knowledge about the quality of soils in the Lukanga Swamp catchment, it is advised to assess the status of soil and land resources (cf. section 7.4.2.2).

Notwithstanding, local people report a lack of fertility of the soil and its degradation. Given the soil management practices used in the area and witnessed in the field visits, soil degradation should come from a loss of soil biodiversity, reduction of organic matter, contamination of soil, nutrient imbalance and soil erosion.

This is because vulnerable land like semi-arid grassland or rangelands in general is increasingly being converted for agricultural unsustainable uses in Sub-Saharan Africa (Liniger & Mekdaschi, 2019) and the Lukanga Swamp area is no exception as demonstrated previously.

These areas are characterised by a series of features and having less resistant soil organic carbon stocks is one of them, which makes them very sensitive areas to unsustainable management practices. For this reason, the following actions are advised:

- Policies and incentives to reduce land conversion; and
- Adoption of sustainable practices to prevent and mitigate general land degradation (cf. sections 7.4.4.1, 7.4.4.3 and 7.4.4.4).



#### 7.4.1.2. Habitat management

In Part I's chapter 4 (Evaluation), the site's habitats were qualified according to relevance and state scales, as follows (Table 5).

**Table 5 – Priority habitats**

| Habitat             | Relevance* | State**              | Value     |
|---------------------|------------|----------------------|-----------|
| Permanent swamp     | Very high  | Medium               | Very high |
| Edaphic grassland   | Very high  | Medium to favourable | Very high |
| Forested land       | High       | Unfavourable         | High      |
| Riparian vegetation | High       | Unfavourable         | High      |
| Open lakes          | High       | Unknown              | High      |

Sources: IUCN, 2020; Beilfuss *et al.*, 2001

\*On a 5-class scale: null; low; moderate; high; very high;

\*\*On a 3+1-class scale: unfavourable; medium; favourable; and unknown/ insufficient data.

Wetland habitats are particularly relevant given their primary productivity, biodiversity, the performance of essential ecological functions (biodiversity refuge; nursery; feeding; breeding/nidification; protection/buffering of other habitats), and their economic value due to the species it supports and functions it performs.

Accordingly, the habitats of highest value were found to be the permanent swamp and the edaphic grassland, particularly towards the west, followed by forested land (where it is less degraded), riparian vegetation and lakes. Overall, the current state of natural habitats decreases in quality eastward and southward, which is in accordance with the encroachment by human settlements and associated intensification of human activities in that zone.

Natural habitats are threatened by a range of factors from distinct origins and with distinct effects, that act synergistically or cumulatively and can jeopardize the conservation of their functions and biodiversity, which in turn translates into impacts on human well-being.

In the Lukanga and its catchment, natural habitats are pressured by: changes in land use and cover (deforestation, fire, grazing, unsustainable harvesting, etc.); species removal and/or introduction (invasion by alien species; overfishing; poaching; etc.); pollution and eutrophication (from agricultural runoff and poor sanitation); and changes of the hydrological regime (from hydraulic projects, water abstraction and climate change).



Given their ecological relevance (**high** or **very high**), and particularly their **medium** to **unfavourable** conservation state, measures are recommended below for these values, taking into account the objectives also defined earlier (Part I, chapter 5 – Objectives).

To deal with the pressures listed above, wetland *habitat management* typically includes active measures such as the control of water levels, the physical control of vegetation, management for maintaining particular species' habitats, and managing anthropic uses (Chatterjee, Philips and Stroud, 2008).

The majority of these approaches is covered in other sections of the action plan (c.f., sections 7.3, 7.4.1.3 and 7.4.2.3). As such, the recommendations in this section refer to regulatory measures for the sub-catchment level and restorative direct action.

#### **A) Restriction or regulation of sub-catchment activities**

Given past trends of lake encroachment by emergent vegetation, the characteristics of the common reed (*Phragmites australis*), and the climatic incertitude of the future, it is safe to assume that shallower lakes, pools and channels can eventually be lost to emergent vegetation entirely, within the permanent swamp. If this were to happen, valuable waterbird and fish habitat would be lost.

Edaphic grassland habitats, in turn, are constituted of dynamic and predominantly herbaceous vegetation determined by the flooding regime – their existence and condition are contingent on the timing and duration of flooding. The floodplain's (and probably river and swamp's) fisheries are also dependent on these alternating phases of flooding and drawdown (Howard-Williams and Thompson, 1985).

Changes in the hydrological regime can be caused by climate change and/or water development projects.

Taking this into account, and in keeping with the precautionary principle, the following measures are recommended:



- Submit to **Environmental and Social Impact Assessment** all development projects (such as levees, embankments, dykes, road ways, weirs, and small dams) suspected to impact the hydrology of the sub-catchment and swamp;
- Monitor the impacts of **major infrastructure developments** within the sub-catchment with potential impacts on the swamp's seasonal hydrological regime.

Within the catchment, land cover changes act as precursors/intensifiers of pollution and nutrient input into the system. The degradation and elimination of terrestrial habitats with protective functions in the catchment, i.e., forests and riparian vegetation, leads to increased run off and siltation, accelerating the deterioration of aquatic systems' ecological conditions. The following measures are recommended:

- halt deforestation completely in the Ramsar site and the 10 km buffer;
- reduce deforestation by 2/3 in the subcatchment (10% deforestation – reduction from the expected scenario of 15% deforestation).

## **B) Habitat restoration**

In addition to the regulation of deforestation, corrective action must also be employed. The following measures are recommended:

- Development of a **reforestation programme** within the catchment, constituted of the following phases: A) site selection; B) planning; C) implementation; and D) follow-up (monitoring and protection);
  - a collaborative and village-driven mechanism for the implementation and follow-up of the reforestation should be established, under the system recommended for forest management (section 7.4.4.5); upon the preliminary definition of regions for restoration (ideally to the west and south quadrants of the swamp's surroundings, together with other sites deemed appropriate in the catchment), village groups can express their interest to take up the role;
  - site selection must take into consideration the following elements: proximity to water bodies and potential of the site in watershed protection; maintenance or promotion of the ecological continuum; soil characteristics;



- within the reforestation programme, tree nurseries should be established, also community-led;
- training of responsible villages and entities, and awareness raising of local users are mandatory actions to ensure the success of reforestation efforts;
- reforested sites must be unequivocally marked on site;
- efforts should be directed towards protecting reforested sites from fire;
- some degree of grazing may be beneficial, as it eliminates shade caused by grass growth;
- Development of a **river restoration programme** within the Critical Conservation and Management Area, to increase the cover of riparian vegetation – particularly in the Lukanga and Mushingashi rivers upstream of the swamp.

Target values for reforesting the Lukanga region will be given in a later stage of the project, based on public consultations, assessment of future scenarios and cost-benefit-analyses.

#### 7.4.1.3. Biodiversity/species management

In Part I's chapter 4 (Evaluation), the site's biological values – here, flora and fauna – were also identified and qualified according to relevance and state scales (Table 6).

**Table 6 – Priority communities and species**

| Species/community              | Relevance | State*                 | Value**    |
|--------------------------------|-----------|------------------------|------------|
| FLORA                          |           |                        |            |
| Phytoplankton and phytobenthos | Very high | Insufficient data      | Very high* |
| Aquatic macrophytes            | Very high | Insufficient data      | Very high  |
| FAUNA                          |           |                        |            |
| Zooplankton                    | Very high | Insufficient data      | Very high  |
| Swamp macroinvertebrates       | Very high | Insufficient data      | Very high  |
| Fish assemblages               | Very high | Suspected unfavourable | Very high  |
| Wild ungulates                 | Very high | Suspected unfavourable | Very high  |
| Waterbirds                     | Very high | Insufficient data      | Very high  |



| Species/community                                  | Relevance | State*            | Value** |
|----------------------------------------------------|-----------|-------------------|---------|
| Yellow-belly bream                                 | High      | Insufficient data | High*   |
| White-backed vulture                               | High      | Insufficient data | High    |
| White-headed vulture                               | High      | Insufficient data | High    |
| <i>Lobogenes michaelis</i> Pilsbry & Bequart, 1927 | High      | Insufficient data | High    |
| Steppe eagle                                       | High      | Insufficient data | High    |

Sources: IUCN, 2020; Beilfuss *et al.*, 2001

\*On a 5-class scale: null; low; moderate; high; very High;

\*\*On a 3+1-class scale: unfavourable; medium; favourable; and unknown/ insufficient data.

Similarly to what was presented for habitats, the site's flora and fauna species and communities are threatened by direct and indirect pressures. Direct threats include: habitat degradation (pollution, eutrophication) or loss (land cover change); alien species introduction and propagation (leading to competition and possibly displacement); overfishing, overharvesting, poaching and illegal wildlife trade; increased mortality from human-wildlife conflict; and depletion of food resources.

Again, the lack of representative and consistent monitoring means there's an absence of solid baseline data on the site's biodiversity, which will undermine any conservation effort. At the basis of these shortcomings, and fuelling an uncontrolled exploitation of flora and fauna, is the ineffective or non-existent management, enforcement and environmental education, result of a lack of financial and human resources in most of the responsible entities.

Given their ecological relevance (**high** or very **high**), and particularly their **unfavourable** or **unknown** state, measures are recommended below for these values, with two primary management objectives: to maintain or achieve a favourable conservation status; and to establish, through surveying, the current state of priority values for which information is lacking.

Species management typically relies on habitat conservation, a more cost-effective and holistic approach (Chatterjee, Philips and Stroud, 2008). Single species management is preferred when specific food-web levels – such as top predators – need to be maintained, when endangered species need to be protected, or when invasive species need to be controlled (Chatterjee, Philips and Stroud, 2008).

The majority of approaches dealing with single-species management or habitat conservation is covered in other sections of the action plan (c.f., sections 7.3, 7.4.1.3 and 7.4.2.4). As such, the recommendations in this context are predominantly related to





the establishment of prohibited actions and best practices for preventing further alien introductions.

## A) Invasive alien species

The introduction of a species or groups of species to a system can disrupt food-webs and reduce the system's capacity to assimilate external pressures, while possibly amplifying other negative impacts.

In wetlands, potential negative effects include: the degradation of water quality (through increased shadow, reduced water flow and decreased oxygen content), and consequent reduction of the system's potential as fish, invertebrate and macrophyte habitat; clogging of water channels and pools, disrupting movement; increased water loss through evapotranspiration; reduced or altered biodiversity; and reduced aesthetic value.

In invasive species management, prevention is the most important phase, since the cost of controlling an established invasion is much higher. Coupled with prevention, early detection and action – before the invasion is established – are key. For this, the site's vulnerability to different species should be assessed, and measures must be developed that are **cost-effective**, to **prevent the introduction**, **allow early detection**, and **effectively eradicate and manage the invasion**.

Overarching action can also be taken to increase the resilience of the system to fight invasions, and to reduce the risk of introduced species achieving their invasive potential. Here, the control of pollution and eutrophication in the catchment (erosion of agricultural land, sewerage and industrial wastewater discharges) – minimizing nutrient run-off into infestations – is key, and is covered in other sections of the Action Plan (e.g., sections 7.4.1.1 and 7.5) (Global Invasive Species Database, 2021).

The following species have been detected in the swamp or are in higher risk of introduction, and thus warrant the development of preventive and/or management measures: *Salvinia molesta* D. Mitch (Kariba weed); *Eichhornia crassipes* (Mart.) Solms (water hyacinth); *Mimosa pigra* L. (giant sensitive plant); *Oreochromis niloticus* (Linnaeus, 1758) (Nile tilapia); *Cherax quadricarinatus* (von Martens, 1868) (redclaw crayfish). Species-specific management recommendations are given in the tables that follow.



Table 7 – Kariba weed

| Taxon                   | <i>Salvinia molesta</i> D. Mitch                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Common names | Kariba weed; water fern; salvinia; giant salvinia; giant water fern |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------|
| Description             | <ul style="list-style-type: none"> <li>• native to South America;</li> <li>• freshwater free-floating fern from the family <i>Salviniaceae</i>;</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |              |                                                                     |
| History of the invasion | <ul style="list-style-type: none"> <li>• first record dates to 2009; inadvertently introduced into the Lukanga wetland on the nets of fishermen from the Kafue River;</li> <li>• manual removal of the weed was tried in 2013 using rakes, pitchforks and sickles, with limited success;</li> <li>• a biocontrol-based project is currently underway by Birdwatch Zambia, in partnership with the Ministry of Livestock and Fisheries, Zambia Agriculture Research Institute (ZARI), Zambia Environmental Management Agency (ZEMA) and the Centre for Agriculture and Bioscience International (CABI).</li> </ul>                                                                                                                                                                                                                                                  |              |                                                                     |
| Ecology                 | <ul style="list-style-type: none"> <li>• optimal temperature ranges between 15°C and 30°C, pH is optimal between 6 and 7.5, and nutrient-rich environments are preferred;</li> <li>• its growth is mainly hindered by plant density, having an estimated maximum biomass of 500 g dry weight/ m<sup>2</sup>;</li> <li>• reproduces asexually through fragmentation of the rhizome;</li> <li>• invades water bodies, preferring slow flowing or standing waters;</li> <li>• natural dispersal occurs through water flow, wind and animals; flooding allows it to spread between wetlands and water bodies;</li> <li>• the invasion is facilitated in sheltered areas, with continued nutrient input (e.g., from cultivation and livestock herding), and in the absence of competitors (e.g., established and diverse macrophyte communities) or grazers.</li> </ul> |              |                                                                     |
| Impacts                 | <ul style="list-style-type: none"> <li>• may significantly alter the swamp's conditions (through increased shade, reduced flow, decreased dissolved oxygen content, etc.) leading to biodiversity loss and potentially affecting commercially important fish species;</li> <li>• forms thick mats that clog water channels, preventing the movement of canoes; it is also a breeding habitat for vectors of malaria and bilharzia;</li> <li>• reduced aesthetic value.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                  |              |                                                                     |
| Vectors of introduction | <ul style="list-style-type: none"> <li>• introduced in equipment transported from infested water bodies (e.g., fishing gear, vehicles and boats).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |                                                                     |
| Zones at risk           | <ul style="list-style-type: none"> <li>• Swamp – PPA</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |                                                                     |



| Taxon               | <i>Salvinia molesta</i> D. Mitch                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Common names | Kariba weed; water fern; salvinia; giant salvinia; giant water fern |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------|
| Management measures | <b>(i) Best-practices for preventing new introductions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |                                                                     |
|                     | <ul style="list-style-type: none"> <li>• awareness raising and campaigning on its impacts and best-practices, to reduce unintentional introduction and spread;</li> <li>• establishment of a “check, clean and dry” protocol; boats, fishing gear and other materials moved from an infested water body/region of the swamp must be inspected, cleaned and dried before moving;</li> <li>• if the utilisation of the weed by local populations is promoted as a supplemental control method, provisions must be made to prevent commercialization and further spreading – such as inspection and fines.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |              |                                                                     |
|                     | <b>(ii) Control of active invasions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |                                                                     |
|                     | <p>Control should be initiated <u>as soon as possible</u> following the detection of an introduction, to prevent establishment of the invasion, reduce costs and increase the eradication success. The following methods are commonly used:</p> <ul style="list-style-type: none"> <li>• <u>Manual and mechanical removal</u>: small infestations can be controlled manually; mechanical removal requires added machinery and costs, and seems impractical in the Lukanga; <i>to promote the systematic manual removal of Kariba weed from the swamp by local users, it can be promoted as a medium for growing mushrooms, or as natural manure</i>;</li> <li>• <u>Biocontrol</u>: the host-specific weevil (<i>Cyrtobagus salviniae</i>) can be introduced as an effective bio-control agent in established invasions; <i>this method is currently implemented, with apparently successful results, and should be promoted</i>;</li> <li>• <u>Chemical control</u>: herbicide application; chemical control should be used only as a last resource; this method also requires added equipment and costs; when used, it must be applied progressively and in smaller infestations at a time, not into the whole wetland at once.</li> </ul> <p>Ideally a combination of different methods (<i>integrated control</i>), depending on the status of the invasion and the nature of the invaded site, should be employed.</p> |              |                                                                     |
|                     | <b>(iii) Research and Monitoring</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |                                                                     |
|                     | <p><i>Covered by the macrophyte monitoring programme</i> (section 7.4.2.4 and subchapter 7.6).</p> <p>Monitoring activities are also being undertaken by BirdWatch Zambia to assess the success of the biocontrol.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |              |                                                                     |

Sources: Kafue River Trust, 2020; CAB International, 2020; Phiri, Nanja and Kihumba, 2020; Hill and Coetzee 2017; Henry-Silva *et al.*, 2008 Mitchell, 1985



**Table 8 – Water hyacinth**

| <b>Taxon</b>                   | <i>Eichhornia crassipes</i> (Mart.)<br>Solms                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Common names</b> | Water hyacinth; Kafue weed; |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| <b>Description</b>             | <ul style="list-style-type: none"> <li>• native to tropical South America;</li> <li>• aquatic free-floating perennial Angiosperm from the family <i>Pontederiaceae</i>;</li> </ul>                                                                                                                                                                                                                                                                                    |                     |                             |
| <b>History of the invasion</b> | <ul style="list-style-type: none"> <li>• according to existing records and the field visits in 2019, it is not present;</li> </ul>                                                                                                                                                                                                                                                                                                                                    |                     |                             |
| <b>Ecology</b>                 | <ul style="list-style-type: none"> <li>• freshwater floating weed;</li> <li>• seed and vegetatively propagating;</li> <li>• the establishment of seedlings is facilitated by a fall in water levels, since these are initially rooted;</li> <li>• vegetative propagation occurs through the horizontal development of daughter plants;</li> <li>• dispersion is then facilitated by water and wind movements;</li> </ul>                                              |                     |                             |
| <b>Impacts</b>                 | <ul style="list-style-type: none"> <li>• may significantly alter the swamp's conditions (through increased shade, reduced flow, decreased dissolved oxygen content, etc.) leading to biodiversity loss and affecting commercially important fish species;</li> <li>• forms thick mats that clog water channels, preventing the movement of canoes; it is also a breeding habitat for vectors of malaria and bilharzia;</li> <li>• reduced aesthetic value.</li> </ul> |                     |                             |
| <b>Vectors of introduction</b> | <ul style="list-style-type: none"> <li>• introduced in equipment transported from infested water bodies (e.g., fishing gear, vehicles and boats).</li> </ul>                                                                                                                                                                                                                                                                                                          |                     |                             |
| <b>Zones at higher risk</b>    | <ul style="list-style-type: none"> <li>• Swamp – PPA</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                       |                     |                             |



| Taxon               | <i>Eichhornia crassipes</i> (Mart.) Solms                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Common names | Water hyacinth; Kafue weed; |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------------|
| Management measures | <b>(i) Best-practices for preventing new introductions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |                             |
|                     | <ul style="list-style-type: none"> <li>• awareness raising and campaigning on its impacts and best-practices, to reduce unintentional introduction and spread;</li> <li>• establishment of a “check, clean and dry” protocol; boats, fishing gear and other materials moved from an infested water body/region of the swamp must be inspected, cleaned and dried before moving;</li> <li>• the use as an ornamental flower is prohibited.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |                             |
|                     | <b>(ii) Control of active invasions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |                             |
|                     | <ul style="list-style-type: none"> <li>• Establishment of a <u>community-based system for early detection and alert of new introductions</u>. This should include the “hiring” of people from strategically located villages and training them in the identification of these species; a reporting and communication system between community agents and managing entities needs to be created for reporting occurrences; this is also an opportunity for income diversification.</li> <li>• Control should be initiated <u>as soon as possible</u> following the detection of an introduction, to prevent establishment of the invasion, reduce costs and increase the eradication success. The following methods are commonly used:               <ul style="list-style-type: none"> <li>○ <u>Manual and mechanical removal</u>: small (and early-caught) infestations can be controlled manually, by pulling; mechanical removal requires added machinery and costs, and seems impractical in the Lukanga;</li> <li>○ <u>Biocontrol</u>; the introduction of weevils is a common biocontrol method; <i>Neochetina</i> spp. are typically used, but other organisms are available;</li> <li>○ <u>Chemical control</u>: herbicide application; chemical control should be used only as a last resource; this method also requires added equipment and costs; when used, it must be applied progressively and in smaller infestations at a time, not into the whole wetland at once.</li> </ul> </li> </ul> <p>Ideally a combination of different methods (<i>integrated control</i>), depending on the status of the invasion and the nature of the invaded site, should be employed.</p> |              |                             |
|                     | <b>(iii) Research and Monitoring</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |                             |
|                     | Covered by the <i>macrophyte monitoring programme</i> (section 7.4.2.4 and subchapter 7.6).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                             |

Sources: Kafue River Trust (2020); CAB International (2020); Global Invasive Species Database (2021)



**Table 9 – Giant sensitive plant**

| Taxon                   | <i>Mimosa pigra</i> L.                                                                                                                                                                                                                                                                                                                                                                                               | Common names | Giant sensitive plant |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|
| Description             | <ul style="list-style-type: none"> <li>small perennial shrub from the family <i>Fabaceae</i>;</li> </ul>                                                                                                                                                                                                                                                                                                             |              |                       |
| History of the invasion | <ul style="list-style-type: none"> <li>referenced in Chabwela <i>et al.</i> 2010 as occurring in “riverine wetland/floodplain” and in “swamp and flood plain”;</li> <li>not detected inside the area during the field work conducted in 2019, and nor referenced either in Chabwela, Chomba and Thole (2017);</li> <li>the current status of the invasion in the Lukanga must be confirmed and monitored.</li> </ul> |              |                       |
| Ecology                 | <ul style="list-style-type: none"> <li>it invades floodplains and other open wet grasslands;</li> <li>seed propagating.</li> </ul>                                                                                                                                                                                                                                                                                   |              |                       |
| Impacts                 | <ul style="list-style-type: none"> <li>forms large monospecific stands, impeding movement of people and livestock, and obstructing access to water resources;</li> <li>alters local biodiversity;</li> <li>«<i>It is regarded as one of the worst alien invasive weeds of wetlands of tropical Africa, Asia and Australia, and the cost of control is often high</i>» (CABI, 2021)</li> </ul>                        |              |                       |
| Vectors of introduction | <ul style="list-style-type: none"> <li>spreads naturally by floating along river systems;</li> <li>can be introduced on cattle as it is transported, or in transport equipment;</li> <li>also commonly spread in land vehicles.</li> </ul>                                                                                                                                                                           |              |                       |
| Zones at higher risk    | <ul style="list-style-type: none"> <li>Grasslands – PPA</li> </ul>                                                                                                                                                                                                                                                                                                                                                   |              |                       |



| Taxon               | <i>Mimosa pigra</i> L.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Common names | Giant sensitive plant |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|
| Management measures | <b>(i) Best-practices for preventing new introductions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                       |
|                     | <ul style="list-style-type: none"> <li>• awareness raising and campaigning on its impacts and best-practices, to reduce unintentional introduction and spread;</li> <li>• establishment of a “check and clean” protocol; transport equipment and cattle must be inspected and cleaned before entering the area.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                       |
|                     | <b>(ii) Control of active invasions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |              |                       |
|                     | <ul style="list-style-type: none"> <li>• Establishment of a <u>community-based system for early detection and alert of new introductions</u>. This should include the “hiring” of people from strategically located villages and training them in the identification of these species; a reporting and communication system between community agents and managing entities needs to be created for reporting occurrences; this is also an opportunity for income diversification (economic incentive).</li> <li>• Control should be initiated <u>as soon as possible</u> following the detection of an introduction, to prevent establishment of the invasion, reduce costs and increase the eradication success. The following methods are commonly used:               <ul style="list-style-type: none"> <li>○ <u>Manual and mechanical removal</u>: control must include below ground plant parts, through digging and uprooting parts to remove them; blade ploughing is also effective; these should also include measures to reduce the seedbank, such as burning and seedling control;</li> <li>○ <u>Biocontrol</u>; the introduction of <i>Carmentia mimosa</i> moths is going to be employed in the Kafue Flats for the biological control of the site's infestation, by the <b>International Crane Foundation</b> (International Crane Foundation, 2021);</li> <li>○ <u>Chemical control</u>: through basal bark, soil application or stem injection of herbicides;</li> </ul> </li> </ul> <p>Ideally a combination of different methods (<i>integrated control</i>), depending on the status of the invasion and the nature of the invaded site, should be employed.</p> <p>Articulation and knowledge sharing between Lukanga's managing entities and the International Crane Foundation is <u>greatly advised</u>.</p> |              |                       |
|                     | <b>(iii) Research and Monitoring</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |                       |
|                     | <i>Covered by the grassland monitoring programme</i> (section 7.4.2.4 and subchapter 7.6).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                       |

Sources: CAB International (2020); Chabwela, Chomba and Thole (2017); Chabwela *et al.* (2010)





**Table 10 – Nile tilapia**

| <b>Taxon</b>                   | <i>Oreochromis niloticus</i><br>(Linnaeus, 1758)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Common names</b> | Nile tilapia |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------|
| <b>Description</b>             | <ul style="list-style-type: none"> <li>African freshwater fish from the family <i>Cichlidae</i>;</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |              |
| <b>History of the invasion</b> | <ul style="list-style-type: none"> <li>introduced in Zambian waters, with the capacity to become invasive;</li> <li>caught in the swamp in 2015 but not in 2019.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |              |
| <b>Ecology</b>                 | <ul style="list-style-type: none"> <li>feeds on phytoplankton and zooplankton;</li> <li>tolerates a wide range of environmental conditions;</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |              |
| <b>Impacts</b>                 | <ul style="list-style-type: none"> <li>as main impacts, can cause native biodiversity loss or degradation, trophic level changes and subsequently altered ecosystems;</li> <li>it is considered an opportunistic pioneer species, in that it is capable of migrating to, reproducing in, and colonizing a wide range of ecological conditions, including disturbed habitats;</li> <li>competes for resources with native fauna; the native greenhead tilapia (classified as VU) is appointed as one of the species more impacted by the Nile tilapia (CABI, 2020); these occupy the same niche: both are herbivores, feeding on phytoplankton and benthic algae, and juveniles of both species tend to be omnivorous, including insect larvae and detritus in their diet as well (Froese and Pauly, 2019);</li> <li>poses a threat to the conservation of native <i>Oreochromis</i> populations' genetic diversity by hybridizing with these (Deines <i>et al.</i>, 2014).</li> </ul> |                     |              |
| <b>Vectors of introduction</b> | <ul style="list-style-type: none"> <li>intentional introduction;</li> <li>inadvertent escape from aquaculture ponds;</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                     |              |
| <b>Zones at higher risk</b>    | <ul style="list-style-type: none"> <li>Swamp and rivers – PPA</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                     |              |



| Taxon               | <i>Oreochromis niloticus</i><br>(Linnaeus, 1758)                                                                                                                                                                                                                                                                                                                                                                                                                          | Common names | Nile tilapia |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
| Management measures | <b>(i) Best-practices for preventing new introductions</b>                                                                                                                                                                                                                                                                                                                                                                                                                |              |              |
|                     | <ul style="list-style-type: none"> <li>awareness raising and campaigning on its impacts and best-practices, to reduce unintentional introduction and spread;</li> <li>the current status of the invasion in the Lukanga sub-catchment must be assessed; <u>if it is absent</u>, then aquaculture of <i>O. niloticus</i> should be prohibited in the entire sub-catchment, and existing point-sources should be eliminated and substituted with native species;</li> </ul> |              |              |
|                     | <b>(ii) Control of active invasions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |
|                     | <p>There is currently not enough information for the recommendation of control measures.</p> <p>It is imperative that research is undertaken to understand the current status of a possible infestation in the wetland and sub-catchment, and to understand the effects on native fauna.</p> <p>When this information is available, management can be adequately designed.</p>                                                                                            |              |              |
|                     | <b>(iii) Research and Monitoring</b>                                                                                                                                                                                                                                                                                                                                                                                                                                      |              |              |
|                     | Covered by the ichthyofauna monitoring programme (section 7.4.2.4 and subchapter 7.6).                                                                                                                                                                                                                                                                                                                                                                                    |              |              |

Sources: Sources: Global Invasive Species Database, 2021; CABI, 2020

**Table 11 – Redclaw crayfish**

| Taxon                          | <i>Cherax quadricarinatus</i> (von Martens, 1868)                                                                                                                                                                                                                                                                                                                         | Common names | redclaw crayfish |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------------|
| <b>Description</b>             | <ul style="list-style-type: none"> <li>aquatic crayfish from the family <i>Parastacidae</i>;</li> </ul>                                                                                                                                                                                                                                                                   |              |                  |
| <b>History of the invasion</b> | <ul style="list-style-type: none"> <li>abundant in the Kafue river downstream of Itezhi-tezhi, and present in the Mushingashi Conservancy, which is just downstream of the swamp and upstream of the KNP;</li> <li>no records exist of its occurrence in the swamp – the current status of a possible invasion in the Lukanga must be confirmed and monitored.</li> </ul> |              |                  |
| <b>Ecology</b>                 | <ul style="list-style-type: none"> <li>native to Australia and Papua New Guinea;</li> <li>occurs in slow to fast flowing freshwater and brackish water;</li> <li>tolerates extreme environmental conditions;</li> </ul>                                                                                                                                                   |              |                  |
| <b>Impacts</b>                 | <ul style="list-style-type: none"> <li>its impacts are still not well known;</li> <li>can spread parasites to native crustaceans and affect artisanal fisheries;</li> <li>food source for species of conservation interest.</li> </ul>                                                                                                                                    |              |                  |
| <b>Vectors of introduction</b> | <ul style="list-style-type: none"> <li>deliberate introduction;</li> <li>inadvertent escape from aquaculture cages.</li> </ul>                                                                                                                                                                                                                                            |              |                  |
| <b>Zones at higher risk</b>    | <ul style="list-style-type: none"> <li>Swamp and rivers – PPA</li> </ul>                                                                                                                                                                                                                                                                                                  |              |                  |



| Taxon                      | <i>Cherax quadricarinatus</i> (von Martens, 1868)                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Common names | redclaw crayfish |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------------|
| <b>Management measures</b> | <b>(i) Best-practices for preventing new introductions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                  |
|                            | <ul style="list-style-type: none"> <li>• awareness raising and campaigning on its impacts and best-practices, to reduce unintentional introduction and spread;</li> <li>• the current status of the invasion in the Lukanga sub-catchment must be assessed.</li> </ul>                                                                                                                                                                                                                                               |              |                  |
|                            | <b>(ii) Control of active invasions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |              |                  |
|                            | <p>There is currently not enough information for the recommendation of control measures.</p> <p>It is imperative that research is undertaken to understand the current status of a possible infestation in the wetland and sub-catchment, and to understand the effects on native fauna.</p> <p>When this information is available, management can be adequately designed.</p> <p>Still, the establishment of a community-based system for early detection and alert of new introductions should be established.</p> |              |                  |
|                            | <b>(iii) Research and Monitoring</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |                  |
|                            | <p>As a first stage, fishermen must be trained in the identification of the red claw crayfish, in order to detect its presence while fishing.</p> <p>If the species' presence is confirmed, a monitoring programme needs to be implemented as well.</p>                                                                                                                                                                                                                                                              |              |                  |

Sources: Global Invasive Species Database, 2021; CABI, 2020

These measures must be implemented across the whole sub-catchment.



#### **7.4.2. Research and monitoring**

One of the biggest limitations in conservation and natural resources management is the unavailability of informative, spatially and seasonally representative, and consistently collected data (Brooks *et al.*, 2006).

In the Lukanga, this is no different – there is still a lack of quantitative baseline data on the physical and ecological processes of the site. More so, the flawed and insufficient dissemination of the little data that is available among institutions and stakeholders further limits the capacity for accurate and sustained management decisions to be made.

A sound monitoring programme must allow the collection of relevant baseline data. That is, useful for not only characterizing current conditions, but also to integrate the follow-up phase – i.e., the evaluation of (i) the conservation plan's implementation, and (ii) the evolution of, in this case, the biophysical character of the wetland and surrounding areas. The latter is also a measure of the plan's success, and provides a basis for future decision-making cycles and to adapt management.

It is important to include multiple measures of success, across the different dimensions of the system in analysis (water quality, habitats, species, socio-economic activities, etc.) (Brooks *et al.*, 2006). However, not all the components of the socio-ecological wetland system can be monitored. To increase its cost-effectiveness and boost the programme's probability of successful implementation, a smaller set of elements to be followed must be established.

Once the most important elements are chosen, specific indicators need to be selected. These are «[measures], generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time» (EEA, 2005).

Monitoring indicators must be suited to the specific objectives of different biological, physical or social values (e.g., fauna, water quality, employment, etc.) and their measurement must be easily replicable (so these can be measured on a consistent basis, facilitating comparative analysis in the future).

Different indicators will be recommended along the following sections, and will be integrated in subchapter 7.6. For the purpose of safeguarding the implementation of the monitoring programme, an effort will be made to select common indicators across



different elements, integrating into the same methodologies, different programmes (e.g., habitat, vegetation and flora monitoring).

Finally, the articulation with established programmes, and capacity building of these same programmes and responsible institutions, will be given priority over the creation of new programmes/arrangements.

#### 7.4.2.1. Surface water and groundwater

Local people refer that water levels of the swamp and wells have been decreasing throughout the past years.

Considering field observations on water resources, the increasing effects of climate change (an increase of average temperatures and changes in rain patterns) and the lack of information on water quantity evolution in Lukanga Swamp watershed (cf. ecological status of the hydrological values), it is particularly important to **monitor levels of surface water and groundwater in the area**.

On the other hand, water quality problems, such as enrichment in metals and some cases nitrates, are probably related to local agriculture practices, as mentioned above. So, measures associated with these practices, namely integrated soil fertility management, are recommended in section 7.4.4.1.

To assess the effectiveness of these measures and the need for new ones, it is also particularly important to **monitor surface and groundwater quality in the catchment**.

In both cases, monitoring data should be the basis for the management of the area, not only to complete information gaps but also to support the verification of the implementation and effectiveness of the conservation and management strategies recommended in the plan.

Recommended surface and groundwater quantity and quality monitoring activities are detailed in the Environmental Monitoring Plan (subchapter 7.6).



#### 7.4.2.2. Soil

As mentioned before, an assessment of the status of soil and land resources is advised. This assessment would allow decision-makers understand:

- The extent and effectiveness of existing or potential sustainable land management measures on soil conservation and land recovery;
- Trends in land conservation and alternatives for optimal land use;
- The type, extent, and severity of various land degradation processes.

A soil quality monitoring in the catchment should include:

- On-site visual assessments: these should be participatory (involving land users) and be supported by technical experts to assess the soil's physical properties (e.g., texture, structure, water holding, capacity and dispersion), and chemical properties (e.g., pH, nutrients and salinity);
- Soil surveys; and
- laboratory testing for specific properties.

Recommended soil quality monitoring activities are detailed in the Environmental Monitoring Plan (subchapter 7.6).



#### 7.4.2.3. Habitats

Given one of the primary conservation objectives for the site is to «establish, through surveying, the current state of those values deemed of priority and for which information is lacking», a standardized and integrated monitoring programme must be developed and implemented.

Taking into account the information presented in Table 5, and the objectives established in Part I (chapter 5), priority monitoring for **habitat management** in the context of the Conservation Plan should target the **swamp** and the **edaphic grassland** habitats. For both of these programmes, monitoring of the following indicators is recommended:

- *ecological continuum* – degree of continuity and connectivity of and between natural habitats, assessed qualitatively;
- *risk of fragmentation* – risk of further deterioration of the ecological continuum based on the observed pressures (advancing anthropic land uses, etc.), assessed qualitatively;
- *conservation status* – distance to original/pristine conditions, based on field observations/measurements of the following parameters: species list, presence/absence and relative dominance of native, ruderal and exotic species (determined through transect surveys as in BirdWatch Zambia, 2020, which is to be considered the reference); presence/absence of degradation indicators; water quality (to articulate with responsible entities, avoiding redundant efforts);
- *extent* of the habitat.





#### 7.4.2.4. Biodiversity/species

##### A) Swamp and edaphic grassland flora

Regarding the site's flora, two main communities should be focused on: aquatic macrophytes and phytoplankton.

Given the importance of both of these groups to the **maintenance of fish populations**, as well as their value as **bioindicators of environmental change**, a clearer understanding of their current condition is needed, so that their evolution can be followed and inform management decisions. In addition, the monitoring of aquatic macrophytes will also cover the monitoring of the Kariba weed invasion, and of a potential introduction of the water hyacinth (section 7.4.1.3).

Building onto what was recommended for habitat monitoring, the following programmes are included in the Environmental Monitoring Plan (subchapter 7.6) for **flora species management**:

- **Aquatic macrophyte monitoring**; to characterize this community in a meaningful way, the following parameters can be obtained through field surveying:
  - number of taxa, or diversity;
  - macrophyte cover; and
  - macrophyte biomass;
- **Phytoplankton monitoring**; to characterize this community in a meaningful way, the following parameters can be obtained through field surveying:
  - community structure (relative abundances);
  - biomass.



## B) Swamp and edaphic grassland fauna

Regarding the swamp's fauna, two main communities should be targeted for monitoring: ichthyofauna and zooplankton.

Similarly, to what was said for microalgae, zooplankton community composition is commonly monitored as a bioindicator for water quality assessments. Fish community structure can also inform on the ecological status of a waterbody or wetland. Given the benefit derived from this particular group by local people, a major goal of management must be to follow community dynamics consistently through time and space.

The Department of Fisheries conducts routine catch assessment, gill net and frame surveys in the swamp (MFL, 2020). The fishery is suspected to be in unfavourable condition (cf. Part I, chapter 4), however, monitoring data is not consistently obtained, so that meaningful evaluations and management adaptations cannot be made. The collection of reliable data is hindered by the low staffing and the dimension and complexity of the wetland, so that a key component of management must be to build the capacity of local DoF offices (section 7.4.3.1).

Establishing a standardized and consistently implemented monitoring programme – or consolidating the monitoring of the fishery conducted by the Department of Fisheries (MFL, 2020) – should further allow to confirm the role of the swamp as breeding habitat for fish, identify the areas that are more important nurseries, confirm the presence and status of the yellow-bellied bream (critically endangered) and of the Nile tilapia (exotic and potentially invasive).

Building onto what was recommended for habitat monitoring, the following programmes are included in the Environmental Monitoring Plan (subchapter 7.6) for **fauna species management**:

- **Ichthyofauna**; to characterize this community in a meaningful way, the following parameters can be obtained through field surveying:
  - species composition;
  - abundance;
  - population structure (based on age or length classes);
  - evolution of capture fisheries production.



- **Zooplankton**; to characterize this community in a meaningful way, the following parameters can be obtained through field surveying:
  - community structure (relative abundances);
  - biomass.

According to Musumali *et al.* (2009), complete frame surveys should be conducted every three (3) to five (5) years.

### C) Waterbirds

Provided resources are available, given the site's Ramsar and IBA designations, research and monitoring of the avifauna community under the Conservation Plan should also be established. To characterize this community in a meaningful way, the following parameters should be monitored:

- number of taxa, or diversity;
- relative abundances.

BirdWatch Zambia already conducts yearly bird counts inside the swamp, so these datasets should be used.

Surveys in other habitats such as grassland, termitaria and Miombo could also be introduced, to confirm the presence/absence and state of critically endangered and endangered species such as the white-backed vulture, the white-headed vulture and the steppe eagle.

The consistent collection of data on this group will allow the assessment of the site's conditions for the establishment of birdwatching-based tourism.



## D) Wild ungulates

Provided resources are available, research and monitoring of the wild ungulate community under the Conservation Plan should also be established. This is particularly important given (i) the importance of this group to the regulation of grassland habitats, (ii) the maintenance of carrion-dependent bird species, and (iii) the number of potentially occurring species that are near threatened (see Part I's Appendix 3 – Ecological assessment), and may have been eliminated due to human-wildlife conflicts.

To characterize the current status of populations, and monitor their evolution, the following parameters should be measured:

- number of taxa, or diversity;
- population estimates.

The implementation of this programme will also allow to properly assess the option to reintroduce large herbivores into the system. Once the current state of wild ungulate populations is known, and social and ecological impacts of a repopulation effort are assessed (management costs; revenue opportunities; worsening of human-wildlife conflicts; destabilisation or maintenance of grassland ecosystems), an informed decision can be taken regarding this option.

### 7.4.2.5. Grazing

The collection of updated information regarding local pastoralists and their practices is recommended, including the creation of a registry system for the following data:

- Household name, location and number of animals;
- Total number of grazers by type (bulk, like cattle, or selective, like goats) and district;
- Periodicity of grazing;
- Length of grazing period;
- Typical routes used.

The implementation of this system should be community-led, through the CRBs, and appropriate links should be created between local users and managers (section 7.2).



In addition, a regular monitoring of the grassland's health under different grazing conditions for the adaptation of management should be undertaken. This is to be articulated with other monitoring efforts, namely, those for habitat management (section 7.4.1.2).

#### **7.4.2.6. Burning practices**

Even though there is already a good understanding of why and how fire is used for landscape management locally, traditional fire management remains a point of contention between rural populations, researchers, policy makers and managers (Eriksen, 2007).

The Lukanga provides an opportunity to promote research into local practices and assess (and possibly legitimize) the potential of traditional ecological knowledge related to fire management in the conservation of Zambezian ecosystems, in comparison to suppression policies typically defended by western ecologists (Eriksen, 2007).

For this, a system for the collection of updated information regarding traditional and current burning practices – to be shared with fire managers and researchers – should be established, including the inventory of:

- Burning purposes;
- Traditional burning practices and regimes according to vegetation type and purpose.



### **7.4.3. Capacity building**

#### **7.4.3.1. Training**

##### **A) Fisheries management**

In order to ensure fisheries management measures (cf., section 7.4.4.2) are appropriately implemented, state institutions need to be capacitated, both technically and financially, ensuring the adequate equipment, human resources and know-how are available (Musumali *et al.*, 2009).

Specifically, strong sanctioning and enforcement mechanisms must be developed (Kaluma & Umar, 2021). The following basic measures should be implemented:

- Grow the local Department of Fisheries' workforce;
- Create an enforcement wing and assign enforcement teams to each village or chiefdom fishery concession zone;
- Invest on equipment: boats and monitoring gear;
- Research on different funding sources.

##### **B) Climate smart agriculture**

People (with 50% female representation) from the different villages or groups of villages in the catchment of the Lukanga Swamp should be trained for best-practices in climate-smart agriculture (CSA) (cf. section 7.4.4.1).

Ministry of Lands and Natural Resources' project "Building the resilience of local communities in Zambia through the introduction of Ecosystem-based Adaptation into priority ecosystems, including wetlands and forests" (2019-2023) includes training of beneficiary communities on the implementation and management of additional livelihood options and climate-resilient agriculture practices, as well as in-field water harvesting techniques (MLNR, 2021, draft project document).



### **C) Fire management**

Capacity building of government institutions and officials concerning fire management is key to ensure the plan's measures are enforced (such as a late dry season fire ban, see section 7.4.4.4). Resource availability (equipment, staff and training) must be improved.

People from the different villages or groups of villages in the catchment of the Lukanga Swamp should also be trained for safe and sustainable burning practices.

### **D) Sustainable forest resource management**

As for fire management, the sustainable exploitation of forest resources depends on regulatory and managing institutions having the technical and financial/human resources to implement management action and enforce restrictions (cf. section 7.4.4.5), so the following capacity-building measures are recommended:

- Capacity building of government institutions and officials concerning sustainable forest management and ecology;
- Capacity building of government institutions and officials to ensure resource availability (equipment, staff and training).

Finally, people from the different villages or groups of villages in the catchment of the Lukanga Swamp should also be trained for best-practices in forest resource use (cf. section 7.4.3.2).

#### **7.4.3.2. Awareness raising and education campaigns**

A crucial mechanism for improving compliance is building the stewardship and accountability of local users towards the resource and the land (Jones, 2014; Sverdrup-Jensen & Nielsen, 1998).

For instance, according to Hollingsworth *et al.* (2015) “most communities in Zambia do not consider themselves as partial owners of the forest reserves, and therefore do not feel a sense of responsibility in helping to manage these resources”.

As such, a number of awareness raising and education campaigns (Table 12) should be developed throughout the site, aiming at:





- Reinstating the perspective that natural resources and ecosystems are valuable common possessions that need to be cherished and protected by local users through collective effort, to ensure their sustainability for future generations;
- Educating and training local users in the new regulations and best-practices to be implemented in the scope of the Conservation Plan.

**Table 12 – Awareness raising and education programmes for implementation in the Conservation Plan areas**

| Programme                                     | Themes                                                                                                                   |
|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Habitats, biodiversity and ecosystem services | Habitats, flora and fauna of the Lukanga Swamp and its surroundings                                                      |
|                                               | Ecosystem services provided by the environment                                                                           |
|                                               | Local communities as stewards of ecosystems and natural values                                                           |
| Fisheries management                          | Importance of maintaining habitats in good health to maintain fish populations                                           |
|                                               | Importance of fish populations and species to the maintenance of ecosystem services                                      |
|                                               | Unsustainable or damaging fishing practices, and how to avoid them                                                       |
|                                               | Training in improved fish processing methods                                                                             |
|                                               | Training in fish marketing and trading skills for women                                                                  |
|                                               | Sanitation and hygiene practices in fishing villages and camps                                                           |
| Burning practices                             | Education and training in safe burning practices                                                                         |
|                                               | Negative and positive impacts of burning                                                                                 |
|                                               | New burning regulations                                                                                                  |
| Forest resources                              | Forest ecosystem services and values                                                                                     |
|                                               | Regenerative practices and best-practice guidelines                                                                      |
|                                               | Unsustainable or damaging practices, and how to avoid them                                                               |
| Climate smart agriculture                     | Unsustainable or damaging cultivation practices, and how to avoid them                                                   |
|                                               | Education and training on integrated soil fertility management, conservative agriculture and improved grazing management |



#### 7.4.4. Socioeconomic development

##### 7.4.4.1. Agriculture

Climate-smart agriculture (CSA) is agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals (Bertram *et al.*, 2017).

Best-practice recommendations for agriculture activities following the CSA approach are thus advised, which for this case can be grouped in three main climate-smart practices:

- Integrated soil fertility management;
- Conservation agriculture;
- Improved grazing management (cf. section 7.4.4.3).

These practices will help prevent and mitigate land degradation; control soil erosion; manage soil organic matter and improve water use and management in agriculture (cf. section 7.4.1.1).

Other activities following the CSA for soil erosion and to improve water efficiency in agriculture include:

- **Enhancing soil surface roughness** with clods, tied ridges or even earth bunds and **planting windbreaks perpendicular to the prevailing winds**;
- **Construction of soil conservation structures**, e.g., stone or earth terraces and bunds and check dams;
- **Rainwater harvesting and proper use**. This last option for soil conservation may also be used as a measure for rainwater harvesting, as an alternative to being dependent on groundwater resources. This is important not only because local people refer water levels in wells are decreasing over time, but also because this water showed high concentrations of metals in all analysed samples.
- **Eliminating the burning of crop residues and reduce burning of grassland to the absolute minimum**. This practice enhances phosphorous and encourage the growth of young plants for grazing animals but reduces the amount of soil organic matter.

Given their contribution to climate change resilience, CSA strategies are resumed in section 7.4.5.2.



## **A) Integrated soil fertility management**

Integrated soil fertility management helps to increase soil's nutrient retention capacity, and nutrients available to plants. This management includes:

- Maximizing the use of organic matter sources (e.g., compost, animal manure and green manure). This is a cost-efficient means to replenish soil organic matter content, and it may include integrated crop and livestock systems: The livestock manure is a source of organic fertilizer and its application helps maintain the health and fertility of soil. However, it is important also to practice controlled grazing (see below) to reduce degradation of vegetation and restore grassland diversity.
- Enhancing nutrient efficiency through crop rotation or intercropping with nitrogen-fixing crops.
- Reducing the input of synthetic nitrogen fertilizers will reduce water contamination (a problem identified in groundwater from the Lukanga Swamp area), but also carbon dioxide emissions that result from their production, and nitrous oxide emissions that result from the application of these inputs and consequent ammonia volatilization.
- Using appropriate placement of nitrogen fertilizer near the zone of active root uptake and synchronizing the timing of nitrogen fertilizer application with plant nitrogen demand.



## B) Conservation agriculture

Conservation agriculture (CA) is a farming system that promotes minimum soil disturbance (*i.e.*, no tillage), maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production.

Conservation agriculture is based in three principles:

- **Minimum mechanical soil disturbance** – Direct seed and/or fertilizer placement. Direct seeding involves growing crops without mechanical seedbed preparation and with minimal soil disturbance since the harvest of the previous crop. The term direct seeding is understood in CA systems as synonymous with no-till farming, zero tillage, no-tillage, direct drilling, etc. Land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops; or spraying herbicides for weed control and seeding directly through the mulch. Crop residues are retained either completely or to a suitable amount to guarantee the complete soil cover, and fertilizer and amendments are either broadcast on the soil surface or applied during seeding.
- **Permanent soil organic cover** – Keeping the soil covered is a fundamental principle of CA. Crop residues are left on the soil surface but cover crops may be needed if the gap is too long between harvesting one crop and establishing the next. Cover crops improve the stability of the CA system, not only on the improvement of soil properties but also for their capacity to promote an increased biodiversity in the agro-ecosystem. While commercial crops have a market value, cover crops are mainly grown for their effect on soil fertility or as livestock fodder. In regions where smaller amounts of biomass are produced, such as semi-arid regions or areas of eroded and degraded soils, cover crops are beneficial as they: protect the soil during fallow periods; mobilize and recycle nutrients; improve the soil structure and break compacted layers and hard pans; permit a rotation in a monoculture; can be used to control weeds and pests.



- **Species diversification** – The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro-organisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop, can be "recycled" by the crops in rotation. This way the rotation crops function as biological pumps.

#### 7.4.4.2. Fisheries

The Lukanga's fishery is a low-cost, low-tech, multi-species artisanal fishery. Fish are sold locally or regionally, bartered for items such as clothes or groceries, or consumed directly.

The reasons appointed for the current inefficient management of the Lukanga's fisheries are mostly related to inadequate enforcement of existing regulations and insufficient collection of relevant data, which hinders the assessment of ecological conditions and adaptation of management.

According to the MFL (2020), the enforcement of fishing restrictions in the Lukanga is hindered by the following issues:

- «Absence of stationed Zambia Police Service;
- Lean departmental workforce;
- Vast catchment area;
- Inadequate equipment (boats, engines, etc.);
- Low disbursements of operational funds towards enforcement officers;
- Lack of an enforcement wing within the department;
- Weak co-management structures».

In line with this, fishermen categorically mentioned the use of the "wrong" fishing gear as one of the main causes of fisheries depletion. According to the DoF (2014), seine nets, gillnets and longlines are the preferred methods in the Lukanga, gillnet mesh sizes vary between 13 and 152 mm (0.5 and 6.5 inches, respectively), and are dominated by the size 63 mm (31.87%). The *kutumpula* or *mukombo* fishing methods are still used in the fishery. These are variants of gill netting where nets with small mesh sizes are deployed around vegetation in shallower reaches of rivers and fishermen then thump on the water with poles to drive the fish out. With this method, nets are pulled more frequently and



relaunched at a faster pace than with other types of gillnetting, and fry are easily caught, upsetting the spawning process (Hayward, 1985, in Imai, 1998).

Coupled with, and exacerbating, the inefficient or inexistent management, the growing influx of migrant fishermen in recent decades adds on the pressures already acting in these natural systems, putting fish populations and resident riparian communities at risk. This influx is driven by the depletion of fisheries across the country, by unemployment rates among younger generations, and delayed government benefits for pensioners (cf., Part I, chapter 5). According to the DoF (2014), all of the active fishermen in the swamp (a total of 3,936 in 2014) are unlicensed, and the fishing ban is not appropriately respected.

Food and income insecurity – which are aggravated by the deterioration of resources and by the unmanaged influx of external users – are key drivers for non-compliance (Jones, 2014). This is well illustrated by local fishermen's claims that they carry on engaging in prohibited practices, despite the possibility of prosecution, because it is the only way to get any fish and income (key informant interviews, 2019).

The present document aims at protecting natural resources – here, fish populations – against unsustainable or destructive use. Because this implies restricting access to natural resources, and because incomers are motile and accustomed to changing sites according to resource availability and/or access, one can expect that local fishermen will bear a significantly higher proportion of the opportunity costs of these restrictions (Jones, 2014).

As such, in addition to ensuring the perpetuity of fish resources, the current Action Plan must also provide for the protection of local people through the development of measures to reduce the leakage of benefits away from riparian communities, ensuring the fair and equitable distribution the fisheries' resources, and ensuring the benefits are enough to support the costs of implementing restrictions (Jones, 2014).

Finally, the legitimacy of official decision-making arrangements and how these establish the rules for collective action can also greatly hinder compliance. If local fishers are not involved, and their knowledge is not recognized and considered during decision-making, trust will be compromised and non-compliance can be expected to rise (Kaluma & Umar, 2021; Jones, 2014; Sverdrup-Jensen & Nielsen, 1998).



As such, and as per the Second National Agricultural Policy (SNAP)<sup>2</sup> (MA & MFL, 2016), the sustainable management of fisheries (under Objective 8) should involve:

- «Decentralizing capture fisheries management to communities;
- Promoting sustainable fishing methods;
- Promoting programmes and appropriate technologies/methods for sustainable utilization of fisheries resources».

### A) Fisheries management strategies

In this section, legislative and decision-making arrangements regarding the exploitation and management of the Lukanga swamp fishery are proposed.

As mentioned earlier (section 7.4) the successful management of common pool resources must make use of a diversity of incentives, taking into account the site's strategic objectives. Measures are recommended aiming at:

- Developing clear legislation for the site;
- Building the capacity of regulatory, top-down, enforcement agencies;
- Implementing *de facto* bottom-up, participative, arrangements for decision-making;
- Promoting knowledge sharing between users, scientists, managers and other stakeholders;
- Protecting resident communities and fish populations, while also allowing migrants to continue accessing the resource.

In the Fisheries Regulations of 2012 (and 2017 amendments), the Lukanga's fishery is classified as a **commercial fishery**. However, no specific provisions are given regarding gear restrictions. It is not clear whether the provisions for the Upper Kafue encompass the Lukanga, nonetheless, these are as follows (Fisheries Regulations, 2012; First schedule – Regulation of Fisheries in Commercial Fishing Areas, A. Prohibited Nets, Upper Kafue Commercial Fishing Area I.I.T):

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<sup>2</sup> Second National Agricultural Policy (SNAP – Ministry of Agriculture and Ministry of Fisheries and Livestock, 2016); fisheries policy currently falls within the National Agricultural Policy, though a stand-alone fisheries policy is being developed (Ministry of Fisheries and Livestock in SADC Secretariat, 2016)





- «gill nets of mesh sizes less than 51 mm [are prohibited] throughout the area»;
- «monofilament nets of a mesh sizes less than 127 mm [are prohibited] throughout the area»;
- «draw/seine nets of any mesh size [are prohibited] throughout the area».

The fishing ban period is also established in these documents, from December 1st to the last day of February.

Finally, fishing licence fees for the Lukanga commercial fishery have been set at:

- Zambian resident: 44 kwachas per annum;
- Zambian non-resident: 167 kwachas per annum;
- Fishing groups or co-operatives: 333 kwachas per annum.

Considering the current conditions of this fishery – namely, the ineffective management and the deteriorating conditions reported by users – the declaration of the site as a **Fisheries Management Area (FMA)**, under Article 26 of Part IV of the Fisheries Act of 2011 is hereby proposed.

This FMA should be created through the **publication of a decree or act** establishing its statute, and the publication of **regulations** establishing the governing structures and collective rules around its zonation and exploitation.

The contents of these documents must be clear, unambiguous, compliant to higher legislative pieces, and will:

- Detail the objectives of the Lukanga Swamp Fisheries Management Area, established under the umbrella designation of Lukanga Swamp Critical Conservation and Management Area (multiple use management area);
- Establish the co-management arrangements, statutes, roles and management processes;
- Establish the process for acquiring and maintaining a fishing licence;
- Establish landing quotas depending on the number of licenced fishermen, for different areas of the fishery;
- Establish prohibited gear;
- Establish mechanisms for setting trading strategies – such as fixed fish prices (independent of species), **if and when deemed appropriate**, as was



done in the Bangweulu swamps (Imai, 1998), as a buffer against external market fluctuations;

- Establish mechanisms for conflict resolution;
- Establish appropriate fines for non-compliance;
- Establish a system for locating, registering (e.g., with the help of handheld GPS devices) and organizing fishing camps within the swamp;
- Define the rules for proper utilization of fishing camps (see best-practice recommendations below for more information).

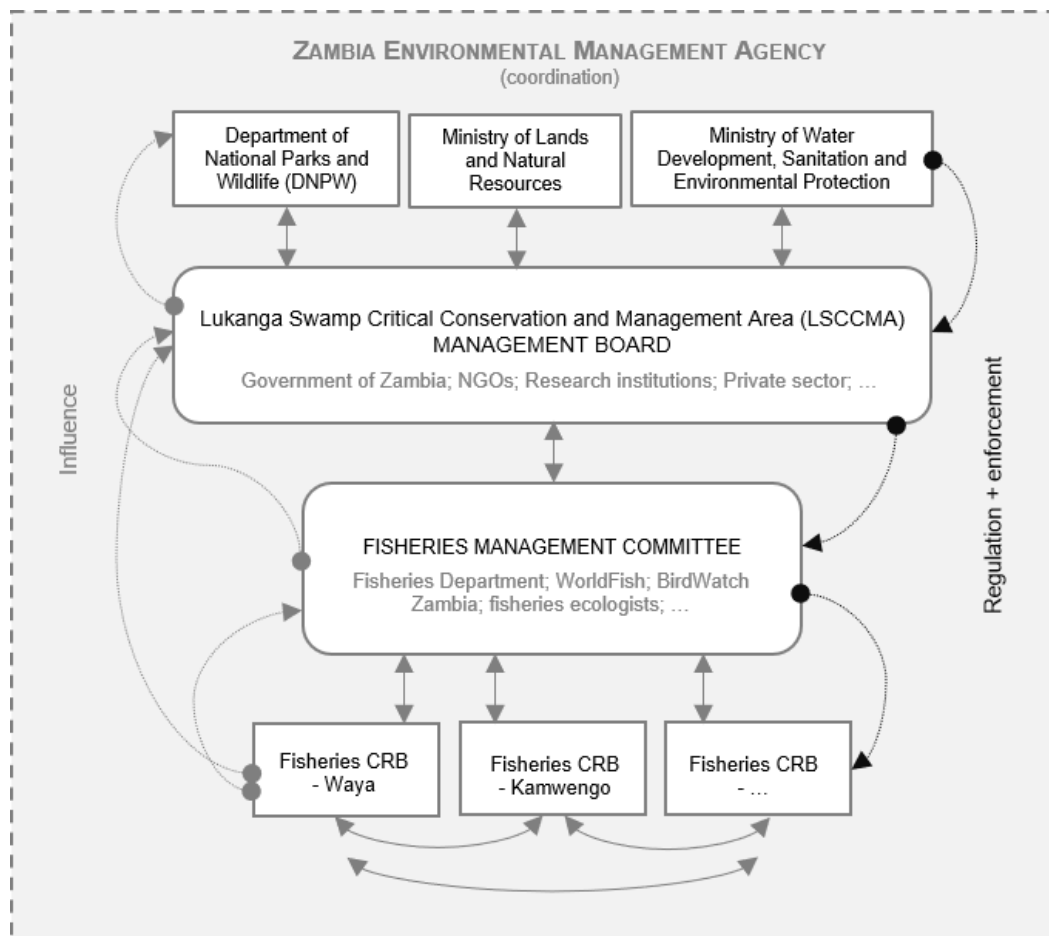
The Lukanga Swamp Fisheries Management Area **Regulations** must be **developed** and **agreed** upon by local populations, through the realization of consultative and deliberative workshops between Fisheries' Community Resource Boards (FCRBs), the Fisheries Management Committee (FMC) and the MUMA Management Board (MUMAMB).

During these working sessions, the overall design for the site's management should be discussed, and the receptiveness of local users assessed. The regulations (zonation and gear restrictions – minimum mesh sizes, prohibited gear types, landing restrictions, etc.) should then be discussed – provided this system is agreed on – and adapted according to updated information about the fishery and the current exploitation systems (Sverdrup-Jensen & Nielsen, 1998).

As stated in section 7.2, a **co-management governing arrangement** is advised, where «users and the government cooperate together as equal partners in decision-making» (Sverdrup-Jensen & Nielsen, 1998).

Public participation must be initiated from the validation phase of the Lukanga Swamp and Catchment Conservation Plan, through the presentation of the draft document to local users, and must then follow through the cooperative development of the operational rules and their enforcement (Sverdrup-Jensen & Nielsen, 1998).

As per Article 29 of the Fisheries Act of 2011, a **Fisheries Management Committee** (FMC) should be appointed for the whole FMA, joining government officials, fisheries and ecology researchers, and NGO representatives specialized in fisheries, under which **Fisheries' Community Resource Boards** (FCRB) should be formed (or, current ones should be restructured), for each fishing village, including local leadership, and representative numbers of elders, men, women and young people (Figure 5).



**Figure 5 – Co-management arrangements for managing the Lukanga's fisheries**

In the figure above, full arrows represent direct communication links between institutions, while dashed arrows represent indirect linkages (for details see section 7.7.2).

Imai (1998) studied the indigenous patterns of fisheries' management in the Bangweulu Swamps and reported that users had actively established a segregation system between different ethnic groups, fishing methods and fishing seasons, which successfully prevented resource shortage and environmental destruction, "without any legal or administrative controls". In Imai's words, "as a result, fish resources in the swamp were well-allocated to multiple fishing units" (Imai, 1991).

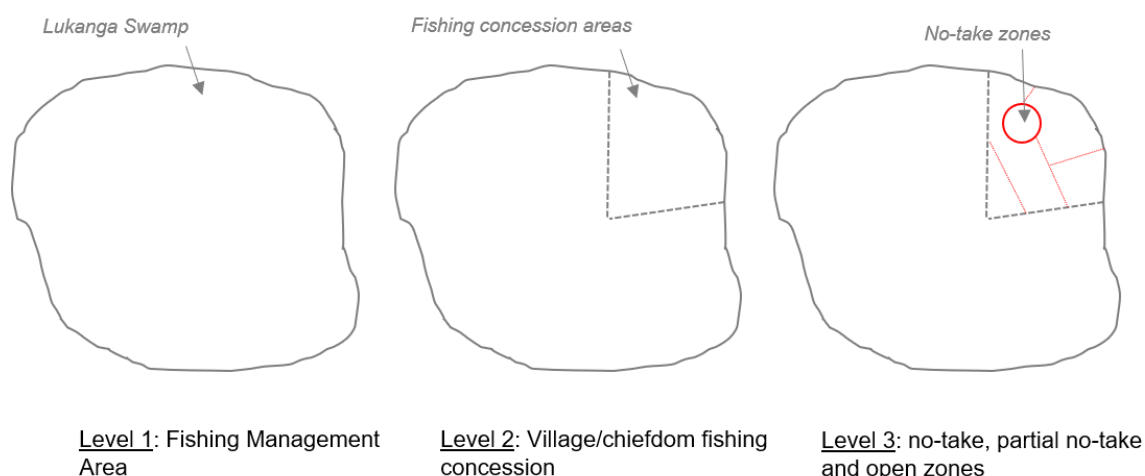
On a different study, Kaluma & Umar (2021) analysed the co-management arrangements in the Mweru-Luapula fishery and their effectiveness, and concluded that co-management may not be effective because the institutional set up either actually maintains the status quo, or allows the sequestering of management by local elites. In these cases, fishermen lose trust in the system and become passive towards



management, reducing compliance. The authors suggest that the formation of cooperatives or small fishing groups tasked with marking fishing units and creating their own rules enhances “their sense of ownership and [incentivizes] their participation in fisheries management” (Kaluma & Umar, 2021).

Following on these examples, as well as the lessons from the study conducted by Sverdrup-Jensen & Nielsen (1998), a sub-division is proposed within the **Lukanga Swamp Fisheries Management Area** for the recovery of fish populations, the sustainability of fishing and for the protection of resident riparian communities. The swamp’s area should be divided into village **fishing concession zones**, within which three (3) additional categories will be defined (Figure 6):

- **No-take zones** (or fish breeding areas); here, fishing is banned year-round to protect spawning;
- **Partial no-take zones**; here, only residents carrying lifetime fishing licenses (see below) are allowed to enter and/or create fishing ponds;
- **Open zones**; here, any person carrying a fishing license (local residents, migrants or tourists) may undertake this activity, and must abide by the Lukanga Swamp Fisheries Management Area Regulations (see below).



**Figure 6 – Schematization of the proposed zonation system**

A preliminary proposal of fishing concession zones is given in section 7.3 and in Map 4 (Appendix 1), including each zone’s permitted and restricted uses. This zonation, however, is not to be implemented before consultative and deliberative workshops are held between the different managing levels to refine it based on updated information



regarding local indigenous management arrangements (fishing seasons, current fishing grounds, current segregation of the activity between ethnic groups, if existent, spatial trends in fish landings, etc.) (Imai, 1998). Within each concession zone, a limited number of fishing camps should be allowed to be set – preferably within open zones.

The final zonation must be communicated and discussed with the remaining resource committees (e.g., Forest Management Committee) NGOs, researchers, and any other group undertaking conservation projects in the area (such as the Kariba weed control project), to ensure it is articulated between the different sectors, and to establish vertical and horizontal linkages that will support its effective implementation (Musumali *et al.*, 2009).

The **on-site delimitation** and **signalization** of **no-take** and **partial no-take zones** is crucial. This should be done by means of informative panels translated into the different languages used in the area, as well as in English.

Regarding **licencing**, Table 13 details the changes that are recommended, aiming at protecting resident fishermen and raising funds for management.

**Table 13 – Current and proposed licensing schemes for access to the Lukanga’s fishery**

| Licence group                                    | Zone                         | Current fees (kw/annum) | Proposed fees (kw)                                            |
|--------------------------------------------------|------------------------------|-------------------------|---------------------------------------------------------------|
| Zambian resident                                 | Lukanga Commercial Fishery   | 44                      | -                                                             |
| Non-Zambian                                      | Lukanga Commercial Fishery   | 167                     | -                                                             |
| Fishing groups or co-operatives                  | Lukanga Commercial Fishery   | 333                     | -                                                             |
| Lukanga resident                                 | Partial no-take + open areas | -                       | 44/ annum (stays the same as is now for any Zambian resident) |
| Migrants/ Zambian residents                      | Open areas                   | -                       | 44 + FMA fee of 20 / annum                                    |
| Non-Zambian/ migrants from surrounding countries | Open areas                   | -                       | 167 + FMA fee of 40 / annum                                   |



| Licence group                                      | Zone                         | Current fees (kw/annum) | Proposed fees (kw)        |
|----------------------------------------------------|------------------------------|-------------------------|---------------------------|
| Fishing groups or cooperatives (Lukanga residents) | Partial no-take + open areas | -                       | 333 + FMA of 50 / annum   |
| Tourists                                           | Open areas                   | -                       | FMA of 500 / fishing trip |
| Canoes                                             | -                            | -                       | 5/ annum                  |
| Motor boats                                        | -                            | -                       | 10/ annum                 |

Source: Fishing Licence Fees Regulations (2012)

The **FMA fees** proposed in Table 13 shall revert in their entirety back to each CRB for the operational cost of management (mending or acquisition of fishing gear, rehabilitation of community markets, construction of fish drying structures, etc.).

A new system for licencing is also proposed, whereby Lukanga resident licences are **lifetime permits** conceding local people access rights to the partial no-take zones and to the open zones of their village fishing concession zone. Zambian resident and non-Zambian resident licences are **annual**, and need to be renewed before each fishing season. Tourist licences are valid for one fishing trip only, and have set dates for start and finish. A system of penalties and compensation should be implemented, where a licence can be revoked if the licence holder has committed more than a set number of offences.

Because the “re-introduction” of gear restrictions will mean that some fishermen will not have the appropriate gear for exploiting the fishery, it is also recommended that, upon the issuing of licences to Lukanga Resident, new fishing nets and other associated equipment be given to the fishermen, free of charge.

Taking into consideration that most of the site’s residents are part-time fishers and part-time farmers, a farming scheme should also be implemented for Lukanga resident licence holders, to further support their food security and empower them towards making sustainable choices.



## B) Best practice-recommendations

Temporary camps are set in floating islands inside the permanent swamp, where fishers can move to for two (2) to three (3) weeks to pursue the fishing activity before returning to their permanent residencies (DoF, 2014).

In these camps, there is no access to safe drinking water or sanitation, which results in frequent cholera outbreaks, especially when water levels drop in the dry season (Murebwa-Chirambo *et al.*, 2017). Low levels of hygiene and poor waste management are also commonly associated with a higher risk of water-borne infections among fishing communities of the region (Kalumbi *et al.*, 2020).

The absence of sanitation and waste management infrastructures not only poses risks to human health through water contamination, but also through the contamination of fish products, all while polluting natural ecosystems.

The following recommendations are given:

- Inventory and registration of fishing camps;
- Development of a set of **rules** and **best-practice guidelines** for the appropriate use of fishing camps;
- Development of a **waste management system** – for, among other things, removing litter from the swamp and safely disposing of it;
- Installation of basic sanitation facilities – such as latrines and handwashing points – within the camps and fishing villages;
- Realization of awareness raising and training actions regarding hygiene measures.

In traditional systems such as the Lukanga fishery, with high rates of poverty and hunger, as well as very limited – if any – access to infrastructure, post-harvest processing of fish is a crucial component of the fishery, and needs to be managed accordingly (Musumali *et al.*, 2009). Between capture and consumption, post-harvest losses in Zambia are estimated to be around 30% (Musumali *et al.*, 2009; WorldFish, 2017).

In addition to these losses, which incur in lower incomes for fishermen and traders, some fish processing technologies can have significant negative impacts, in particular those that use fuelwood as the primary source of energy, which are also the dominant processes in Zambia (Kwofie *et al.*, 2019). In general, these can have the following effects:





- Since most methods for smoking the fish rely on fuelwood or charcoal, high rates of fishing result in high rates of deforestation, significantly contributing to forest degradation and loss around wetland ecosystems;
- The combustion of fuelwood releases sequestered carbon stocks, ultimately contributing to the aggravation of climate change;
- Fuelwood combustion also emits pollutants (carbon dioxide, carbon monoxide, hydrocarbons, etc.) that, in addition to polluting the atmosphere, poses serious health risks, increasing the incidence of respiratory diseases and lung cancers, for example;
- The risk of injuries through physical contact, such as severe burns, is also high;
- Sun drying and smoking methods expose fish to environmental contaminants, moulds and pathogenic bacteria.

Between 2014 and 2017, the **Cultivate Africa's Future** (CultiAF) project was implemented by WorldFish and funded by the International Development Research Center (IDRC-CRDI), aiming at combating fish losses through research on technical and social innovation. They concluded that the adoption of **improved post-harvest technologies** coupled with **education on gender relations** helped to combat fish losses (improving fish security) while also changing attitudes and behaviours around gender equality (WorldFish, 2017)<sup>3</sup>.

As such, the adoption of safer, innovative and improved technologies for fish-processing should be encouraged in the Lukanga Swamp Fisheries Management Area. Equally, given women make up the majority of fish processors and traders – being therefore more susceptible to the health risks posed by these methods – and that they generally have less access to government extension services and training (WorldFish, 2017), the social arrangements across the fishing value-chain need also be addressed. See above, in section 7.4.3.2, Awareness raising and education campaigns.

To optimize the fish smoking process – both reducing post-harvest losses and reducing the need for harvesting fuelwood – community improved smoking kilns can be constructed in each fishing village (Figure 7).

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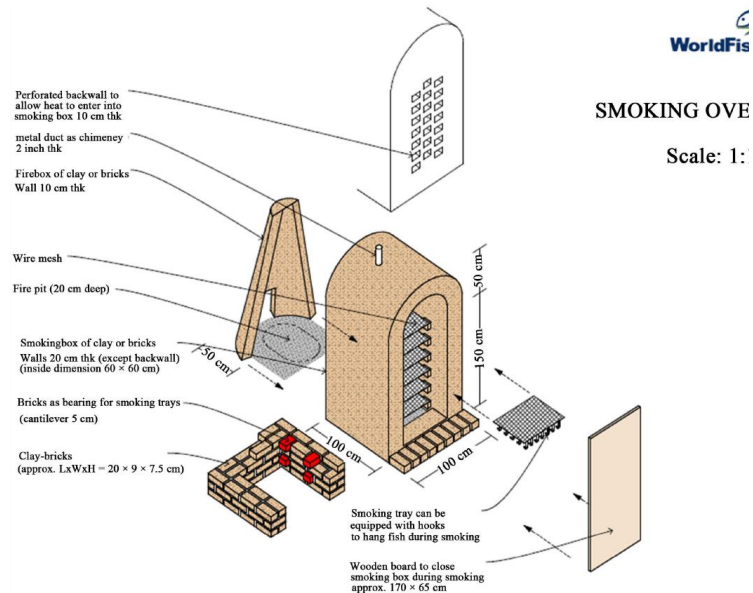
<sup>3</sup> See the project's brochure "Research reduces Post-Harvest fish losses: empowering women and men fishers, processors and traders", available at: <https://www.worldfishcenter.org/content/research-reduces-post-harvest-fish-losses>.



Kwofie *et al.* (2019) – who conducted an investigation on the energy dynamics of fish smoking in Zambia – found that the kiln method increased the quantity of fish processed in one go by five folds, reduced fuel use by 48%, and reduced smoking time per kilogram of processed fish by 39%.



Source: Kwofie *et al.* (2019)



Source: WorldFish, in Kwofie *et al.* (2019)

**Figure 7 – Photo and schematic diagram of a smoking kiln**

To optimize the sun drying process – reducing post-harvest losses and improving working conditions for processors, in particular for women – the use of solar tent dryers is recommended (Figure 8).

In the scope of the CultiAF project conducted in the Barotse Floodplains, WorldFish (2017) also found that the use of these structures, in contrast to traditional sun drying, significantly reduced processing time and post-harvesting losses.



Source: WorldFish (2017)

**Figure 8 – Solar tent dryer designed and developed through the “Improving livelihoods and gender relations in the Barotse Floodplain fishery” project, by a participatory action research group in Mukakani fishing camp, Mongu District**





Smoked and dried fish is, however, still susceptible to rotting and insect infestation. **Salting** (Figure 9) is the best option for increasing the product's longevity, while also significantly reducing processing time (Kaminski, 2019).



Source: Steve Cole (2016), for WorldFish (2017)

**Figure 9 – Fish salting in the Barotse Floodplain**

Finally, the implementation and/or construction of these improved technologies is not without costs. To allow the site-wide implementation of these technologies, financing solutions such as microfinancing or accessing donor funds for community projects (for poverty reduction, gender equality, reduction of green-house gas emissions, forest protection, etc.) should be identified. Articulation with the implementors of the CultiAF project could be greatly beneficial to help tailor these methods to the Lukanga's particularities.



#### 7.4.4.3. Grazing

Around the Lukanga, most cattle, goats and sheep are reared free range, under the traditional migration pattern of transhumance. During the wet season, when the grassland is flooded, livestock is herded in the upland; and as water recedes during the dry season, herds recolonize the floodplain.

Grazing pressure is an essential driver and element of African landscapes, accelerating the nutrient cycle and defining to an extent the composition of the vegetation.

Appropriate levels of grazing stimulate the production of biomass, increase habitat heterogeneity and redistribute nutrients. Controlled grazing includes any system in which the producer controls the grazing pattern of the livestock – it covers seasonal grazing, may involve enclosures, physical or social fencing, rotations, grazing reserves (fodder banks), regulation of grazing and mobility:

- The manipulation of animal movement is used to control when, what and how much the animals graze. Grazing management involves evaluation of the nutritional and forage needs of animals, assessment of forage quality and quantity, and then the regulation of access to the pasture/ range.
- Fencing plays a critical role in the success of controlled grazing. Controlled grazing is often equated to 'rotational grazing' where pasture is subdivided into several smaller paddocks by fencing. Livestock then graze in one of the paddocks until the forage has been eaten, and then are rotated sequentially to the next paddock, leaving the grazed paddock to recover.

Indiscriminate and uncontrolled grazing can surpass the system's carrying capacity, and incur in significant pressures which hinder the system's long-term health and provision of services. Many extensive grazing systems suffer from overgrazing and seriously reduced biodiversity of above-ground vegetation. This is due to declining land availability and poor livestock management leading to overstocking and leads to a decline: 1. Of soil quality in rangelands; 2. In soil structure and resilience (e.g., through loss of deep rooting species that can cycle nutrients and water from deep in the soil profile).

Indeed, the Second National Agricultural Policy's (SNAP) **objective 8**, states that the «sustainable utilization of rangeland (grassland ecosystem) and pastures for livestock production» (MA & MFL, 2016) needs to be promoted.



In this context, a programme of measures for mitigating the negative impacts of livestock herding in the site's grasslands and to potentiate a sustainable communal grazing system, compatible with the maintenance of natural values and that benefits local populations, is given below.

Taking advantage of the site's designation as a Critical Conservation and Management Area and resulting creation/ capacity building of management institutions, the **development of a Grazing Management Plan** is recommended.

The Grazing Management Plan should include, but not be limited to:

- Registry of animal owning households and number of animals (cf., section 7.4.2);
- Establishment of the appropriate stocking density and rate (= number of animals grazing on a given area of land for a given time) according to the type of grassland;
- Determination of the grassland's carrying capacity (= number of animal units per year that the ecosystem can support without undergoing detrimental changes);
- Map of herd drinking points and assessment of the need to install additional water points, to reduce soil erosion around these;
- Outline of an optimal grazing system (= management of the distribution of grazers in time and space/ or how the animals are moved across the landscape);
  - as mentioned above, this can include a rotation system, where a given patch is protected from grazing during a set number of years after having been grazed for a season, to increase patch heterogeneity across floodplain landscapes;
  - grazing can also be forbidden during critical times, such as the vegetation's growing period;
  - limiting the amount of time a herd is concentrated drinking in the edge of water bodies and licking at termite mounds, can help minimize the damage to vegetation and soil;
- Establishment of regulatory incentives for maintaining grazing within the limits; these include the implementation of permits (e.g., residents only, or a limited number of "licenses to graze") and quotas (e.g., maximum number of animals per household or village);



- Development of economic incentives for the diversification of herds with either goats or cattle, depending on current proportions, to promote the appropriate ratio of bulk to selective grazers that maintains a species rich and resilient grassland;
- Specifications for adapting any element of the plan in response to specific results obtained from monitoring the grassland's health;
- Establishment of mechanisms to facilitate public participation and access to extension services, which provides participation and knowledge incentives.

The improvement of extension services is a fundamental element of the management of socio-economic uses. These should include regular visits to owners of herds for the collection of information, registering of complaints, and reiteration of best-practice guidelines.

#### 7.4.4.4. Use of fire

Dry-season fires are an inherent element of Zambezian ecosystems, and burning has been used as a landscape management tool for centuries.

Around the Lukanga, this is used seasonally to promote the growth of fresh herbs for cattle, to prepare the land for cultivation, and to eliminate original cover for the conversion of natural land to cultivated land. Within the swamp itself, controlled areas are burnt towards the end of the dry season in order to open up patches of decreased cover and increased nutrients, purposefully increasing reproductive and feeding habitat availability for fish, which can be harvested later on.

If left unchecked, however, fire results in (Gibson, 2009): the elimination of the forest's role in the regulation of regional climate through carbon uptake and stocking; the reduction of above-ground plant biomass; the alteration of species composition, depending on the fire regime (continuous burning favours annuals and species adapted to seasonal burning); lowering of the soil albedo and increase of soil temperature; volatilization and release of nutrients; and results in a higher susceptibility to wind and water erosion.

Accordingly, one of the "Strategic Interventions" under Target 7 of the Second National Biodiversity Strategy and Action Plan (NBSAP2) (MLNREP, 2014) is to «Promote





management of wildfires in biodiversity areas such as forests, GMAs, NPs and wetlands».

For the management of fires in and around the swamp, the following measures are proposed, exclusively for the site scale.

### A) Fire management strategies

One of the reasons appointed for the ineffective management of fire in Zambia's state lands is the shift towards top-down government control (Hollingsworth *et al.*, 2015). Because responsible entities lack resources to appropriately develop measures and enforce management, local populations are left to exploit the situation unsustainably.

On the other hand, in communal lands, customary law and management systems substitute government responsibility. However, because there is no nation-wide integrated fire management strategy, nor are there systematic plans or guidelines, management varies across the territory (Hollingsworth *et al.*, 2015). There is still the need to review current legislation and to develop a National Fire Management Strategy that integrates over-arching objectives, while providing for site-tailored institutional arrangements for fire management (Hollingsworth *et al.*, 2015).

For now, it is recommended that **community decision groups**, are established to include local populations and chiefs in fire management, together with government officials, either under forest management arrangements (section 7.4.4.5.A)), or through the creation of a new managing branch, exclusive for fire – since fire management includes grassland and swamp ecosystems as well. Indeed, it has been shown that involving communities in fire management, in making them better-informed, increases awareness and compliance to legal regulations.

In addition, a data-informed and intentional burning regime is a fundamental tool for the conservation of natural values (Hollingsworth *et al.*, 2015; SANBI, 2013; Robins, 2007). This can be achieved through the development of a **Fire Management Plan** – through community collaboration and with direct support from the Forestry Department and ZEMA – specifying guidelines for maintaining the traditional use of fire practices in a sustainable and safe way.



The Fire Management Plan should include, but not be limited to:

- Safety guidelines; methods for safe burning according to different uses in different vegetation types (including within the swamp);
- Guidelines for fighting wildfires and development of mechanisms for effective fire response in the Lukanga; villagers should be formally trained in firefighting, and can be hired to assist in firefighting efforts when needed;
- Management objectives according to land cover and use – grazing in the grassland or woodland, fishing in the swamp, etc.;
- Fire regime; this includes establishing the appropriate timing for the fire and the type of fire in accordance to the objectives for each land use (see best practice recommendations below);
- Guidelines to increase efficiency of fire use according to different desired results;
- Guidelines for the implementation of prescribed patch mosaic burning in the early dry season to prevent late dry season fires where deemed necessary (where fuel has accumulated);
- Promotion of grassland habitat heterogeneity by maintaining a mosaic of areas with different fire regimes, i.e., frequency, season, extent, intensity, type and time since last burn;
- Articulation of the Fire Management Plan with the Grazing Management Plan, as fire is routinely used to promote fresh growth for grazing;
- Mechanisms for the adaptation of the Fire Management Plan on a yearly or two-year basis.

Where appropriate, **incentives** should be introduced to increase compliance and to substitute fire as a tool, namely:

- through a shift to a less fire-dependent farming system;
- through the introduction or promotion of alternative hunting methods;
- through the clarification of land tenure – a clear ownership will incentivize owners to responsibly and safely manage their land (section 7.4.4.5.A)).



Here, the introduction of a **Payments for Ecosystem Services (PES)**<sup>4</sup> scheme for compensating local users that alter their farming or hunting practices – if and when these changes incur in a reduction of their income – could be useful not only to generate compliance (effectively maintaining the health of the wetland), but also for gathering funds, since benefiterers of the said services – here, watershed protection, for instance – should be responsible for paying them.

## **B) Best-practice recommendations**

In Zambia, the month of peak fire activity is august for all vegetation/land use types, except forest and thicket vegetation in protected areas, for which it is July. However, long-term effects of late dry season burning seem to be negative according to local communities in other regions of Zambia (Eriksen, 2007). Similarly, outside protected areas, the fire-return interval (between 1.2 and 2.2 years depending on the vegetation) has been reduced over time, meaning there are more frequent fires.

The effects of fire on grassland vegetation are not only dependent on the season, but also on the scale and pattern of the fire (Gibson, 2009). Periodic, low frequency, small-scale fire regimes generate and maintain the spatial heterogeneity of the vegetation structure across the regional landscape (Gibson, 2009; SANBI, 2013). In contrast, uncontrolled, large and frequent fires will decrease diversity and heterogeneity, thus decreasing ecosystem resilience (Gibson, 2009).

That being said, the following measures are recommended as a rule of thumb for better fire management in the Lukanga:

- On land, burning should be employed:
  - early in the dry season to promote habitat heterogeneity and biodiversity, to create fire-breaks (as it is more easily controlled while the vegetation retains a high level of humidity), and to prevent larger fires later in the season; or
  - right before the first rains in farmed fields to ensure that the ash is not removed by the wind, but incorporated into the soil;

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<sup>4</sup> According to the working definitions under the National Wetlands Policy of 2018 (MLNR, 2018), PES, «also known as payments for environmental services (or benefits), refers to the appropriate incentives that are offered for the management of wetlands which provide ecosystem goods and services». As a guiding principle, this implies that «investors have a duty to pay for the management of wetlands which provide ecosystem goods and services which they derive».



- In the swamp, burning should be avoided during the summer (growing season; from November to April);
- A “burning ban” should be established, prohibiting deliberate fires between August and September;
- In the forests/ woodlands, the current mean fire return interval of **1.8/2.2 years** should be increased to **4 years**.

#### 7.4.4.5. Use of forest resources

Plant products directly harvested from the area’s forested land include:

- Wood forest products: timber for energy (firewood, charcoal) and construction;
- Non-wood forest products as wild food and traditional medicine:
  - fruit, fungi, nuts, roots, leaves, bark and seeds;
  - this is a significant activity for rural communities, and is practiced not only in forest land (i.e., miombo, munga, chipya and Baikiae) but also in other wooded land classes (i.e., termitaria);
  - the consumption of mushrooms and indigenous wild fruits, for instance, are important nutritional complements to rural people’s diets in the rainy season, the “hunger” months

Throughout Zambia, forest habitats have become seriously degraded from unsustainable resource exploitation and lack of effective management. In fact, forest reserves around the Lukanga – namely the Lukulaisho Local Forest – have been substituted almost entirely by cultivated land.

In addition to their inherent values, forest ecosystems provide a number of essential services to the maintenance of wetlands. The National Water Policy (Ministry of Energy and Water Development, 2010), appoints the reduction of the use of fuel-wood from woodlands, forests and wetlands, as a key strategy to manage water resources.

Recommendations are presented below for the sustainable management of forest resource use. An integrated approach is key, coupling the promotion of sustainable practices (supported by adequate enforcement, awareness raising and education), with the direct restoration of forest vegetation (presented in section 7.4.1.2.B)).



In this section, the term forest is used loosely to describe any vegetation community greater than 1 ha with a woody tree cover of more than 40% (it includes open woodlands, the dominant formations in the site).

### **A) Forest resource management strategies**

Wood collection for charcoal production is an impactful activity (Chidumayo & Gumbo, 2013), and one of the main threats to the sustainability of forest resource extraction in Zambia, and around the Lukanga. For this, management strategies presented in this section focus mostly on charcoal production.

Adding to charcoal, wood is also abundantly collected to support the fishing activity in the swamp. This is done for the construction of dugout canoes, and, more importantly, for constructing the structures on top of which the fish is processed.

The sustainable exploitation of forest resources is possible, and the maintenance of traditional uses can be compatible with biodiversity and ecosystem service conservation.

However, as for fire and fisheries management (sections 7.4.4.2 and 7.4.4.4), the following shortcomings apply. On one hand, regulatory and managing institutions do not have the technical and financial/human resources to implement management action and enforce restrictions. On the other, local users must be included in planning, must have access to training, education and extension services, and must develop a sense of stewardship and responsibility towards the natural values they depend on. Incentives need to be introduced that regulate resource use and/or substitute wood products where possible.

Recognizing the vulnerability of the site's communities, the role charcoal plays as a key source of energy locally, and that forests provide a renewable source of energy, management should focus on (Chidumayo & Gumbo, 2013):

- Improving (or introducing) the planning for wood production from natural and planted forests, for charcoal in particular;
- Improving harvesting methods;
- Improving post-harvesting processing technologies;
- Implementing marketing arrangements and rules around the Lukanga's forest products.



The sustainable exploitation of forests is contingent on bestowing local users with exclusive property rights (Chidumayo & Gumbo, 2013), so that a similar exploitation model as the proposed for the fishery is advised (cf., section 7.4.4.2). The following measures are recommended:

- Definition of clear, long-term, forest tenure – i.e., exclusive exploitation rights – to local communities; here, the licencing system<sup>5</sup> should be re-designed to fit this model of local ownership;
- Development and implementation of Forest Management Plans (FMP) for the area, allocating forest patches to sustainable production or conservation purposes – this can be a rotating system of harvesting blocks and forest reserves, for instance; management and planning around these community forests should be awarded to local groups through the formation of participative structures (or capacitation of current ones) such as Community Resource Boards (CRBs);
- In exchange for the obtention of exclusive property rights to the Lukanga's Community Forests, local communities should adhere to regulatory provisions and sustainable practices (e.g., those in section 7.4.4.5.B)) as agreed with state governing institutions such as the Forestry Department, who retains regulatory and enforcement responsibilities;
- Introduction of a Payments for Ecosystem Services (PES<sup>4</sup>) scheme – in this case, payment to maintain climate regulation and watershed protection, for instance –, with two purposes:
  - relieving the costs of banning all harvesting from Forest Reserves; in this context, households excluded from harvesting from one of their allocated patches for a set amount of time (if the system is rotational) must be compensated proportionally;
  - compensating extra work undertaken in the context of implementing sustainable practices;
- Allocation of exclusive trading rights for wood-based fuel and/or products to local communities; to improve trading of the site's forest products (which include not only charcoal but honey and mushrooms, for instance), and protect residents, clear marketing rules and arrangements should be developed;

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<sup>5</sup> Under Part VI of the Forest Act of 2015, felling, cutting or taking/removing any major forest produce (in which charcoal is included) from state or customary land is subjected to licencing.



- Finally, improving the marketability of the site's forest products through labels such as "eco", "sustainable", etc. (provided sustainable practices are actually adhered to and are effective in promoting forest health) could allow these to be marketed at higher prices in particular markets; this has been done under the Community Forests Program (see below), who created the brand Eco-Charcoal<sup>6</sup>; a similar branding could be developed for the Lukanga's products – not only charcoal, but honey, for instance –, where supporting the brand supports the enforcement of sustainable practices, which in turn supports wetland conservation and the protection of wider ecosystem services.

This should also promote the feelings of stewardship and responsibility towards resources, increasing compliance.

Programs such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) could provide a source of funding for improved forest management. Together with the Forestry Department (FD) and the Department of National Parks and Wildlife (DNPW), BioCarbon Partners, Ltd., implemented the Community Forests Program (CPF) in Zambia, aiming at exemplifying and supporting the Government of Zambia with its REDD+ strategy (BioCarbon Partners, 2018). This was implemented in the districts of Mambwe and Rufunsa, from 2014 to 2019, and the implementing parties should be consulted for their knowledge.

The development of community-level forest management plans at project intervention sites is programmed under the Ministry of Lands and Natural Resources (MLNR)'s project "Building the resilience of local communities in Zambia through the introduction of Ecosystem-based Adaptation into priority ecosystems, including wetlands and forests" (2019-2023), financed by the Least Developed Countries Fund (LDCF), managed by the Global Environment Facility (GEF). The idea is to afford traditional authorities and local communities management rights over local forests and so the project also envisages the formation of Community Forest Management Groups (CFMGs) at the local level, under the technical guidance of Forestry Department officials in relevant District Development and Coordination Committees (DDCCs); CFMGs may be formed by Village Action

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<sup>6</sup> Eco-Charcoal web page: <http://www.eco-charcoal.com/>





Groups (VAGs) which are sub-components of Community Resource Boards (CRBs) (MLNR, 2021, draft project document).

Regarding non-wood forest products, and within the creation of community-led tree nurseries in the scope of the reforestation programme (section 7.4.1.2.B)), **indigenous fruit trees should also be grown**, for plantation in household gardens and around cultivation patches.

The table below lists the indigenous fruit trees commonly collected in rural Zambia (more specifically, in the Copperbelt), and of possible occurrence in the Conservation plan area.

**Table 14 – Indigenous fruit trees of possible occurrence in the Conservation plan area and their uses**

| Species                                                | Common name       | Uses         |
|--------------------------------------------------------|-------------------|--------------|
| <i>Adansonia digitata</i> L.                           | Baobab; Muuyu     | FF           |
| <b><i>Anisophyllea boehmii</i> Engl.</b>               | Mufungu           | FF; IRB; DRB |
| <i>Diospyros mespiliformis</i> Hochst. Ex A. DC.       | -                 | FF           |
| <i>Landolphia kirki</i> Dyer                           | Kirk's Landolphia | FP           |
| <b><i>Parinari curatelifolia</i> Planch. Ex Benth.</b> | Mupundu           | FF; SO       |
| <i>Strychnos cocculoides</i> Baker                     | Kasongole         | FF; DR       |
| <i>Strychnos innocua</i> L.                            | Mulumgi           | FF; SO       |
| <i>Strychnos pungens</i> Soler.                        | -                 | FP           |
| <i>Syzygium guineense</i> (Willd.) DC.                 | -                 | FF           |
| <i>Trichilia emetica</i> Vahl.                         | -                 | FF; SO       |
| <b><i>Uapaca kirkiana</i> Mull. Arg.</b>               | Masuku            | FF; ILB      |

Source: Adapted from Kalaba, 2007.

Legend:

In bold: preferred species.

Uses: FF – fruit eaten fresh; FP – fruit eaten in a pulp; SO – oil extracted from seeds; IRB – infusion from roots and barks; DRB – decoction of roots and bark; ILB – infusion of leaves and bark; DR – decoction of roots.

The promotion of alternative energy sources – such as through the distribution of household solar equipment –could also help relieve the pressure on forest ecosystems.



## B) Best practice recommendations

In what concerns the activities linked to forest resource extraction, a number of best practices can be employed to reduce the negative impacts of these uses, and improve the regenerative capacity of the vegetation – hence.

Improved technologies and best-practice guidelines should be developed and disseminated throughout local populations, to promote the sustainable use of forest resources:

- Promotion of Improved kiln technologies;
- Promotion of Improved fish processing technologies (cf., section 7.4.4.2.B));
- Substitution of energy inefficient equipment in households, reducing the waste of wood products and/or the need for charcoal;
- Guidelines for harvesting bark to avoid negatively impacting the tree's health and survival (prevention of ring barking, reduction of fungal infestation, promotion of the use of leaves for medicinal purposes in the place of bark);
- Guidelines for harvesting mushrooms to enable the perpetuity of their populations;
- Guidelines for leaving/conserving important fruit trees such as *Parinari curatelifolia*, *Strychnos cocculoides* and *Uapaca kirkiana* in farmed fields during clearing operations;
- Guidelines to improve post-harvest natural regeneration of forest/woodland vegetation; these should include, for instance, cutting at a minimum height and only above a specific stem size, preferably before the onset of the rainy season; protecting harvested blocks from fire in the first two years; promoting light cattle-grazing to limit competition from grasses, among other.



#### **7.4.5. Climate change resilience**

There is a large range of possible response options for adapting to climate change, when referring for example to water resources. These options can be related to policies, investments, institutions, water management, farming practices and capacity development, both within the water and agriculture sectors and beyond.

The strategies here presented are divided according to their coverage into regional and local scale.

##### **7.4.5.1. Regional scale (watershed management)**

The present conservation plan refers to an area which is very much dependent on the watershed it is in. This immediately related the Lukanga Swamp catchment, but also for the Upper Kafue River, since there is a temporary seasonal connection between both areas. Watershed management occurs through a continuous and adaptative cycle with different phases, which can be specifically applied to the water sector. The “enabling environment” is one of these phases, and perhaps the first to start with, as it forms the basis of the actions, processes, traditions, and institutions by which authority is exercised and collective decisions are taken and implemented.

The enabling environment is composed of the policy framework, legislation, institutional and financial arrangements. The policy framework and legislation for the protection of the water resources exist in Zambia (e.g., National Water Policy, 2010; National Policy on Environment, 2009; National Policy on Climate Change, 2016; Water Resources Management Act No. 21, 2011; Environment Management Act No. 12, 2011). However, a watershed management plan for the Kafue River was not yet developed and vertical and horizontal coordination mechanisms (e.g., watershed management committees) that foster policy alignment, and cooperation across different government sectors and levels for watershed management seem to some extent ineffective or non-existent.

There are national and regional agencies with the responsibility to collect hydrology, precipitation, and hazard information, but, according to available information, monitoring data on these topics has not been done continuously and has been very localised. Moreover, the management of an area and the creation of management plans when there is no monitoring of the territory is a real challenge, despite punctual moments when information is collected in a non-structured manner. The challenge comes because there



is not a diagnosis based on solid information that covers the entire basin over a minimum period to contain seasonal but also interannual phenomena.

The measures for Kafue river basin upstream are presented elsewhere, in section 7.5.

Given the above context and considering the goal of the present conservation plan for a wetland area, several measures and recommendations are here developed for the Lukanga Swamp catchment, without the context of a superior plan for the management of the whole Kafue River or even the Upper Kafue Basin. The measures for the water resources on a regional scale are focused on the sustainability of the wetland area, considering the two primary management objectives for the site indicated previously, and considering the ecological status of the hydrological values “surface water quantity” and “groundwater quantity”.

Given increasing effects of climate change (an increase of average temperatures and changes in rain patterns), and considering what has been observed in the area about water resources, the following strategies are key for the sustainable use of water resources (besides water quantity monitoring proposed in section 7.4.2.1):

- **The rate of deforestation must decrease, and the area occupied with forests with native species should be increased in the watershed.** The success of this measure will have a huge impact on water resources, but also on soil erosion. Consult the strategies for forest resources in sections 7.4.3.1, 7.4.3.2 and 7.4.4.5.
- The following **local-scale measures should be fostered throughout the whole Lukanga Swamp catchment.** This must be integrated through capacity building initiatives in the different villages of the area (section 7.4.3).



#### 7.4.5.2. Local scale (climate-smart agriculture)

The major impacts of climate change on agriculture are expected to result from its effect on the water cycle. Although there is no evidence of a decrease in surface water or groundwater quantities in the Lukanga Swamp area (*cf.* Part I of the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, chapter 4 – Evaluation), water resources must be used sustainably, as the effects of climate change will certainly intensify in the future. Besides, the impacts of climate change on water resources used for agriculture must be situated in a wider context. Responses to address these impacts need to consider other pressures affecting water resources, such as the increasing demand and competition for water by all sectors and the degradation of water quality.

An approach that views potential responses to climate change through a “water lens” must be used when designing climate-smart agriculture strategies (like those proposed in section 7.4.4.1).

Many farm-level adaptations will be spontaneous and in response to changing conditions, but they will not necessarily be designed for climatic changes. Other adaptations will need to be planned, often with external financial support. Of prime importance is increasing the ability of farming systems to cope with more variable supplies of rainwater. This will require improving the capacity to store water in the soil, surface reservoirs or underground reservoirs.

Any action that increases the capacity of the farming system to access water when needed will increase the system’s resilience to climate variability. Actions in this area include:

- On-farm rainwater harvesting;
- Enhancement of the soil’s capacity to hold moisture;
- Where possible, more systematic access to groundwater.

Ecosystem-based Adaptation (EbA – the use of biodiversity and ecosystem services to help people address the adverse effects of climate change) can also complement or offer alternatives to conventional agricultural practices – such as climate-resilient agriculture. So, its introduction in Lukanga Swamp is already being programmed by the Ministry of Lands and Natural Resources under the project “Building the resilience of local communities in Zambia through the introduction of Ecosystem-based Adaptation into priority ecosystems, including wetlands and forests” (2019-2023), financed by the Least Developed Countries Fund (LDCF), managed by the Global Environment Facility (GEF)



(MLNR, 2021, draft project document). The impacts of EbA on the supply of ecosystem services under climate change conditions will also be an important aspect of the project's research programme.

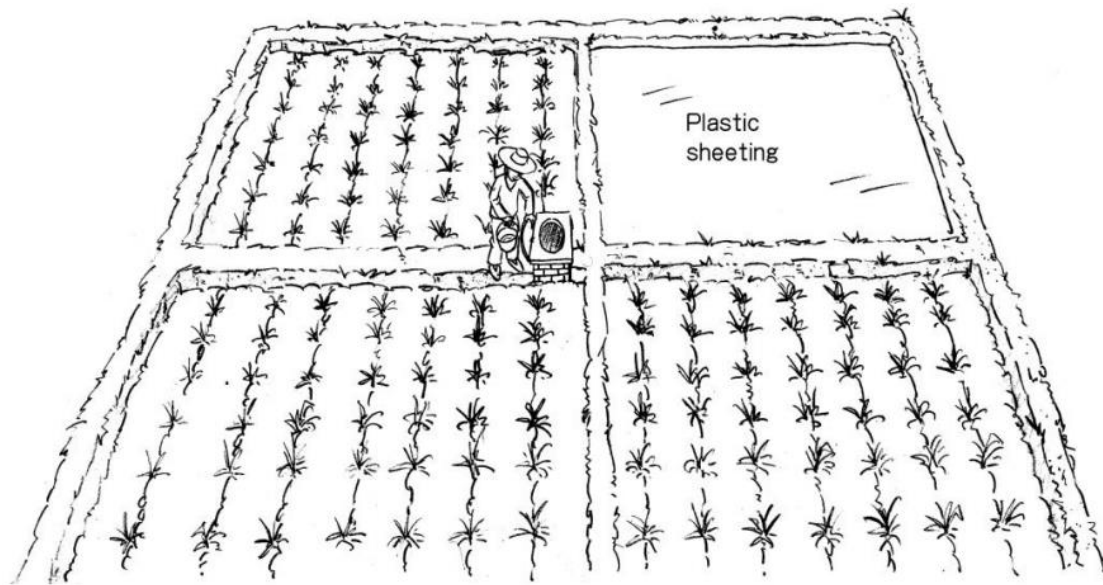
“Strengthening climate resilience of agricultural livelihoods in Agro-Ecological Regions I [Bangweulu and Lukanga] and II in Zambia Project” (2018–2025), implemented by the Ministry of Agriculture, also aims at strengthening the resilience of the agro-based value chain for smallholder farmers in the targeted region against climate change risks; this is to ensure that climate-informed decision-making, critical inputs, production techniques and post-production strategies (including linkages to markets) are in place to increase the resilience of livelihoods and bring both female and male farmers as well (“Building the resilience of local communities in Zambia through the introduction of Ecosystem-based Adaptation into priority ecosystems, including wetlands and forests” draft project document, MLNR, 2021).

### **A) On-farm rainwater harvesting**

On-farm rainwater harvesting is important in most of the villages in the Lukanga Swamp area as they are very much dependent on groundwater for daily uses. Simple rainwater harvesting structures can have an important impact over agriculture fields from a village.

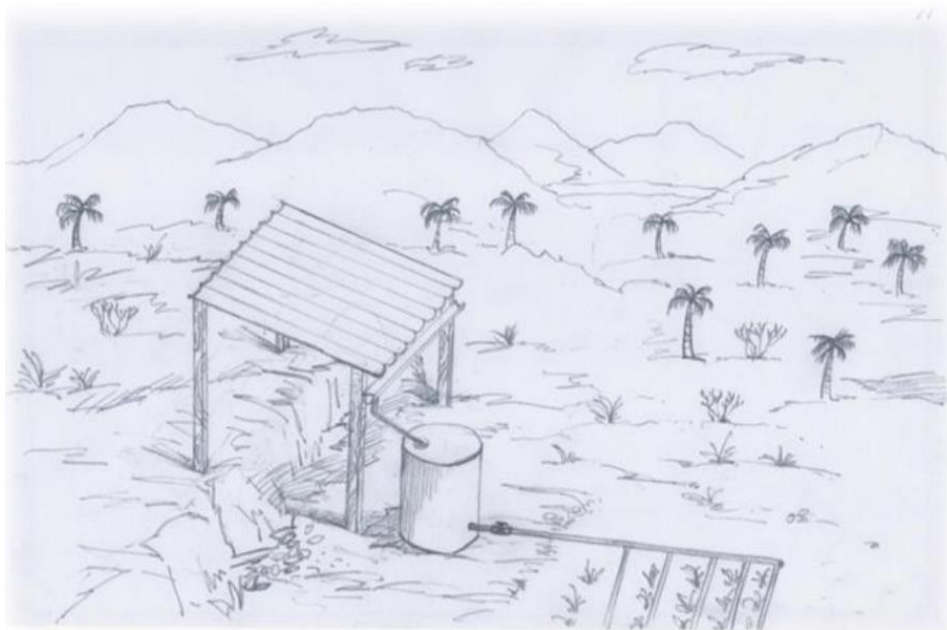
The basic structure of the rainwater harvesting system could include the water catchment, conveyance, and storage and supply systems to the field, but it may be simpler (Figure 10 and Figure 11):

- Catchment and surfaces may be natural or artificial slopes (rooftops, hillsides, tree trunks and canopies, greenhouse roofs and plastic-covered ground surfaces in the cropped field). Catchment and surface systems must be of rainwater collection efficiency.
- Conveyance systems carry water from catchment to storage in gutters and pipes or earthen channels. Rainwater harvesting is for on-farm collection and storage: hence, a simple conveyance system serves the purpose.
- Storage systems are usually drums, tanks, ponds and/or mini-dams. Storage construction material may be earthen, cement or plastic, including plastic bags, depending on suitability and affordability to the farmer. Seepage and infiltration should be avoided.



Source: FAO (2014).

**Figure 10 – Storage tank is in the centre of the field**



Source: FAO (2014).

**Figure 11 – Layout of mini-rooftop rainwater harvesting system for vegetable irrigation**





## **B) Enhancement of the soil's capacity to hold moisture**

Since climate change has an impact on every element of the water cycle, particular attention should be placed on using water efficiently.

Water storage in the soil depends on many factors, including the amount and intensity of rainfall, soil depth, soil texture (e.g., clay content), soil structure, soil temperature, and the content and type of soil organic carbon. Different soil types, textures and structures have different degrees of water permeability and offer different levels of protection for soil organic matter. Within the soil, stable forms of soil organic carbon, such as humus, can hold up to 7 times their own weight in water (FAO, 2021).

Soil management can increase water infiltration, strengthen the capacity of the soil to store water and reduce soil water evaporation.

Groundcover management can have highly significant effects on soil surface conditions, soil organic matter content, soil structure, porosity, aeration, bulk density. This has a direct influence on infiltration rates, the water storage potential of the soil and water availability to plants.

Roots, and the organisms that thrive in undisturbed soils create channels that improve soil porosity and the water infiltration rate.

Minimising soil compaction increases the effectiveness of rainfall, enhances productivity, reduces erosion and the dispersion of soil particles, and lowers the risks of waterlogging. Compacted soils or soils with a hardpan may waterlog easily and then dry out quickly.

Sandy soils can be managed productively even in hot, dry climates by adding organic matter (e.g., green manure, animal manure, composted material) and, in irrigated systems, supplying nutrients through drip irrigation.

The good management of soil-crop-water interrelations can maintain and increase soil organic matter, improve the soil's nutrient retention capacity, and enhance soil biodiversity. This integrated management can create optimal conditions for crop production, while simultaneously increasing the resilience of production systems to climate change.



In crop production systems, good management practices to increase soil organic matter (*i.e.*, enhance soil's capacity to hold moisture) include (FAO, 2021)<sup>7</sup>:

- direct seeding (no-tillage) in combination with protective soil cover, crop diversification and crop rotation;
- the elimination of the burning of crop residues;
- integrated soil fertility management to increase the soil's nutrient retention capacity and the availability on nutrients to plants;
- the precise management of nitrogen;
- integrated pest management, which includes the sustainable use of herbicides.
- the construction of soil conservation structures, such as stone and earth terraces and bunds, and check dams;
- irrigation or partial irrigation where needed or possible;
- the harvesting and proper use of rainwater (see solutions above);
- the development of reliable sources of information and extension services that are tailored to local conditions; and
- appropriate soil erosion control practices.

In grazing systems, soil organic matter can be increased through controlled grazing, which reduces the degradation of vegetation and restores grassland diversity. Although burning is often a preferred strategy to enhance phosphorus and encourage the growth of young plants for grazing animals, burning should be reduced to the absolute minimum to increase soil organic matter.

Integrated crop and livestock systems can be used to enhance soil fertility. Pasture cropping, a practice where an annual crop is grown out-of-phase with perennial pasture, builds soil at higher rates than perennial pastures alone.

All the above measures and practices help increasing organic matter in the soil and therefore enhance soil's capacity to hold moisture.

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<sup>7</sup> These practices are further developed in the soil quality value below.



### **C) More systematic access to groundwater**

Most of the villages visited in 2019 had wells, some of them built recently. However, since a systematic survey of wells was not taken, it is impossible to know if every village in the Lukanga Swamp catchment has easy access to groundwater. It would be important that the government guarantees this.



## 7.5. Strategies concerning the Upper Kafue Basin

Similarly to the Lukanga Swamp watershed, the management of the Upper Kafue river basin should monitor and regulate the activities that are likely to impact healthy functioning of the swamp ecosystems and its surroundings, endangering biodiversity and human populations alike.

Nonetheless, governance of areas included in the Kafue River catchment, including the Upper Kafue Basin and inside this part the Lukanga watershed should be seen holistically. For this reason, water governance for the whole area should be dealt considering all uses present in the catchment through a specific management instrument (e.g., Kafue River Basin Management Plan).

The Lukanga Swamp functions like a sponge, absorbing water that comes in during the wet season (or from the periodically flooding of the Kafue through overflow), releasing it slowly during the dry period, providing a safe source of water to the downstream Kafue River during the dry season. In addition, the water from the Kafue River that overflows into the swamp will be filtered of contaminants to be later returned into the Kafue River again. These ecosystem services provided by the swamp are in part also dependent on what happens in the Upper Kafue River in terms of water management, land use and practices in the catchment. For this reason, the conservation of the Lukanga Swamp area is also dependent on the management of the Upper Kafue River catchment.

The ecosystem services described above depend in part on the overflow from the Kafue River into the Lukanga Swamp, and water levels in the swamp may to some extent be dependent on this overflow. For these reasons, interventions that lead to the regularization of the Kafue river flows upstream of the places where there is seasonally overflow to the swamp will interfere with the whole system.

In this context, the following activities should be restricted and need to be regulated in the Upper Kafue river basin:

- Interventions that alter water and flood levels across the basin, impacting the seasonal flooding pattern in the Lukanga wetland;
- Degradation of forest and riparian habitats to ensure the maintenance of terrestrial habitats with protective functions in the catchment;
- Industrial and domestic waste discharges into the wetland and river system;
- Invasive weed introduction.



In practice, any development project – and in particular river regularization interventions (such as levees, embankments, dykes, road ways, weirs, and small dams) – suspected to impact the hydrology of the UKRB, Lukanga watershed and swamp, must be **submitted to Environmental Impact Assessment (EIA)**, including the evaluation of cumulative impacts. Impacts on the swamp's hydrology need to be monitored and appropriately mitigated.

To ensure compliance with this measure, a legal instrument should be created mandating the development of EIA studies in the basin, and ideally setting thresholds above which projects should be reviewed or cancelled.

Regarding **land-use** at the different management scales, a clear difference can be observed between the upper basin and the watershed when it comes to forest reserves. While the sub-catchment has but a few local and national forests, the Upper Kafue River catchment has an abundance of these designations, including two large National Forests explicitly aimed at the protection of the basin's headwaters. National Forest designations aim at securing areas of national importance, conserving ecosystems and biodiversity, promoting improved forest resource management and sustainable use, as well as water catchment and head waters management (Forest Act, 2015). Given this explicit purpose of buffering water systems, efforts should be directed, in the scope of the Lukanga Conservation Plan, towards **preventing deforestation in the reserves of the Upper Kafue Basin**.

The prevention and control measures detailed in section 7.4.1.3.A) for invasive alien species should be implemented across the Upper Kafue Basin.

In addition, it is key to guarantee through regular inspections and analyses to surface water and groundwater that mining activities in the Copperbelt follow laws and regulations established for this economic sector. Under the "Polluter Pays" guiding principle of the National Wetlands Policy (MLNR, 2018), «a person or institution responsible for pollution of the wetland will bear the cost of restoration and clean-up of the affected area to its natural and acceptable state». As such, a system should be introduced to hold polluting companies accountable for their activities, through the payment of fines that will fund corrective action and other management needs under the Lukanga Swamp Conservation Plan.



## 7.6. Environmental monitoring plan

### 7.6.1. Objectives and scope

In the context of the Conservation Plan for Lukanga Swamp and Upper Kafue Basin it is key to start an environmental monitoring plan. The management of the swamp should be founded on solid information that covers the entire catchment over a minimum period to contain seasonal and interannual phenomena.

The goal of the monitoring plan is to build up a database on the different media in the Lukanga Swamp catchment and Upper Kafue Basin, in order to gradually picture a more accurate diagnosis on the area and allow a continuously more focused management on the area. The consecutive results will allow to understand if measures being taken in the catchment are assuring their purpose or if adaptation of these or new ones are needed.

The monitoring plan here presented focus on different media: surface water, groundwater, soil, sediment, habitats and biological communities.

Monitoring water resources comes from several reasons. They are essential resources for the people and biota living in the Lukanga Swamp catchment and of course the quantity and quality of water resources are key values that allow the existence of different habitats in the area.

The soil monitoring programme here presented is focused on soil used for agriculture practices, and is a key tool in sustainable soil management, including judicious fertilization. If soil is treated sustainably there will be less need for occupying forested areas and other natural areas in the catchment.

Because soil health is not something that can be measured directly, there is need for indicators that are easily measured. Regular testing of key soil attributes is uncommon. As an example, Schmidhalter (2005) claimed that only 1% of agricultural soils globally are sampled annually for determining levels of nitrogen (widely said to be the most important plant macronutrient). Soil testing is even less common in Sub-Saharan Africa. For this reason, the monitoring here recommended is a low-tech approach for soil testing in remote areas, with specific tailoring to the Eastern and Southern African context based on the SIMLESA Soil Manual (Roxburgh *et al.*, 2018). For more information, this manual can be downloaded here:

[https://www.researchgate.net/publication/330103156\\_SIMLESA\\_Soil\\_Manual\\_Simple\\_protocols\\_and\\_resources\\_for\\_rapid\\_soil\\_field\\_testing\\_in\\_Africa](https://www.researchgate.net/publication/330103156_SIMLESA_Soil_Manual_Simple_protocols_and_resources_for_rapid_soil_field_testing_in_Africa).



The monitoring of sediments is relevant as they are used as proxies for water contamination, because in many cases they are the (temporary) destination of contaminants.

The monitoring of habitats (permanent swamp and seasonally flooded grasslands) and biological communities (fish, zooplankton, aquatic macrophytes, etc.) will allow researchers and managers to build a better understanding of the ecological dynamics and functions of the system, which is key to its effective management.

Fish, zooplankton, phytoplankton and aquatic macrophytes, in addition, are useful bioindicators of environmental change, being commonly used in water quality assessments and biomonitoring of river and wetland systems – such as under the European Union’s Water Framework Directive.

Macrophyte monitoring is simpler and can also be informative regarding the system’s conditions. Even though standardized biomonitoring protocols and reference values for wetland monitoring in Zambia are not yet established, the monitoring efforts undertaken in the scope of the Swamp’s management provides an opportunity to develop a pilot study for this purpose. Such a study has been conducted for river biomonitoring in the country, through the SAFRASS<sup>8</sup> project, which resulted in a *Zambian Macrophyte Trophic Ranking scheme (ZMTR)* (Kennedy *et al.*, 2016; Lowe *et al.*, 2015) and a *Zambian Invertebrate Scoring System (ZISS)* (Dallas *et al.*, 2018; Lowe *et al.*, 2015) that aim at capacitating local managers with rapid assessment protocols for data-driven management.

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<sup>8</sup> SAFRASS: Southern African River Assessment Scheme

“The project involves a partnership of Universities and stakeholder agencies institutes from Zambia (University of Zambia; Kasanka Trust), South Africa (University of Cape Town; North-West University) and the UK (Universities of Aberdeen and Glasgow), and has two main objectives: (i) to build the local capacity (amongst partnership members and relevant stakeholders such as water management agencies) needed to construct cheap, effective biomonitoring procedures to assess river water quality and support biodiversity functioning in rivers of southern tropical Africa, using Zambia and northern South Africa as the initial target regions for the Action; and (ii) to promote and strengthen the ability of local water management agencies to assess water quality and riverine biodiversity support functioning in southern tropical African rivers, by utilising the enhanced research capability and knowledge gained by them during the project to further develop the pilot scheme produced as an output of the project, into a viable methodology for implementation within the target region. A main focus of the project will be the construction of a pilot biomonitoring scheme to help assess river health (including biodiversity support capability and minimum ecological flow requirements etc.), and a utilization of the improved capacity of the network partners and stakeholders to undertake a testing programme for the pilot biomonitoring scheme in South African and Zambian rivers; and demonstration of application of the new scheme in relation to river flow management procedures aimed at maintaining riverine biodiversity, in order to inform research and implementation policies in southern tropical Africa.”

Available at: <http://www.safrass.com/objectives/>





Finally, the monitoring of natural systems will also allow the early detection of new invasive species' introductions, and the control of infestation progression; as well as to confirm the presence of globally endangered and critically endangered species.

## **7.6.2. Monitoring parameters**

### **7.6.2.1. Surface water and groundwater**

Different types of parameters should be monitored regarding water quantity and water quality.

For water quantity, groundwater levels, stream water levels and streamflow will be measured.

The following parameters should be monitored in both types of water resources for water quality:

- Temperature;
- pH;
- Conductivity;
- Redox potential;
- Dissolved oxygen;
- Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn);
- Nitrate;
- Phosphorus;
- Biochemical Oxygen Demand (BOD<sub>5</sub>);
- Chemical Oxygen Demand (COD).



#### 7.6.2.2. Soil

In the monitoring it is recommended that eight soil characteristics are interpreted from field visits:

- **Soil texture** – used to estimate the water holding capacity of a soil, as well as its ability to hold nutrients such as potassium, calcium, mineral nitrogen (nitrate) which are more readily stored in higher clay content soils;
- **Soil colour** – can be an approximation of several important soil properties, including organic matter content, and drainage characteristics;
- **Soil bulk density** – provides an important physical measure of a soil's porosity, affecting water infiltration and rooting depth; important component in calculating the total nutrient content of soils in  $\text{kg ha}^{-1}$ ;
- **Soil gravimetric water content** – crucial when calculating soil bulk density and its water capacity, as well as the mass content of soil nutrients (such as nitrogen);
- **Soil pH** – has the potential to affect crop growth and can often be relatively simple to overcome (particularly acidic soils);
- **Electrical conductivity** – provides a measure of soil salinity, which if high enough could disrupt plant uptake of soil water and nutrients. High soil salinity can be addressed through gypsum ( $\text{CaSO}_4$ ) application
- **Soil mineral nitrogen** – primary form of plant-available soil nitrogen, and is mostly present in soils as nitrate-N due to rapid nitrification. As one of the most important crop macronutrients, soil N is critical in determining the potential yield of a crop at the beginning of a season and whether the application of fertiliser is advisable.

A site characterisation is also needed to interpret data gathered.

#### 7.6.2.3. Sediment

Monitoring of sediments should focus on:

- Metals and metalloids (Al, As, Cd, Co, Cu, Cr, Fe, Pb, Hg, Ni, Zn);
- Total organic carbon;
- Grain-size.



#### 7.6.2.1. Habitats

Priority monitoring for habitat management should target the permanent swamp and the edaphic grassland.

For both, the following parameters should be monitored:

- ecological continuum; degree of continuity and connectivity of and between natural habitats, assessed qualitatively;
- risk of fragmentation; risk of further deterioration of the ecological continuum based on the observed pressures (advancing anthropic land uses, etc.), assessed qualitatively;
- conservation status;
- extent of the habitat.

#### 7.6.2.2. Flora

Priority monitoring for flora management should target aquatic macrophytes, phytoplankton, and grassland flora.

For this, the following parameters should be monitored:

- Aquatic macrophytes:
  - number of taxa, or diversity;
  - macrophyte cover; and
  - macrophyte biomass;
- Phytoplankton:
  - community structure (species diversity and relative abundances);
  - biomass;
- Terrestrial grassland flora:
  - Number of taxa, or diversity;
  - Cover.



### 7.6.2.3. Fauna

Priority monitoring for fauna management should target the swamp's ichthyofauna and zooplankton.

In addition, given the site's Ramsar and IBA designations, and provided financial resources are available, monitoring of waterbirds is also recommended. The consistent collection of data on this group will allow the assessment of the site's conditions for the establishment of birdwatching-based tourism.

Finally, given the importance of ungulates to the regulation of grassland habitats, to the maintenance of carrion-dependent bird species, and given the number of potentially occurring species that are near threatened (see Part I's Appendix 3 – Ecological assessment), and may have been eliminated due to human-wildlife conflicts – provided financial resources are available – monitoring of this group is also recommended. This would allow the assessment of the option to reintroduce large herbivores into the system, which could play an important role in the area's potential as a touristic destination.

The following parameters should be monitored:

- Ichthyofauna:
  - species composition;
  - abundance;
  - population structure (based on age or length classes);
- Zooplankton:
  - community structure (species and relative abundances);
  - biomass.
- Waterbirds:
  - number of taxa, or diversity;
  - relative abundances.
- Ungulates:
  - number of taxa, or diversity;
  - population estimates.



### 7.6.3. Spatial distribution of sampling stations

For the location of sampling stations several factors were considered. Of crucial importance were a good representation of the different areas (catchment and swamp) and accessibility, especially during the rainy season.

The spatial scope of the environmental monitoring plan, detailed below, is compiled in Map 5 (Appendix 1).

#### 7.6.3.1. Surface water

Fourteen stations for surface water collection were defined, being 5 stations in the swamp, 6 stations in streams draining into and from the swamp, and 3 stations in the Kafue River (Table 15 and Figure 12). The cross-section up- and downstream of the gauging station should be as constant as possible and no obstructions (e.g., by plants or abrupt changes in flow direction) should occur downstream. For example, if a station is near the road (e.g., 11SW and 12 SW) the station should be downstream of the road.

**Table 15 – Location of stations for surface water collection and *in situ* analyses**

| Station number | Latitude       | Longitude | Type of water body | Description                                                                         |
|----------------|----------------|-----------|--------------------|-------------------------------------------------------------------------------------|
| 1SW            | -<br>14.234942 | 27.669635 | Swamp              | Open lake near Chilwa Island. Station 28Oc from the EQA                             |
| 2SW            | -<br>14.326142 | 27.937798 | Swamp              | Area with low vegetation density near Waya. Station 26Oc from the EQA               |
| 3SW            | -<br>14.447499 | 27.925781 | Swamp              | Area with low vegetation density near Kaswende. Station 27Oc from the EQA           |
| 4SW            | -<br>14.525685 | 27.659352 | Swamp              | Open lake near Kabosha. Station 25Oc from the EQA                                   |
| 5SW            | -<br>14.410332 | 27.732409 | Swamp              | Open lake in centre of the swamp area.                                              |
| 6SW            | -<br>14.026741 | 27.839144 | Stream             | Lukanga River, near the road between Shamputa and Mukubwe. Station 11S from the EQA |
| 7SW            | -<br>14.104430 | 28.092999 | Stream             | Mufukushi River, close to Mpunde. Station 10S from the EQA                          |



| Station number | Latitude       | Longitude | Type of water body | Description                                                                                                          |
|----------------|----------------|-----------|--------------------|----------------------------------------------------------------------------------------------------------------------|
| 8SW            | -13.64159      | 27.61706  | Stream             | Kafue River. The station is where the road from Munkumpu encounters the Kafue river. Station 7Oc from the EQA        |
| 9SW            | -<br>14.112375 | 27.410839 | Stream             | Kafue River, near Lufubu. Station 14S from the EQA                                                                   |
| 10SW           | -<br>14.372917 | 27.18543  | Stream             | Kafue River. The station is immediately downstream from the junction with the Lukanga River. Station 1S from the EQA |
| 11SW           | -<br>14.572744 | 27.287036 | Stream             | Mushingashi River. Station 2S from the EQA                                                                           |
| 12SW           | -<br>14.570536 | 27.471297 | Stream             | Muundu River. Station 18S from the EQA                                                                               |
| 13SW           | -14.63323      | 27.586285 | Stream             | Mufuwa River, immediately to the west of Chitanda. Station 4S from the EQA                                           |
| 14SW           | -<br>14.436256 | 27.510353 | Stream             | Lukanga River, 3.5 km downstream from the swamp outlet. Station 3S from the EQA                                      |

EQA – Environmental Quality Assessment



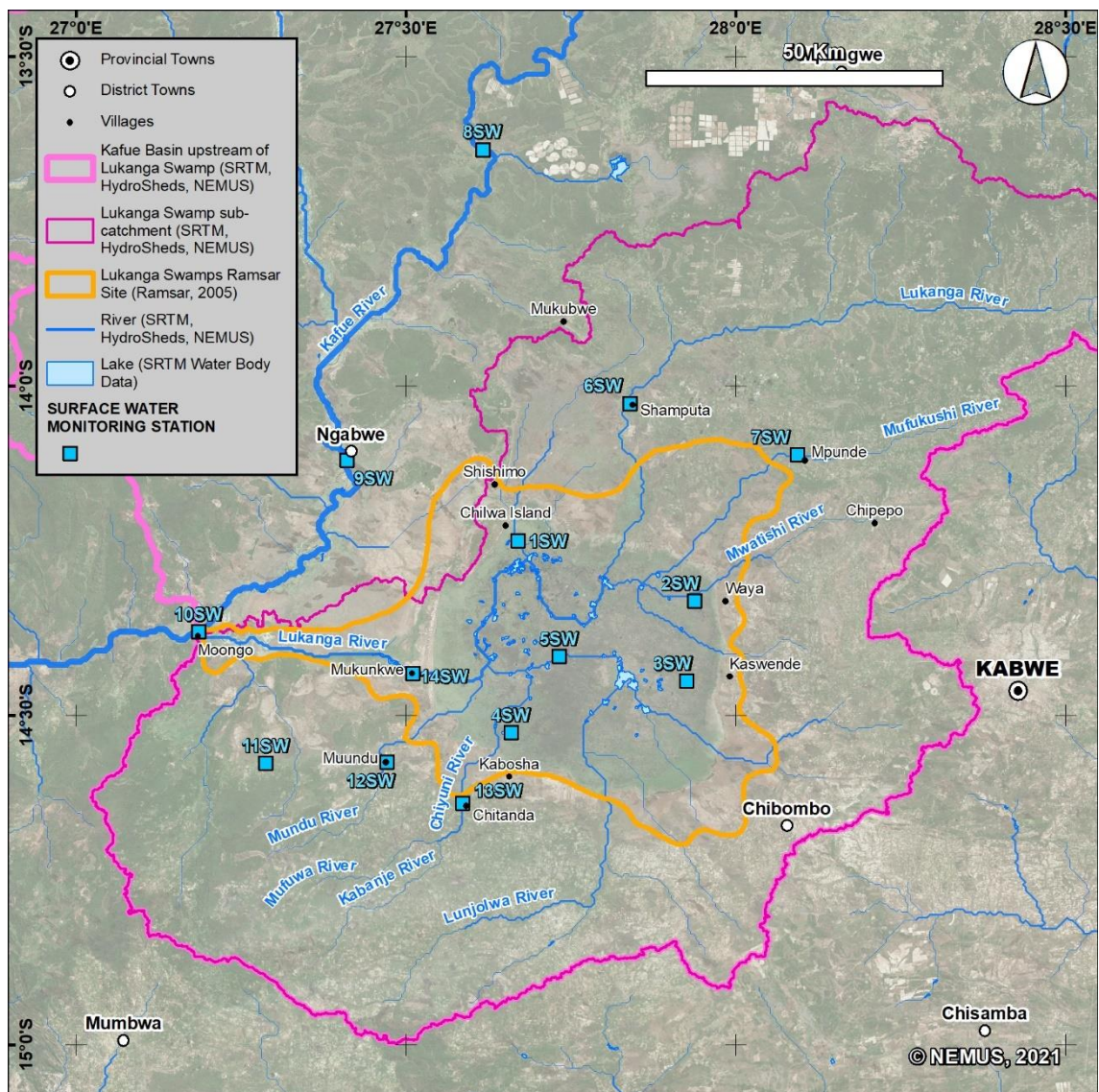


Figure 12 – Location of stations for surface water collection and analyses





### 7.6.3.2. Groundwater

Twelve wells were selected for groundwater collection and for *in situ* analyses (Table 16 and Figure 13).

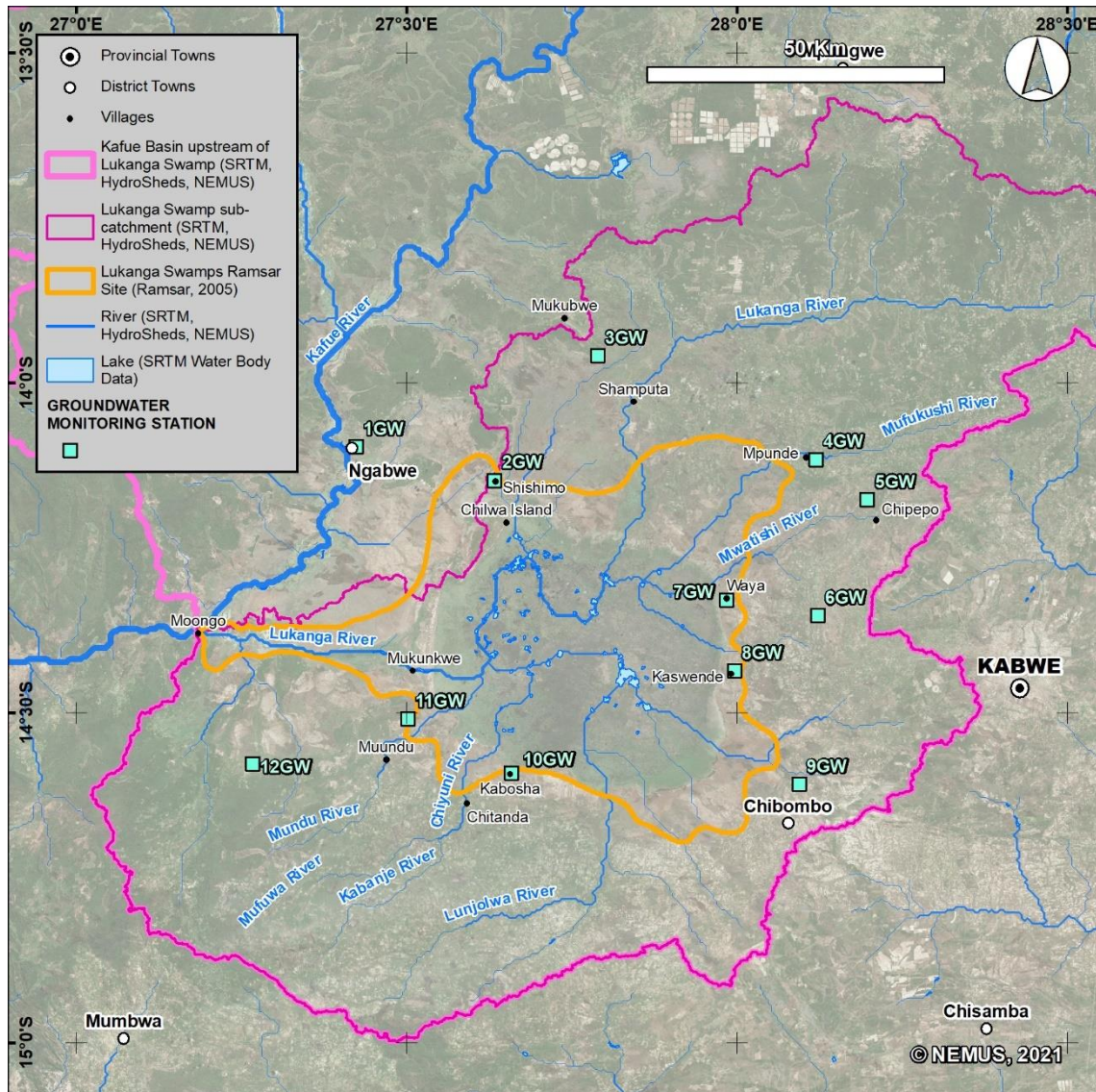


Figure 13 – Location of stations for groundwater collection and analyses



**Table 16 – Location of stations for groundwater collection and *in situ* analyses**

| Station number | Latitude   | Longitude | Type of water point | Description                                                                             |
|----------------|------------|-----------|---------------------|-----------------------------------------------------------------------------------------|
| 1GW            | -14.096906 | 27.423463 | Sealed well         | Near Lufubu. Station 16S from the EQA                                                   |
| 2GW            | -14.147797 | 27.632973 | Sealed well         | In Shishimo. Station 25S from the EQA                                                   |
| 3GW            | -13.959004 | 27.789172 | Sealed well         | Common area near between Mukubwe e Shamputa. Station 23S from the EQA                   |
| 4GW            | -14.116109 | 28.11901  | Sealed well         | Common area near Mpunde. Station 8bS from the EQA                                       |
| 5GW            | -14.176996 | 28.19719  | Open well           | Close to Chipepo. Station 5S from the EQA                                               |
| 6GW            | -14.352622 | 28.122331 | Sealed well         | Near the road between Waya and Kabwe. Station 29S from the EQA                          |
| 7GW            | -14.329142 | 27.983745 | Sealed well         | In Waya. Station 9S from the EQA                                                        |
| 8GW            | -14.436397 | 27.996556 | Sealed well         | Near Kaswende. Station 22S from the EQA                                                 |
| 9GW            | -14.607876 | 28.094386 | Sealed well         | North of Chibombo. Station 20S from the EQA                                             |
| 10GW           | -14.590843 | 27.658371 | Sealed well         | In Kabosha with a solar pump. Water was stored in a container. Station 26S from the EQA |
| 11GW           | -14.509435 | 27.502101 | Open well           | South of Mwanakabwata. Station 28S from the EQA                                         |
| 12GW           | -14.577488 | 27.267126 | Open well           | Near the Mushingashi River. Station 27S from the EQA                                    |

EQA – Environmental Quality Assessment



### 7.6.3.3. Soil

Eleven areas were selected for *in situ* analyses (Table 17 and Figure 14). Unlike the locations indicated previously in Table 15 and Table 16, locations for soil are general. They refer to villages whose soils should be studied. Three locations in each village can be selected for these analyses.

**Table 17 – Location of stations for soil collection and *in situ* analyses**

| Station number | Latitude   | Longitude | Description |
|----------------|------------|-----------|-------------|
| So1            | -14.591624 | 27.656549 | Kabosha     |
| So2            | -14.437076 | 27.508925 | Mukunkwe    |
| So3            | -14.379509 | 27.186764 | Moongo      |
| So4            | -14.573116 | 27.275681 | Ipongo      |
| So5            | -14.437438 | 27.995645 | Kaswende    |
| So6            | -14.328841 | 27.983602 | Waya        |
| So7            | -14.112684 | 28.104081 | Chilenga    |
| So8            | -13.943636 | 27.775601 | Mukubwe     |
| So9            | -14.148443 | 27.633998 | Chichimo    |
| So10           | -14.657834 | 28.072599 | Chibombo    |
| So11           | -13.881135 | 28.039516 | Makankula   |



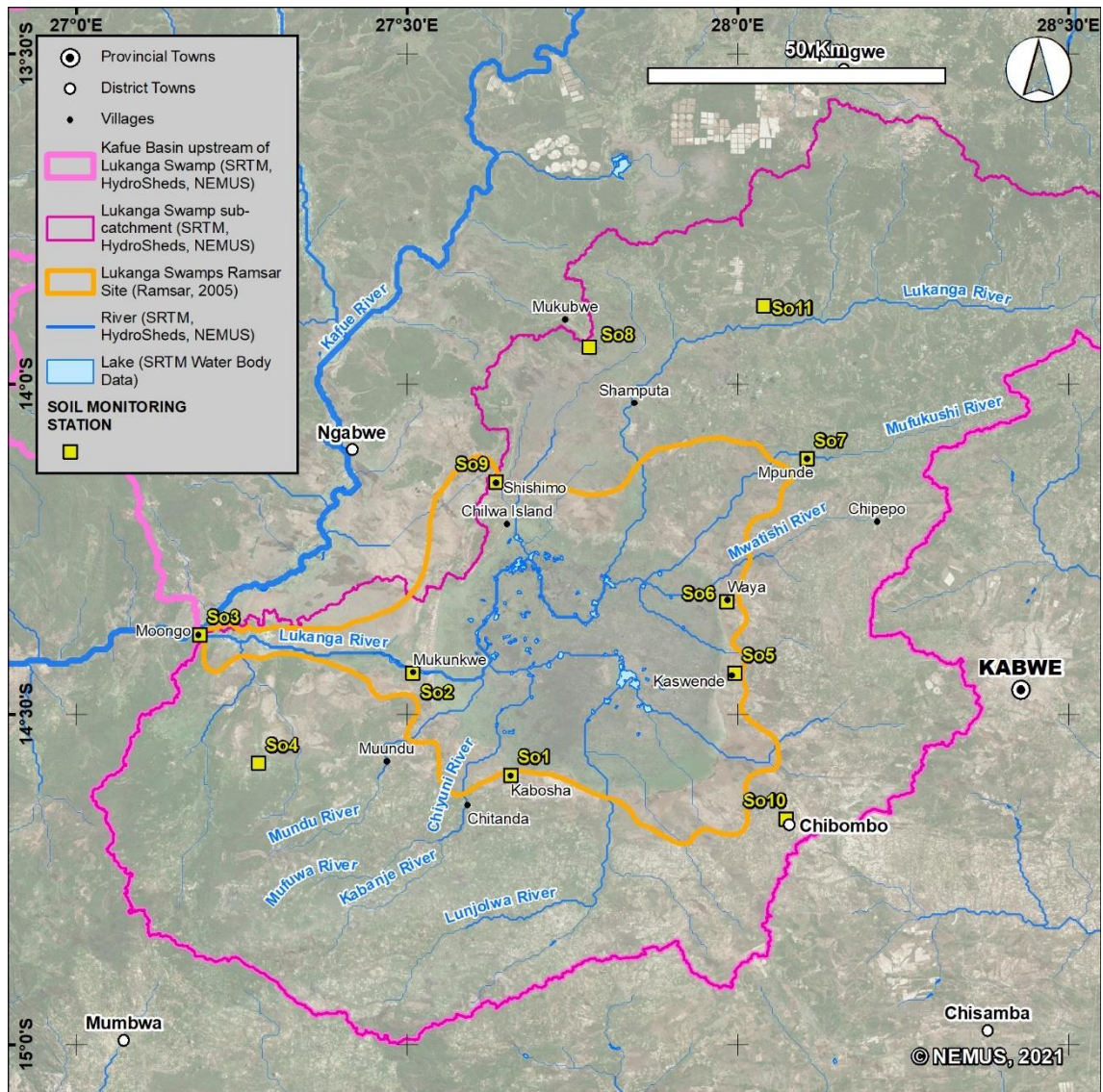


Figure 14 – Location of stations for soil collection and analyses





#### 7.6.3.4. Sediment

Ten stations were selected to collect sediment samples in different permanent streams in the Lukanga catchment and in the Kafue River (Figure 15 and Table 18).

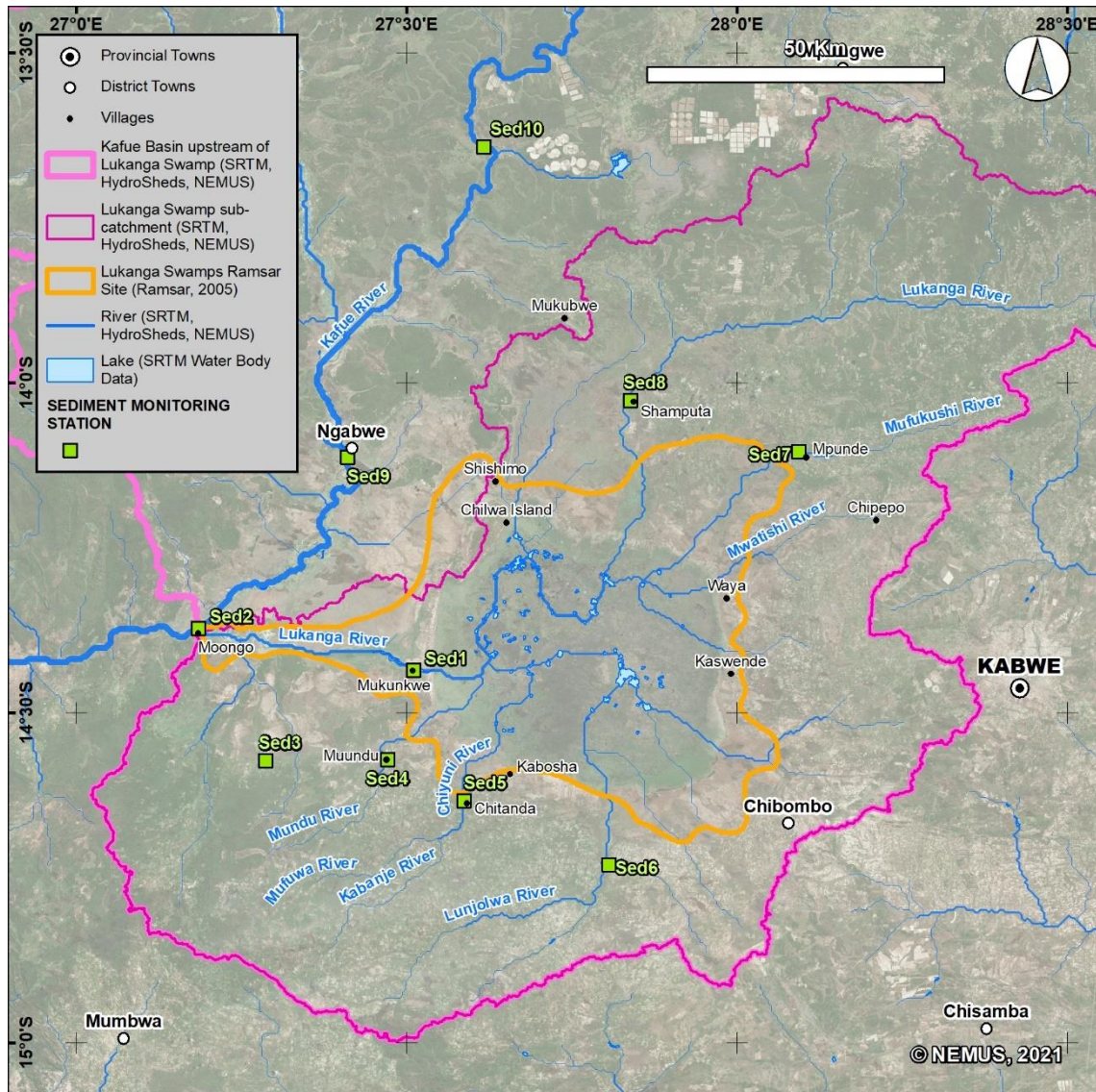


Figure 15 – Location of stations for sediment collection



Table 18 – Location of stations for sediment collection

| Station number | Latitude   | Longitude | Description                                          |
|----------------|------------|-----------|------------------------------------------------------|
| Sed1           | -14.435615 | 27.510708 | Lukanga River (downstream from swamp)                |
| Sed2           | -14.372306 | 27.185215 | Kafue River (downstream from Lukanga River junction) |
| Sed3           | -14.572778 | 27.286978 | Mushingashi River                                    |
| Sed4           | -14.570161 | 27.471449 | Mundu River                                          |
| Sed5           | -14.633079 | 27.586940 | Mufuwa River                                         |
| Sed6           | -14.730186 | 27.805586 | Lunjolwa River                                       |
| Sed7           | -14.104484 | 28.092851 | Mufukushi River                                      |
| Sed8           | -14.027104 | 27.838836 | Lukanga River (upstream from swamp)                  |
| Sed9           | -14.112651 | 27.410445 | Kafue River                                          |
| Sed10          | -13.643145 | 27.616263 | Kafue River (upstream point)                         |

#### 7.6.3.5. Habitats

Eight (8) sites were defined for monitoring the swamp and grassland habitats: Moongo; Mukunkwe; Kabosha; Chipito; Kaswende; Waya; Shishimo and Kamwengo (in Chilwa Island).

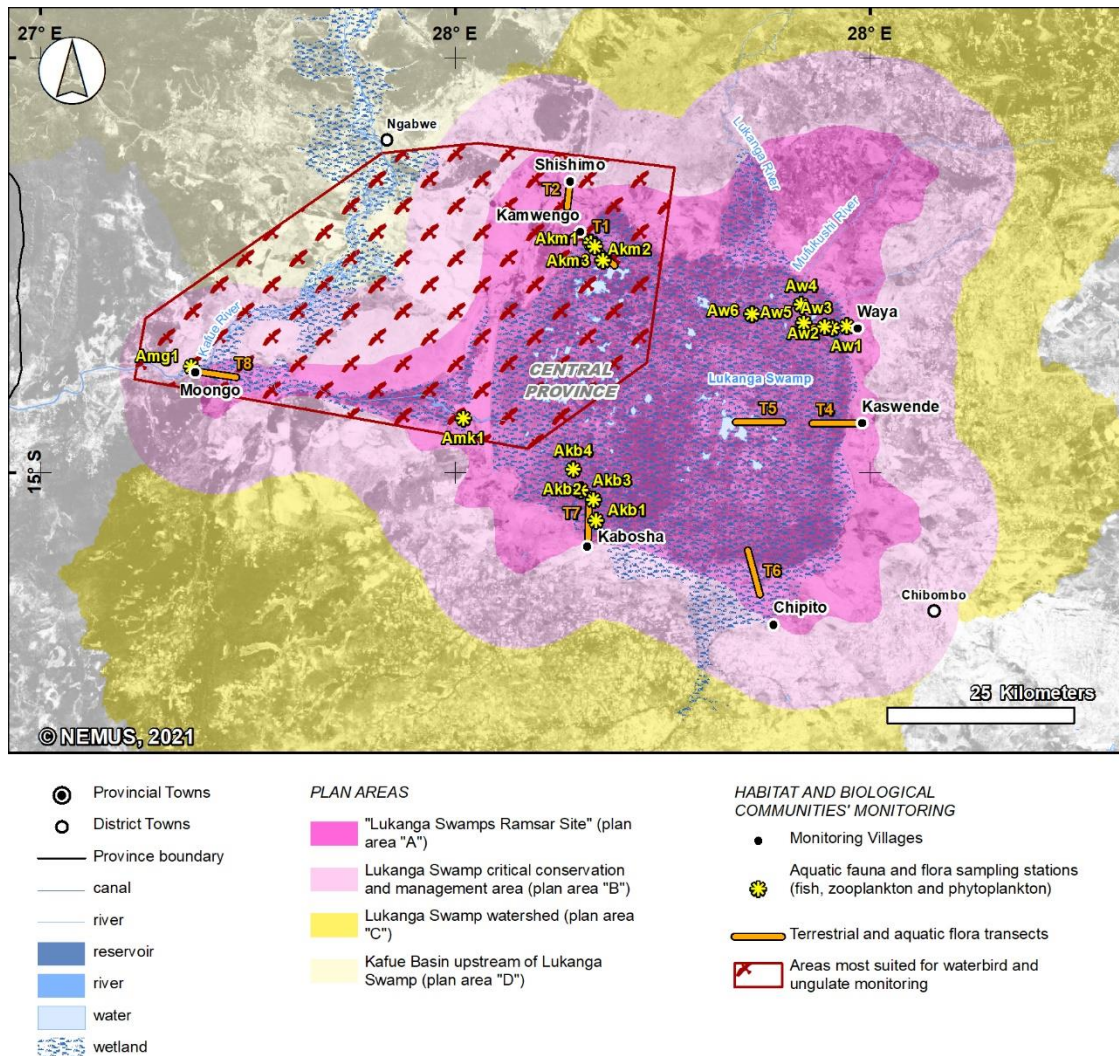
These are village names that indicate where to access the swamp and grassland, and are **not the monitoring stations *per se***. A proposal of transects for each of these sites is given in Table 19 and Figure 16.



**Table 19 – Location of the transects for habitat monitoring**

| Transect number | Starting point |               | Finishing point |               | Description                                                                                                                                            |
|-----------------|----------------|---------------|-----------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | Latitude       | Longitude     | Latitude        | Longitude     |                                                                                                                                                        |
| T1              | 14°22'36.85"S  | 27°10'48.67"E | 14°23'7.53"S    | 27°14'7.82"E  | Oriented west to east from Moongo; mostly grassland, but crosses river meanders                                                                        |
| T2              | 14°34'48.80"S  | 27°39'36.61"E | 14°31'33.01"S   | 27°39'39.63"E | Oriented south to north, from Kabosha; grassland, swamp and lake                                                                                       |
| T3              | 14°38'48.93"S  | 27°51'59.75"E | 14°35'39.27"S   | 27°51'8.73"E  | Oriented southeast to northwest, from Chipito; mostly grassland                                                                                        |
| T4              | 14°26'27.92"S  | 27°59'8.52"E  | 14°26'27.34"S   | 27°55'47.79"E | Oriented east to west, from Kaswende; grassland and swamp                                                                                              |
| T5              | 14°26'21.66"S  | 27°53'39.18"E | 14°26'21.13"S   | 27°50'17.25"E | Oriented east to west, from Kaswende; swamp and lake                                                                                                   |
| T6              | 14°19'28.60"S  | 27°58'46.54"E | 14°19'28.94"S   | 27°55'26.33"E | Oriented east to west, from Waya; grassland and swamp                                                                                                  |
| T7              | 14°12'43.40"S  | 27°39'8.04"E  | 14°15'1.44"S    | 27°41'31.15"E | Oriented northwest to southeast, from Kamwengo to Lake Suye; swamp and lake                                                                            |
| T8              | 14°9'11.78"S   | 27°38'17.31"E | 14°10'48.66"S   | 27°38'3.97"E  | Oriented north to southwest from Shishimo to Chilwa island; crossing a channel between these; mostly grassland, but with some permantely flooded areas |





**Figure 16 – Location of areas, stations and transects for monitoring habitats and biological communities**

Along the length of these transects (which vary from 3 to 6 km, depending on the site), smaller – ~500 m – transects should be defined, along which quadrat plots must then be located, either randomly (established off-site) or at set distances.

To define the area of the quadrats, the minimum area method should be used. Typically, herbaceous vegetation can be sampled with 0.25 m<sup>2</sup> (0.50 x 0.50 m) quadrats.

Because of the physical constraints of the terrain, the transects presented in Table 19 will most likely not be the final survey transects. The final survey transects should be



defined on-site through a preliminary reconnaissance campaign to assess the conditions of the field, and must remain the same for the duration of the monitoring programme.

#### 7.6.3.6. Flora

The sites given in section 7.6.3.5 for habitats double as the monitoring sites for flora, i.e., aquatic macrophytes and terrestrial grassland flora.

Regarding the stations for phytoplankton, these should be the same as for ichthyofauna and zooplankton sampling (see section 7.6.3.7, and Table 20) – these three groups must be monitored together.

#### 7.6.3.7. Fauna

Table 20 and Figure 16 present the proposed sampling stations for ichthyofauna, zooplankton and phytoplankton. An effort was made to define enough stations so as to cover the site's different biotopes and conditions, while also trying to reduce the effort.

**Table 20 – Location of stations for fish, zooplankton and phytoplankton sampling**

| Station number | Latitude      | Longitude     | Description                                    |
|----------------|---------------|---------------|------------------------------------------------|
| Aw1*           | 14.32344°     | 027.97241°    | Waya                                           |
| Aw2*           | 14.32575°     | 027.95456°    | Waya                                           |
| Aw3*           | 14.32421°     | 027.94565°    | Waya                                           |
| Aw4*           | 14.29765°     | 027.91705°    | Waya                                           |
| Aw5            | 14°19'11.72"S | 27°55'13.06"E | Waya, swamp channel                            |
| Aw6            | 14°18'33.03"S | 27°51'27.70"E | Waya, lake                                     |
| Akb1           | 14°33'29.53"S | 27°40'11.30"E | Kabosha, swamp channel                         |
| Akb2           | 14°31'59.60"S | 27°40'1.46"E  | Kabosha, swamp channel                         |
| Akb3           | 14°31'18.55"S | 27°39'6.26"E  | Kabosha, small lake                            |
| Akb4           | 14°29'46.13"S | 27°38'33.69"E | Kabosha, lake                                  |
| Amg1           | 14°22'21.17"S | 27°10'54.03"E | Moongo, Lukanga and Kafue rivers confluence    |
| Amk1           | 14°26'6.22"S  | 27°30'34.07"E | Mukunkwe, Lukanga river, in the swamp's outlet |
| Akm1           | 14°13'21.91"S | 27°39'49.86"E | Kamwengo, swamp channel/pond                   |
| Akm2           | 14°13'38.90"S | 27°40'6.71"E  | Kamwengo, lake Suye                            |
| Akm3           | 14°14'38.44"S | 27°40'40.63"E | Kamwengo, channel between lakes                |
| Akm4           | 14°16'17.53"S | 27°41'58.88"E | Kamwengo, small lake                           |

\*These are the same stations sampled in 2019 by BWZ & DoF(2019)



Regarding waterbirds and ungulates, a general area is given in Map 5 (Appendix 1), in which to define their specific monitoring sites.

The transects defined for habitat monitoring (section 7.6.3.5, Table 19) can also be used for bird point counts.

A preliminary survey should be conducted to assess in what areas are wild ungulates more likely to occur (within the Itundu Plain, that is; Figure 16), or have been observed, through population interviews or aerial surveys (costly); after this is completed, those sites should be sampled in every monitoring campaign.

#### **7.6.4. Sampling frequency**

##### **7.6.4.1. Surface water and groundwater**

Surface water and groundwater samples and water quantity parameters (water levels, water flows) should be collected twice each year. The first campaigns should be done by the end of the wet season (April-May), and the second campaign of the year should be done by the end of the dry season (October-November).

If loggers are installed (*cf.* Section 7.6.5) these campaigns are for collection of samples, for manual measurements to calibrate the instruments and to obtain data recorded throughout the past six months.

##### **7.6.4.2. Soil**

Soil *in situ* analyses should be done once a year by the end of the dry season (October-November).

##### **7.6.4.3. Sediment**

Sediment collection should be done once a year by the end of the dry season (October-November).



#### 7.6.4.4. Habitats

Habitats monitoring – which **includes the monitorization of flora** – should be undertaken twice, once towards the end of the dry season (October) and once at the end of the raining season, when water is starting to recede (April), to account for the different phonologies and vegetation communities present.

Ideally, a first characterization campaign should be undertaken aiming at establishing reference conditions against which the results from subsequent monitoring efforts will be assessed.

#### 7.6.4.5. Flora

The monitoring of aquatic macrophytes and terrestrial grassland flora is done in the context of habitats monitoring, so that its sampling frequencies are the same as detailed in section 7.6.4.4.

Regarding the monitoring of phytoplankton, as this must be done together with the monitoring of ichthyofauna and zooplankton, sampling frequencies will be the same as detailed in section 7.6.4.6.

**Ideally**, because phytoplankton is a very dynamic community which responds rapidly to environmental change, monitoring should cover seasonal variations. The establishment of phytoplankton reference conditions for monitoring environmental/ecosystem changes is typically done through monthly sampling over the course of a minimum of two years, and should at least cover **different phases of the dry season**. At the very least, because zooplankton and fish monitoring is proposed for the end of the raining season, phytoplankton analysis should be additionally undertaken in June and again in October.

#### 7.6.4.6. Fauna

Sampling frequencies for faunal groups depend on each group's characteristics and on the monitoring's objectives. The following frequencies are recommended:

- Ichthyofauna:
  - once a year, in the end of the raining season (March/April);
- Zooplankton:



- once a year, in the end of the raining season (March/April), together with fish sampling;
- Waterbirds:
  - once a year, as per BWZ (2020), during the raining season;
- Ungulates:
  - every three (3) years; for every monitoring campaign, every site should be sampled twice, in different days.

In addition, complete frame surveys of the fisheries should be undertaken every 4 years (Musumali *et al.*, 2009).

## 7.6.5. Sampling and data collection methods

### 7.6.5.1. Surface water

To collect information on the monitoring parameters indicated in section 7.6.2, different methods are used (Table 21).

**Table 21 – Sampling and data collection methods for surface water media**

| Group of monitoring parameters                                                                                                                                  | Collection methods                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stream water levels                                                                                                                                             | Data logger and readings in staff gauge during campaigns                                                                                                                                      |
| Streamflow                                                                                                                                                      | For water depths smaller than 1 m, streamflow can be measured wading in the stream with the OTT ADC (OTT, 2017). For water depths above 0.60 m, the RiverSurveyor® (Sontek, 2016) can be used |
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen;                                                                                               | <i>In situ</i> analysis with a multiparameter probe                                                                                                                                           |
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD5); Chemical Oxygen Demand (COD) | Surface water collection with bottles, preserved in cold until arrival to the laboratory                                                                                                      |

The installation of the stations and the loggers should be timed to coincide with the lowest water levels at the end of the dry season, as this enabled to figure out the installation depth of the loggers.



#### 7.6.5.2. Groundwater

To collect information on the monitoring parameters indicated in section 7.6.2, different methods are used (Table 22).

**Table 22 – Sampling and data collection methods for groundwater media**

| Group of monitoring parameters                                                                                                                                  | Collection methods                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Groundwater levels                                                                                                                                              | Data logger and readings with a scale during campaigns                                                                                    |
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen;                                                                                               | <i>In situ</i> analysis with a previously calibrated multiparameter probe. Data is stored in a file of the probe but also in a field book |
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD5); Chemical Oxygen Demand (COD) | Groundwater collection with bottles, preserved in cold until arrival to the laboratory                                                    |

The installation of the loggers should be timed to coincide with the lowest water levels at the end of the dry season, as this enabled to figure out the installation depth of the loggers.





### 7.6.5.3. Soil

**Table 23 – Sampling and data collection methods for soil media**

| Group of monitoring parameters | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Site characterisation          | In the field, record the following information in the input sheet: Describer's name, affiliation and contract details; Date – day/month/year; GPS reference for the site ( <i>i.e.</i> , latitude and longitude measurements); Record the village name; Record the farmer's name and phone number; description of recent weather is needed to provide context for the results of any analysis that is to take place. This should include asking the farmer about any recent rainfall, any notable events such as a heatwave or frost; Write down any information about the type of landform ( <i>e.g.</i> , is the field on a Floodplain, Terrace, Hill slope, or Valley?); Measure the elevation (m) and calculate an estimated slope gradient (%) of the field. This can be completed using most smartphones; Describe the surface uniformity of the field, noting any soil colour changes, areas of gravel or rocks; Write down any observations on the soil's capacity for drainage – look for signs of flooding and / or ponding; ask the farmer if there is water ponding during heavy rains.; Make a note of any potential signs of erosion (cause by water, wind, or landslide) and the type of erosion (rill, gully, sheet); Record the type of and state of surrounding vegetation (trees / shrubs / pasture / crops); Take photographs of the site and any distinguishing features of the soil or crop plants that will complement the site description |
| Soil sampling                  | <u>Sampling strategy</u> : Take many soil samples; Avoid taking samples from areas that might not properly represent the rest of the field; Make composite samples ( <i>i.e.</i> , multiple samples mixed together) to provide more representation within each analysis sample; Take soil samples in a field along a transect at regular intervals to avoid human bias.<br><u>Take individual samples correctly</u> : use different sampling depth intervals (0-20 cm and 20-50 cm). If fields with maize are being studied, it should be deeper (150 cm). Composite samples should represent equal depth intervals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Soil texture                   | The hand method involves taking a handful of soil, wetting it with water, noting changes as it is worked into a ball and then squeezed between your thumb and forefinger. To classify the soil consult Table 24. For more information consult Roxburgh <i>et al.</i> (2018)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |





| Group of monitoring parameters | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil colour                    | <p>Take the shovel and dig a mini soil pit 40 cm wide, 60 cm long, and 50 cm deep. Examine the soil surface layer (0-20 cm) inside the mini soil pit. Use the guide in Table 4 to select a colour that most closely matches what you see. Repeat step 6 for the subsoil layer (20-50 cm). It is recommended that soil colour be assessed in the middle of the day and in direct sunlight.</p> <p>Where no single colour is dominant, the colour is said to be mottled.</p> <p>Characteristics of soil groups are in Table 25.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Soil bulk density              | <p>Measure the length of the sample cylinder being used and record it in the 'Bulk Density Input Sheet' (mm); Measure the diameter of the sample cylinder being used and record it in the 'Sheet'; Weigh the sample cylinder using the field scale and record the weight in the 'Sheet'; Clear soil surface of the sample area (i.e. clearing any crop residue); Place the soil sampling cylinder on the soil with the open ends on the soil and facing up to the sky; Place the wooden block on top of the soil sampling cylinder; Use the sledge hammer to carefully hammer in the sampling cylinder into the soil until approximately 3 cm remain above the soil surface – take extra care to avoid hammering the cylinder completely into the soil as this will lead to soil compaction and inaccurate bulk density calculations; Before removing the soil cylinder, use the measuring tape to measure the distance from the top of the cylinder to the soil surface. Do this in at least three separate places and record the results of each measurement to get an accurate result; Use the small shovel to dig out the metal sampling cylinder. Take extra care not to hit the ring itself and make sure you remove extra soil underneath the cylinder. Once the cylinder is removed from the soil, use the knife to remove all soil from outside the ring and to carefully cut off extra soil at the bottom of the ring; Once all the soil outside of the sample cylinder is removed, place it on the field scale and record the weight on the 'Sheet'; At this stage, the gravimetric water content is all that is needed to calculate final bulk density. The gravimetric water content can be calculated using the known volume of the cylinder and assuming a particle density of 2.65 g / cm<sup>3</sup>. This method can be consulted in the following line. It is recommended that 3-5 bulk density samples are taken per field at each depth interval.</p> |



| Group of monitoring parameters | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil gravimetric water content | <p>1. Take a representative soil sample (see section “soil sampling” above) and mix it together in the bucket/tuba; a. You will need at least 100 mL of soil for each sample being tested; b. You will need to test each sample analysed for other attributes that requires gravimetric water content – e.g. Bulk Density; 2. Measure the height of the graduated measuring cylinder and record it on the ‘Soil Gravimetric Water Input Sheet’; 3. Measure the diameter of the graduated measuring cylinder and record it on the ‘Sheet’; 4. Weigh the graduated measuring cylinder (with the lid on) using the field balance and record weight to the closest 1g on the ‘Sheet’; 5. Add 250 mL of water to the cylinder and weigh (with lid) – record the weight to the nearest 1 g in the ‘Sheet’; 6. Add 100 mL of soil into the cylinder (use the teaspoon) and record the weight (with lid on) to the nearest 1 g in the ‘Sheet’; 7. Make sure the cylinder is properly sealed, start the timer for 3 minutes and then shake the mixture until the timer is done; 8. Record the final volume of the soil-water solution (mL) in the cylinder on the ‘Sheet’; 9. The solution should have reduced in volume after shaking due to trapped air in the soil releasing; 10. Wash the soil and water out from the cylinder before reusing; 11. Perform steps 5-10 for all soil samples that require testing for gravimetric water content; a. NOTE: each sample measured for bulk density will need its gravimetric water content estimated separately; 12. Once all samples have been tested, enter the recorded data for each sample into a separate row in an excel file and calculate the final estimate of soil gravimetric water content using the equations outlined in Roxburgh <i>et al.</i> (2018).</p> |



| Group of monitoring parameters | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil pH                        | <p>Assuming the existence of a pH meter (the one used for water resources monitoring can be used): Take a representative soil sample (see section “soil sampling” above) and mix it together in the bucket/tuba; a. You will need at least 50 mL of soil for each sample being tested; b. We recommend bulking 5-15 cores into each composite sample for testing to ensure a representative sample; c. Test to 180 cm depth (if possible); Weigh the measuring/mixing cylinder (lid on) and record in the ‘Soil pH Input Sheet’; Add 250 mL of water to the cylinder, weigh the cylinder with water (lid on) and record in the ‘Sheet’; Add 50 mL of the soil sample (until the volume of soil and water in the cylinder reaches 300 mL); Weight the soil-water mixture in the cylinder (with lid on) and record the weight in the ‘Sheet’; Mix the solution well in an ‘end over end’ fashion for a minimum of 3 minutes per sample (use timer); Take out a piece of the Whatman filter paper and cut a radial line (i.e. from edge of the circle to the centre point); Curl the filter paper into a cone shape and staple together near the edge of the paper; Place filter paper in the solution pointed side in first and allow to stand for 3 minutes while you calibrate the pH meter; Prepare timer for 30 seconds; Put the pH meter in the soil-water suspension that has filtered through the paper (about 3 cm deep); Take the reading after 30 seconds with one decimal or upon the pH meter settling for more than 3 seconds, which-ever is first; Record the pH value in the ‘Sheet’; Remove the pH meter from the suspension, and rinse the glass electrode tip thoroughly with deionized (DI) water in a separate beaker/cup</p> |



| Group of monitoring parameters  | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electrical conductivity         | <p>Assuming the existence of an EC meter (the one used for water resources monitoring can be used): 1. Collect a representative soil sample; a. You will need at least 7 g of soil for each sample being tested; b. We recommend bulking 5-15 cores into each composite sample for testing to ensure a representative sample; c. Test to 180 cm depth (if possible); 2. Calibrate the EC meter according to the instructions from the manufacturer; 3. Weigh the falcon tube with lid on and record weight in the 'Soil EC Input Sheet'; 4. Add 35 mL of water to the measuring cup; 5. Place the EC meter 3 cm into the water to record the EC value of the tap/bore water in the 'Sheet'; 6. Weigh 7g of the field moist soil sample (record exact weight in the input sheet) and place into a 50 mL falcon tube (or container with lid); 7. Add the 35 mL of water and carefully seal the tube/container with a lid; 8. Setup the stopwatch or phone to time for 3 minutes; a. Mix the solution well by shaking it with your hands in an end-over-end fashion; 9. Time of mixing is important. 10. Mix for a minimum of 3 minutes per sample; 11. After mixing, note the final volume of the soil-water mixture (it should have reduced during mixing) in the 'Sheet'; 12. Take a circular piece of Whatman filter paper and cut a line through from edge to the middle. Shape the filter paper into a cone and place pointed end of the cone onto the surface of the soil-water mixed solution; 13. Allow to stand for a minimum of 3 minutes (use timer again); 14. Prepare the timer for 30 seconds; 15. Put the EC meter in the filtered soil-water mixture that appears above the filter paper (about 3 cm deep). Record the value to one decimal place (in the input sheet) after 30 seconds, or when the EC meter value is the same for more than 10 seconds; 16. Remove the EC meter from the soil-water mixture and rinse the glass electrode tip thoroughly with tap water; 17. Carefully dry excess water off by dabbing with a tissue before resting the EC meter or taking another measurement; Repeat steps 6-16 for all samples to be tested.</p> |
| Soil mineral nitrogen (nitrate) | <p>The procedure for field testing soil for nitrate levels should be seen in Roxburgh <i>et al.</i> (2018). For these tests, a calibrated test strip reflectometer and nitrate colorimetric strip tests will be needed.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |



**Table 24 – Guide to determining soil texture based on a) whether it will form a ball; b) how many centimetres that ball can be made into a ribbon; and c) the feel, appearance, and durability of the wet soil in the hand**

| Ball                              | Ribbon (cm) | Feel                                                                                                                        | Texture                                        |
|-----------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| Will not form a ball              | nil         | Single grains of sand stick to fingers                                                                                      | Sand (S)                                       |
| Ball just holds together, fragile | ~0.5        | Feels very sandy, visible sand grains                                                                                       | Loamy sand (LS)                                |
| Can be handled                    | 1.5 to 2.5  | Sandy, slight stickiness                                                                                                    | Coarse sandy loam (CSL), Fine sandy loam (FSL) |
| Ball holds together               | 2.5         | Spongy, smooth, not gritty or silky                                                                                         | Loam (L)                                       |
| Ball holds together               | 2.5         | Slightly spongy, fine sand can be felt                                                                                      | Loamy fine sand (LFS)                          |
| Ball holds together               | 2.5         | Very smooth to silky                                                                                                        | Silt loam (SL)                                 |
| Ball holds together strongly      | 2.5-4       | Sandy to touch, medium sand grains visible                                                                                  | Sandy clay loam (SCL)                          |
| Ball holds together               | 4-5         | Plastic, smooth to manipulate                                                                                               | Clay loam (CL)                                 |
| Ball holds together strongly      | 5-7.5       | Plastic, smooth, slight resistance to shearing (breaking when squeezed) between thumb and forefinger                        | Light clay (LC)                                |
| Ball holds together strongly      | >7.5        | Plastic, smooth, handles like plasticine, can be moulded into rods without fracture, moderate shearing resistance           | Medium clay (MC)                               |
| Ball holds together strongly      | >7.5        | Plastic and smooth, handles like stiff plasticine, can be moulded into rods without fracture, very firm shearing resistance | Heavy clay (HC)                                |

Source: Roxburgh *et al.* (2018).



**Table 25 – Main soil colour groups, corresponding Munsell chart details, and their characteristics**

| Soil colour                    | Typical Munsell Hue/value/chroma                                          | Soil types and characteristics                                                                              |
|--------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Black                          | 5YR/<3/1-2<br>7.5YR/<3/1-2<br>10YR/<3/1-2                                 | Peat or organic soils – high in organic matter<br><br>Soils derived from limestone under reduced conditions |
| White, pale or bleached<br>Red | -/8/<4<br>10R/-/6-8<br>2.5YR/-/6-8                                        | Sandy soils<br><br>Well-drained soils with high content of iron oxides                                      |
| Yellow or yellow-brown         | 7.5YR/>6/>6<br>10YR/>6/>6<br>2.5Y/>6/>3<br>5Y/>6/>2                       | Imperfectly drained to moderately well-drained soils with high content of iron oxides                       |
| Brown                          | 2.5YR/<7/3-4<br>5YR/<6/3-4<br>7.5YR/<6/3-4<br>10YR/<6/3-8<br>2.5YR/<5/2-6 | Moderate soil organic matter levels, and some iron oxides                                                   |
| Greyed, grey or blue-grey      | Gley charts or colour charts -/3-7/1                                      | Near permanent waterlogging; anaerobic (reduced) conditions                                                 |
| Mottles                        | Orange, yellow, red                                                       | Intermittent waterlogging; intermittent anaerobic (reduced) conditions                                      |

Source: Roxburgh *et al.* (2018).

#### 7.6.5.4. Sediment

**Table 26 – Sampling and data collection methods for sediment media**

| Group of monitoring parameters                                     | Collection methods                                                                                                                                                                                                   |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Metals and metalloids (Al, As, Cd, Co, Cu, Cr, Fe, Pb, Hg, Ni, Zn) | A single sample can be collected into a plastic bag with a plastic shovel or bucket. The separation normally occurs in the laboratory.<br><br>The sediment sample should be kept cold until reaching the laboratory. |
| Total organic carbon                                               |                                                                                                                                                                                                                      |
| Grain-size                                                         |                                                                                                                                                                                                                      |



#### 7.6.5.5. Habitats

**Table 27 – Sampling and data collection methods for habitats**

| Monitoring parameters |                                              | Collection methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat extent        |                                              | Map the swamp and grassland habitats through digitization from satellite images (of the most recent dry season) in a SIG environment, and measure the surface area of different mapping units; the cartographic units – and, especially, their boundaries – must then be validated through ground truthing, i.e., through rapid field assessments, or through the transect surveys conducted for species data (see below)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Ecological continuum  |                                              | Expert assessment of the habitats map produced for estimating the habitats' extent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Risk of fragmentation |                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Conservation status   | Species<br>(presence/absence data and cover) | Define quadrat plots along the transects (as per section 7.6.3.5 – 0.50x0.50 m quadrats, subdivided in smaller 10x10 cm squares); at each plot:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                       | Degradation indicators<br>(presence/absence) | <ul style="list-style-type: none"><li>• register the plot's number, the name of the observer, the date, time, GPS coordinates and the habitat (grassland, swamp, termitaria, etc.);</li><li>• list the vegetation strata within the quadrat – tree, shrub, herb, non-vascular, floating, submerged – and estimate relative covers (percentages of the quadrat) and the prevailing height of each stratum;</li><li>• list all identified plants by strata, to the lowest taxonomic level possible, with the support of field guides, and estimate relative covers (percentages of the quadrat);</li><li>• if identification on the site is not possible for particular species, it will be necessary to retain specimens for later full identification (see below for instructions);</li><li>• finally, record any degradation indicators (cut, burnt or trampled vegetation) and stressors/pressures (resource use) observable in the surroundings.</li></ul> <p>Random directed walks can also be employed to search for invasive or protected species.</p> |





**Table 28 – Instructions for the collection of specimens for later identification**

| Instructions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>(1) Select specimens that are mature and have key structures needed for taxonomic identification – leaves, stems, flowers and/or fruits, roots, rhizomes; collect as complete a specimen as possible;</p> <p>For plants that are immature or senescent at the time of sampling (e.g., grasses or sedges with only leaf blades and no flowers or fruits; forbs that are seedlings, have unremarkable leaf shapes, or missing flowers), do the following:</p> <ul style="list-style-type: none"> <li>○ If the species has &gt;5% cover, collect it anyway. It is possible that a regional expert may be able to identify the species even if it is incomplete.</li> <li>○ If the species is &lt;5% cover, record a pseudonym and estimate cover as usual, but collecting a specimen is optional.</li> </ul> <p>(2) Place the fresh plant material collected for each individual species into its own plastic bag (one species per bag) to contain the specimen until it can be pressed. Using a permanent marker, write the Plant Sample ID Number on the outside of the bag;</p> <p>(3) Press and label plants upon arrival to the vehicle (ideal), or back at the office/lab:</p> <ul style="list-style-type: none"> <li>○ Place each individual species inside its own folded A3 of newsprint paper, label it with the species' ID;</li> <li>○ Array the plant so that stems and leaves and any flowering or fruiting material are separated and clearly visible;</li> <li>○ Place the newsprint folders between sheets of blotting paper;</li> <li>○ Stack the blotting paper/newsprint/blotting paper sandwiches on top of each other;</li> <li>○ Cover the stack with the wooden frame on top and on the bottom;</li> <li>○ Tie the rope tightly around the stack;</li> <li>○ If possible, change the blotting paper every two days; or more frequently, if the plants are wetter.</li> </ul> |



#### 7.6.5.6. Flora

**Table 29 – Sampling and data collection methods for flora**

| Monitoring parameters       |                                           | Collection methods                                                                                                                                                                                                                                                                    |
|-----------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aquatic macrophytes         | Number of taxa                            | See Table 27                                                                                                                                                                                                                                                                          |
|                             | Cover                                     |                                                                                                                                                                                                                                                                                       |
|                             | Biomass                                   | Collect plant material (along the same transect mentioned above) at each plot using a cylinder core<br>At the laboratory, remove algae (if present), and weigh the remaining material, dry it, and then re-weight it; biomass is expressed as % of dry weight (DW) per m <sup>2</sup> |
| Terrestrial grassland flora | Number of taxa                            | See Table 27                                                                                                                                                                                                                                                                          |
|                             | Cover                                     |                                                                                                                                                                                                                                                                                       |
| Phytoplankton               | Species diversity and relative abundances | Collect water samples at the sites of fish sampling; at the lab, sub-sample these and identify and quantify taxa using a microscope                                                                                                                                                   |
|                             | Biomass                                   | From the same samples as above, determine the chlorophyll $\alpha$ concentration (in $\mu\text{g L}^{-1}$ )                                                                                                                                                                           |



#### 7.6.5.7. Fauna

**Table 30 – Sampling and data collection methods for fauna**

| Monitoring parameters |                                                       | Collection methods                                                                                                                                                                                                                                                          |
|-----------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ichthyofauna          | Species composition                                   | Catch composition from gillnet surveying; the following information should be recorded: identification to the lowest possible taxonomic level; counting; measurement of total and standard lengths (mm) and wet weight (g), determination of sex and sexual maturity stage) |
|                       | Abundance                                             |                                                                                                                                                                                                                                                                             |
|                       | Population structure (based on age or length classes) |                                                                                                                                                                                                                                                                             |
| Zooplankton           | Community structure (species and relative abundances) | Water sample collection + microscopic analysis of species (identification and quantification)                                                                                                                                                                               |
|                       | Biomass                                               |                                                                                                                                                                                                                                                                             |
| Waterbirds            | Number of taxa (diversity)                            | Point counts at 3 km intervals along boat transects within the swamp (see BWZ, 2020 for details) and walking transects in the grassland                                                                                                                                     |
|                       | Relative abundances                                   |                                                                                                                                                                                                                                                                             |
| Ungulates             | Number of taxa (diversity)                            | Distance sampling along line transects in the grassland (see Le Moullec <i>et al.</i> , 2017 for details)                                                                                                                                                                   |
|                       | Abundance estimates                                   |                                                                                                                                                                                                                                                                             |



## 7.6.6. Data analysis methods and criteria

### 7.6.6.1. Surface water

Data analysis methods and criteria for surface water are summarised in Table 31.

**Table 31 – Data analysis methods and criteria recommended for surface water**

| Group of monitoring parameters                                    | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                     |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stream water levels                                               | Automatic measurements of the water level variations are recorded by data loggers. These data are checked and calibrated by manual water level measurements using staff gauges during field campaigns. HOB0® data loggers can be used since they have been used in other monitoring campaigns done in Zambia. However, other data loggers may be used. |
|                                                                   | This information will allow to monitor the quantity of surface water and build interannual trends, and take actions if needed.                                                                                                                                                                                                                         |
| Streamflow                                                        | Rating curves that relate river water levels to streamflow must be established by conducting successive streamflow measurements during field campaigns.                                                                                                                                                                                                |
|                                                                   | Streamflow measurements are only needed until the rating curves are being defined. After this, stream flows are only needed if important morphological aspects are changed in the upstream part of the catchment.                                                                                                                                      |
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen; | YSI® Multiparameter probe or other that analyses the indicated parameters.                                                                                                                                                                                                                                                                             |
|                                                                   | This information will allow to monitor the quality of surface water and take actions if needed, based on the use given to that water and the guideline values from Table 32.                                                                                                                                                                           |



| Group of monitoring parameters                                                                                                                                               | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD <sub>5</sub> ); Chemical Oxygen Demand (COD) | <p>In the laboratory the following methods can be used:<br/>Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma – Mass Spectrometry (ICP-MS), Ion Chromatography (IC), Atomic absorption spectroscopy (AAS), Other methods.</p> <p>It is important that the method used for the different parameters has a detection and quantification limit lower than the threshold used as guideline (see Table 32).</p> <p>This information will allow to monitor the quality of surface water and take actions if needed, based on the use given to that water and the guideline values from Table 32.</p> |

**Table 32 – Guideline and standard values for different water uses**

| Parameter                        | Drinking water   |               | Irrigation water | Minimum Environmental Quality |
|----------------------------------|------------------|---------------|------------------|-------------------------------|
|                                  | Zambian Standard | WHO Guideline | FAO Guideline    | European standards            |
| pH                               | 6.5 – 8.5        | 6.5 – 8.5     | 6.5 – 8.4        | 5.0 – 9.0                     |
| Conductivity (μS/cm)             | 1500             | -             | 700 – 3000*      | -                             |
| Chemical Oxygen Demand (mg/l)    | -                | -             | -                | 30.0***                       |
| Biochemical Oxygen Demand (mg/l) | -                | -             | -                | 5.0                           |
| Nitrates (NO <sub>3</sub> -)     | 44.3             | 50            | 22.15 – 132.9*   | -                             |
| Phosphorus                       | -                | -             | -                | 1.0                           |
| As (mg/l)                        | 0.01             | 0.01          | 0.1**            | 0.1                           |
| Cd (μg/l)                        | 0.003            | 0.003         | 0.01**           | 0.01                          |
| Cr (mg/l)                        | 0.05             | 0.05          | 0.1**            | 0.05                          |
| Co (mg/l)                        | 0.5              | -             | 0.05**           | -                             |
| Cu (mg/l)                        | 1.0              | 2.0           | 0.2**            | 0.1                           |
| Hg (mg/l)                        | 0.001            | 0.006         | -                | 0.001                         |



| Parameter | Drinking water   |               | Irrigation water | Minimum Environmental Quality |
|-----------|------------------|---------------|------------------|-------------------------------|
|           | Zambian Standard | WHO Guideline | FAO Guideline    | European standards            |
| Pb (mg/l) | 0.01             | 0.01          | 5**              | 0.05                          |
| Zn (mg/l) | 3.0              | -             | 2.0**            | 0.5                           |

Notes:

\* Interval corresponds to “slight to moderate” degree of restriction class;

\*\* Recommended Maximum Concentration;

\*\*\* According to European standards, it must be below 30 mg/l to be able to be treated for human consumption.

#### 7.6.6.2. Groundwater

Data analysis methods and criteria for surface water are summarised in Table 33.

**Table 33 – Data analysis methods and criteria recommended for groundwater**

| Group of monitoring parameters | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Groundwater levels             | Automatic measurements of the groundwater level variations are recorded by data loggers. These data are checked and calibrated by manual water level measurements using dip meters during field campaigns. HOBO® data loggers can be used since they have been used in other monitoring campaigns done in Zambia. However, other data loggers may be used. Although all the proposed wells are in use, the hypothesis is that if hourly measurements are taken by the data logger, the resulting dataset would show the natural static water level at 04:00 a.m., as no pumping activities occur at night. This methodology was confirmed in Fahle <i>et al.</i> (2017). |
|                                | This information will allow to monitor the quantity of groundwater and build interannual trends, and take actions if needed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



| Group of monitoring parameters                                                                                                                                  | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen;                                                                                               | YSI® Multiparameter probe or other that analyses the indicated parameters.                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                                                                                 | This information will allow to monitor the quality of groundwater and take actions if needed, based on the use given to that water and the guideline values from Table 32.                                                                                                                                                                                                                                                                  |
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD5); Chemical Oxygen Demand (COD) | In the laboratory the following methods can be used:<br>Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma – Mass Spectrometry (ICP-MS), Ion Chromatography (IC), Atomic absorption spectroscopy (AAS), Other methods.<br>It is important that the method used for the different parameters has a detection and quantification limit lower than the threshold used as guideline (see Table 32). |
|                                                                                                                                                                 | This information will allow to monitor the quality of groundwater and take actions if needed, based on the use given to that water and the guideline values from Table 32.                                                                                                                                                                                                                                                                  |

#### 7.6.6.3. Soil

**Table 34 – Data analysis methods and criteria recommended for soil**

| Group of monitoring parameters | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil texture                   | By using Table 35 it is possible to estimate the total water storage capacity of the soil from field texture.<br>Simply sum the water storage capacity for each layer/horizon of soil to the required depth. Please note that this will be a crude estimate. The water storage capacity is also strongly influenced by soil structure (with better structured soils holding more water). Also note that fine sandy soils will hold more water than coarse sands. |





| Group of monitoring parameters | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil colour                    | Key factors to discuss are whether the soil is high in organic matter, sandy, and prone to waterlogging. In addition, a further guide to estimating organic matter content of soil based on colour (for wet and dry soil) is available in Table 36. Soils with more organic matter will tend to be higher in fertility and have good structure – therefore they should be able to support good crop growth and higher yields. Soils that are sandy will tend to have lower capacity to hold soil moisture, meaning they are less suited to production unless rainfall is high and regular. Sandy soils are also more prone to compaction and are higher in bulk density. Soils with low drainage will become waterlogged during high rainfall events. Waterlogging can damage crops and lead to loss of yield. |
| Soil bulk density              | Soil bulk density (on its own can) be used to provide clear advice to farmers. Firstly, the ideal bulk density will depend on the texture of the soil (Table 35). Bulk density will naturally increase with soil depth and a general rule is that bulk density values above 1.6 g/cm <sup>3</sup> typically restrict plant root growth.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Soil gravimetric water content | This feature is a direct measure of the water contained in the soil. Besides this determination will be used in the following parameters.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Soil pH                        | pH values between 5.5 and 8 are considered acceptable for plant growth, with values between 6-7 considered optimal. Outside of these values, the ability of plants to take up nutrients from the soil will be constrained. Table 35 (below) allows quick interpretations of soil pH readings. Some plants, including maize, cowpea, pigeon pea and coffee can be cultivated successfully on more acidic (pH < 6.5) soils. For most others, soil acidity will restrict plant growth. Table 36 lists common crops and vegetables grown in Africa and their optimal pH ranges.                                                                                                                                                                                                                                    |



| Group of monitoring parameters  | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electrical conductivity         | Salinity affects plants at all stages of development and for some crops sensitivity varies from one growth stage to another. Its effect is also dependent on the depth in the soil profile, with salinity in shallow soil more detrimental to plant growth than in subsoils. In general, based on an EC measurement in a 1:5 soil-to-water extract, values of $\leq 0.07$ dS/m are safe for all crops in all soil types (Table 39). Readings from 0.07-0.15 dS/m will affect only sensitive crops. Values between 0.15-0.45 dS/m will not affect yields of maize but may potentially affect legume yields, while values from 0.34-1.8 dS/m can correspond to high salinity that is detrimental to productivity of all maize and legume varieties. Table 39 below provides values for categorising salinity specific to each soil texture. |
| Soil mineral nitrogen (nitrate) | As a general rule of thumb, soil nitrate-N concentrations below 20 ppm are considered low and crop growth will most likely be limited without N fertiliser. Nitrate levels below 11 ppm are very low. Soil nitrate-N levels below 50 kg N/ha are also considered low and crops are likely to respond favourably to N fertilisers assuming agronomic management is adequate. When nitrate levels are below the threshold values provided in Table 40, crops are likely to suffer N deficiency. In such cases, farmers may manage this deficiency through N fertilisers or through adjusting their agronomic management to reduce plant competition for limited soil N.                                                                                                                                                                     |



**Table 35 – Estimated water holding capacity, infiltration/erosion and bulk density implications for different soil textures**

| Texture         | Estimated water stored per 10 cm of soil depth (mm)* | Infiltration (low = higher erosion risk) | Ideal bulk density (see protocol 3.3) |
|-----------------|------------------------------------------------------|------------------------------------------|---------------------------------------|
| Sand            | 4                                                    | Very rapid                               | < 1.60                                |
| Loamy sand      | 4                                                    | Very rapid                               | < 1.60                                |
| Fine sandy loam | 5                                                    | Very rapid                               | < 1.40                                |
| Loam            | 6-7                                                  | Moderately rapid to rapid                | < 1.40                                |
| Loamy fine sand | 6-7                                                  | Moderately rapid to rapid                | < 1.60                                |
| Silt loam       | 6-7                                                  | Moderately rapid to rapid                | < 1.40                                |
| Sandy clay loam | 6-7                                                  | Very slow to slow                        | < 1.10                                |
| Clay loam       | 8                                                    | Extremely slow to moderate               | < 1.10                                |
| Light clay      | 10                                                   | Very slow to moderate                    | < 1.10                                |
| Medium clay     | 10-12                                                | Very slow to moderate                    | < 1.10                                |
| Heavy clay      | 12                                                   | Extremely slow to moderate               | < 1.10                                |

Source: Roxburgh *et al.* (2018).

**Table 36 – Estimated values of organic matter content of soils based on their apparent soil colour when wet and dry**

| Colour     | Munsell Value |         | Moist soil |                                   |         | Dry soil  |                                    |
|------------|---------------|---------|------------|-----------------------------------|---------|-----------|------------------------------------|
|            |               | S       | LS, SL, L  | SiL, Si SiCL, CL, SCL, SC, SiC, C | S       | LS, SL, L | SiL, Si, SiCL, CL, SCL, SC, SiC, C |
| Light grey | 7             |         |            |                                   | < 0.3   | < 0.5     | < 0.6                              |
| Light grey | 6.5           |         |            |                                   | 0.3-0.6 | 0.5-0.8   | 0.6-1.2                            |
| Grey       | 6             |         |            |                                   | 0.6-1   | 0.8-1.2   | 1.2-2                              |
| Grey       | 5.5           |         |            | < 0.3                             | 1-1.5   | 1.2-2     | 2-3                                |
| Grey       | 5             | < 0.3   | < 0.4      | 0.3-0.6                           | 1.5-2   | 2-4       | 3-4                                |
| Dark grey  | 4.5           | 0.3-0.6 | 0.4-0.6    | 0.6-0.9                           | 2-3     | 4-6       | 4-6                                |
| Dark grey  | 4             | 0.6-0.9 | 0.6-1      | 0.9-1.5                           | 3-5     | 6-9       | 6-9                                |
| Black grey | 3.5           | 0.9-1.5 | 1-2        | 1.5-3                             | 5-8     | 9-15      | 6-15                               |
| Black grey | 3             | 1.5-3   | 2-4        | 3-5                               | 5-12    | > 15      | > 15                               |
| Black      | 2.5           | 3-6     | > 4        | > 5                               | >12     |           |                                    |
| Black      | 2             | > 6     |            |                                   |         |           |                                    |

Source: Roxburgh *et al.* (2018).



**Table 37 – A guide to soil conditions associated with various soil pH readings**

| Soil pH | Indications                                                                   | Associated conditions                                                                                                          |
|---------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <5.5    | Soil is deficient in Ca and/or Mg and should be limed                         | Poor crop growth due to low cation exchange capacity and possible aluminium toxicity and expected P deficiency                 |
| 5.5-6.5 | Soil is lime-free and should be closely monitored to detect acidifying trends | Satisfactory for most crops                                                                                                    |
| 6.5-7.5 | Ideal range for most crops                                                    | Soil cation exchange capacity is near 100% base saturation                                                                     |
| 7.5-8.4 | Free lime exists in soil                                                      | Usually excellent filtration and percolation of water due to high Ca content on clays. P and micronutrients are less available |
| >8.4    | Invariably indicates sodic soil*                                              | Poor physical conditions of soil. Water infiltration and percolation are slow. Possible root deterioration.                    |

Source: Roxburgh *et al.* (2018).

**Table 38 – Optimal pH ranges of different crop species commonly grown in Eastern and Southern Africa**

| Crop type       | Crop            | ECe value causing 50% yield loss |
|-----------------|-----------------|----------------------------------|
| Legumes         | Beans           | 5.5-6.5                          |
|                 | Cowpea (forage) | 5.5-7                            |
|                 | Soybean         | 5.5-7                            |
| Grain crops     | Maize           | 5.5-7                            |
|                 | Rice            | 5-6.5                            |
|                 | Sorghum         | 5.5-7                            |
|                 | Wheat           | 5.5-7                            |
|                 | Barley          | 6.25-7.75                        |
| Oil seed crops  | Sunflower       | 5.5-6                            |
| Vegetable crops | Onion           | 6-6.5                            |
|                 | Carrot          | 5.5-7                            |
|                 | Lettuce         | 6-7                              |
|                 | Potatoes        | 5-5.5                            |
|                 | Cabbage         | 5.5-7                            |
|                 | Spinach         | 6-7                              |
|                 | Tomato          | 5.5-6.75                         |

Source: Roxburgh *et al.* (2018).



**Table 39 – Soil salinity classification for soils of varying textures**

| Soil texture                                        | Degree of salinity (Electrical Conductivity)* |           |           |           |           |         |
|-----------------------------------------------------|-----------------------------------------------|-----------|-----------|-----------|-----------|---------|
|                                                     | Very low                                      | Low       | Medium    | High      | Very High | Extreme |
|                                                     | -----dS/m-----                                |           |           |           |           |         |
| Coarse sand, loamy sand, sandy loam<br>(0-20% clay) | <0.07                                         | 0.07-0.15 | 0.15-0.34 | 0.34-0.63 | 0.63-0.93 | >0.93   |
| Sandy loam or Sandy clay loam<br>(20-40% clay)      | <0.09                                         | 0.09-0.19 | 0.19-0.45 | 0.45-0.76 | 0.76-1.21 | >1.21   |
| Sandy clay, sandy clay loam, Loam<br>(40-60% clay)  | <0.12                                         | 0.12-0.24 | 0.24-0.56 | 0.56-0.96 | 0.96-1.53 | >1.53   |
| Loam, Silt loam, Clay loam, Clay<br>(60-80% Clay)   | <0.15                                         | 0.15-0.30 | 0.30-0.70 | 0.70-1.18 | 1.18-1.87 | >1.87   |
|                                                     |                                               |           |           |           |           |         |

\* EC measurement values based on a 1:5 soil-water extract

☐ 'Very low': no effect; 'Low': moderately sensitive crops affected; 'Medium': moderately tolerant crops affected; 'High': tolerant crops affected; 'Very High': very tolerant crops affected; 'Extreme': too saline for crop production

Source: Roxburgh *et al.* (2018).

**Table 40 – Estimated maize crop demand for nitrogen when targeting various yields**

| Seasonal outlook guide<br>(ENSO forecast) | Target yield<br>(kg ha <sup>-1</sup> ) | Estimated total crop N demand<br>(kg ha <sup>-1</sup> ) |
|-------------------------------------------|----------------------------------------|---------------------------------------------------------|
| El Niño (ENSO negative)                   | 1000                                   | 26                                                      |
| El Niño (ENSO negative)                   | 1500                                   | 39                                                      |
| El Niño (ENSO negative)                   | 2000                                   | 52                                                      |
| El Niño (ENSO negative)                   | 2500                                   | 65                                                      |
| La Niña (ENSO positive)                   | 3000                                   | 78                                                      |
| La Niña (ENSO positive)                   | 3500                                   | 90                                                      |
| La Niña (ENSO positive)                   | 4000                                   | 103                                                     |
| La Niña (ENSO positive)                   | 4500                                   | 110                                                     |

Source: Roxburgh *et al.* (2018).



#### 7.6.6.4. Sediment

**Table 41 – Data analysis methods and criteria recommended for sediment**

| Group of monitoring parameters                                     | Data analysis methods and criteria                                                                                                                                                            |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Metals and metalloids (Al, As, Cd, Co, Cu, Cr, Fe, Pb, Hg, Ni, Zn) | ICP-MS or other method. It is important that the method used for the different parameters has a detection and quantification limit lower than the threshold used as guideline (see Table 42). |
|                                                                    | Comparison with quality guidelines (Table 42); Construction of enrichment factors using Fe, Al, TOC or grain-size fractions                                                                   |
| Total organic carbon                                               | Combustion method or other                                                                                                                                                                    |
|                                                                    | TOC will be used to determine if eventual contamination is associated with organic matter                                                                                                     |
| Grain-size                                                         | Method with sieves                                                                                                                                                                            |
|                                                                    | Classification of the sediment based on its texture                                                                                                                                           |

**Table 42 – Sediment quality guideline (SQG) of the National Oceanic Atmospheric Administration (NOAA)**

| Metal or metalloid | ERL (ppm) | ERM (ppm) |
|--------------------|-----------|-----------|
| As                 | 8.2       | 70        |
| Cd                 | 1.2       | 9.6       |
| Cr                 | 81        | 370       |
| Cu                 | 34        | 270       |
| Pb                 | 46.7      | 218       |
| Hg                 | 0.15      | 0.71      |
| Ni                 | 20.9      | 51.6      |
| Zn                 | 150       | 410       |

ERL – Effects Range-Low; ERM – Effects Range-Medium

Source: O'Connor & Paul (2000).



#### 7.6.6.5. Habitats

**Table 43 – Data analysis methods and criteria recommended for habitats**

| Monitoring parameters |                                           | Data analysis methods and criteria                                                                                                                                                           |
|-----------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat extent        |                                           | Comparison with previous results; if a negative trend is detected, its causes should be investigated                                                                                         |
| Ecological continuum  |                                           | Comparison with previous results; if a negative trend is detected, its causes should be investigated; the pressures that continue to be prevalent – or remain unmanaged – must be approached |
| Risk of fragmentation |                                           |                                                                                                                                                                                              |
| Conservation status   | Species (presence/absence data and cover) | Calculation of diversity indexes and comparison with previous results; if statistically significant changes are detected, their causes should be investigated and managed                    |
|                       | Degradation indicators (presence/absence) | Comparison with previous results; if degradation indicators persist, their causes should be investigated and managed                                                                         |





#### 7.6.6.6. Flora

**Table 44 – Data analysis methods and criteria recommended for flora**

| Monitoring parameters       |                                           | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aquatic macrophytes         | Number of taxa (diversity)                | Calculation of diversity indexes and comparison with previous results; if statistically significant changes are detected, their causes should be investigated and managed; the composition of the sample in terms of generalist, opportunist, sensible, etc., taxa should also be statistically tested, as well as a possible relation to environmental parameters (pH, T°, turbidity, depth, etc.), for the detection of spatial or temporal patterns, and for the possible development of a trophic classification or degradation ranking scheme for Zambian wetlands; if invasive species are detected, provisions should be made for their immediate eradication and prevention of further introductions |
|                             | Cover                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                             | Biomass                                   | If statistically significant changes are detected between years, their causes should be investigated and managed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Terrestrial grassland flora | Number of taxa (diversity)                | Calculation of diversity indexes and comparison with previous results; if statistically significant changes are detected, their causes should be investigated and managed; if invasive species are detected, provisions should be made for their immediate eradication and prevention of further introductions                                                                                                                                                                                                                                                                                                                                                                                               |
|                             | Cover                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Phytoplankton               | Species diversity and relative abundances | Calculation of diversity indexes and comparison with previous results; if statistically significant changes are detected, their causes should be investigated and managed; the composition of the sample in terms of generalist, opportunist, sensible, etc., taxa should also be statistically tested, as well as a possible relation to environmental parameters (pH, T°, turbidity, depth, etc.), for the detection of spatial or temporal patterns, and for the possible development of a trophic classification or degradation ranking scheme for Zambian wetlands                                                                                                                                      |
|                             | Biomass                                   | If statistically significant changes are detected between years, their causes should be investigated and managed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



#### 7.6.6.7. Fauna

**Table 45 – Data analysis methods and criteria recommended for fauna**

| Monitoring parameters |                                                       | Data analysis methods and criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ichthyofauna          | Species composition                                   | <p>Determination of CPUE and population indexes and comparison with previous years; if statistically significant changes are detected, their causes should be investigated and possibly managed; the composition of the sample in terms of generalist, opportunist, sensible, etc., taxa should also be statistically tested, as well as a possible relation to environmental parameters (pH, T°, turbidity, depth, etc.), for the detection of spatial or temporal patterns, and for the possible development of a degradation ranking scheme for Zambian wetlands; if endangered or critically endangered species are detected, provisions should be made for their strict protection; if invasive species are detected, provisions should be made for their immediate eradication and prevention of further introductions</p> |
|                       | Abundance                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                       | Population structure (based on age or length classes) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Zooplankton           | Community structure (species and relative abundances) | <p>Calculation of population indexes and comparison with previous years; if a statistically significant change is detected, its causes should be investigated and possibly managed; the composition of the sample in terms of generalist, opportunist, sensible, etc., taxa should also be statistically tested, as well as a possible relation to environmental parameters (pH, T°, turbidity, depth, etc.), for the detection of spatial or temporal patterns</p>                                                                                                                                                                                                                                                                                                                                                              |
|                       | Biomass                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Waterbirds            | Number of taxa (diversity)                            | <p>Calculation of population indexes and comparison with previous years; if a statistically significant change is detected, its causes should be investigated and possibly managed; if endangered or critically endangered species are detected, provisions should be made for their strict protection</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                       | Relative abundances                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |



| Monitoring parameters |                            | Data analysis methods and criteria                                                                                                                                                                                                                                                                  |
|-----------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ungulates             | Number of taxa (diversity) | Calculation of population indexes and comparison with previous years; if a statistically significant change is detected, its causes should be investigated and possibly managed; if endangered or critically endangered species are detected, provisions should be made for their strict protection |

### 7.6.7. Monitoring plan revision criteria and frequency

#### 7.6.7.1. Surface water

The following table shows criteria and frequency for plan revision.

| Group of monitoring parameters                                                                                                                                  | Monitoring plan revision criteria and frequency                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stream water levels                                                                                                                                             | Revision of the monitoring plan for the stream water levels should be done in 5 years. If some stream is consistently dry during the dry season (5 consecutive years), this should be substituted by another that does not dry during the year. After the first 5 years the possibility of expanding the monitoring to other streams should be evaluated. |
| Streamflow                                                                                                                                                      | Streamflow measurements are only needed until the rating curves are being defined. After this, stream flows are only needed if important morphological aspects are changed in the upstream part of the catchment.                                                                                                                                         |
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen;                                                                                               | If pH, conductivity, and dissolved oxygen values do not comply for two consecutive years with the thresholds for the uses they are used for (drinking in some cases, irrigation in others), the monitoring in this specific station should be intensified and further studied in order to understand the problem                                          |
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD5); Chemical Oxygen Demand (COD) | If any of the parameters show concentrations that do not comply for two consecutive years with the applicable thresholds (drinking in some cases, irrigation in others), the monitoring in this specific station should be intensified and further studied in order to understand the problem                                                             |



#### 7.6.7.2. Groundwater

The following table shows criteria and frequency for plan revision.

| Group of monitoring parameters                                                                                                                                  | Monitoring plan revision criteria and frequency                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| groundwater levels                                                                                                                                              | Revision of the monitoring plan for the groundwater levels should be done in 5 years. If some well is consistently dry during the dry season (3 consecutive years), this should be substituted by another that does not dry during the year. After the first 5 years the possibility of expanding the monitoring to other wells should be evaluated. |
| Temperature; pH; Conductivity; Redox potential; Dissolved oxygen;                                                                                               | If pH, conductivity, and dissolved oxygen values do not comply for two consecutive years with the thresholds for drinking purposes, the monitoring in this specific station should be intensified and further studied in order to understand the problem.                                                                                            |
| Dissolved trace metals and metalloids (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn); Nitrate; Phosphorus; Biochemical Oxygen Demand (BOD5); Chemical Oxygen Demand (COD) | If any of the parameters show concentrations that do not comply for two consecutive years with the thresholds for drinking purposes, the monitoring in this specific station should be intensified and further studied in order to understand the problem                                                                                            |

#### 7.6.7.3. Soil

In three years, the monitoring plan should be revised. If the yields per hectare for that specific village have not increased during this period, and capacity building on sustainable agriculture have taken place in that specific village, it means that measures need to be taken. An option would be to expand the monitoring to neighbouring areas to assess the existence of better soils for agriculture.

#### 7.6.7.4. Sediment

After three years of monitoring the area can be considered understood in terms of sediment composition. This specific monitoring plan for sediment can be retaken for a single campaign every 5 years.



#### **7.6.7.5. Habitats**

After the first 10 years of the programme's implementation, it is recommended that its methodologies be reviewed and adapted if needed.

#### **7.6.7.6. Flora**

After the first 10 years of the programme's implementation, it is recommended that the methodologies for terrestrial flora and macrophytes monitoring be reviewed and adapted if needed.

Regarding phytoplankton, following the establishment of baseline conditions – through regular monitoring over the course of at least two years – monitoring frequencies can be reduced to cover only the timeframes considered to hold greater informative value, such as in the dry season.

#### **7.6.7.7. Fauna**

After the first 5 years of the programme's implementation, it is recommended that the methodologies for fisheries monitoring be reviewed and adapted if needed. For the remaining monitoring efforts, this revision can be done at the 10-year mark.



## **7.7. Implementation and follow up**

### **7.7.1. Implementation schedule**

The Conservation Plan for Lukanga Swamp and Upper Kafue Basin has been developed for implementation covering approximately 30 years from 2021 to 2050, phased between short-term (2021-2025), medium-term (2026-2035) and long term (2036-2050).

The management strategies proposed take these time-frames into account and Table 37 (Summary of the proposed management strategies; scales, time frames, responsibilities and follow up indicators), below, indicates the time frame for implementation of each action.

In the short-term, when (human and financial) resources are still being mobilized, the institutional arrangement and governance issues should be stabilized to ensure accountability for implementing the Plan's road map. Emphasis should be on stakeholder engagement, capacity building and public awareness to inform about the guidelines for the region's sustainable management, organisation and responsibilities. Data collection and monitoring should also start from the onset of the Conservation Plan's implementation, as well as the development of management plans and programmes. For some of the proposed conservation and management actions, as the creation of community-led tree nurseries, it is also essential that pilot projects start at this stage.

In the medium-term, it is assumed that the institutional, financial and planning frameworks are consolidated. So, conservation and management actions and best practices should be fully adopted and implemented. This includes the continuity and expansion of pilot projects, building on the pros and cons of the experiments conducted in the short term, and all restoration actions, including the ones planned in the previous implementation period. Legal issues such as financial incentives should also be set and fully operational at this stage. Ongoing actions such as monitoring should be reviewed.

Strategies for the long-term, at this stage, are merely indicative. Still, the completion of conservation and management actions initiated in the previous periods is expected. Also, the refinement and evaluation of ongoing actions, like monitoring, should be conducted to support the verification of the conservation plan's effects.

For the final version of the Conservation Plan, a more specific road map for implementation will be defined, describing the specific goals to be reached in each period and the path towards them.



### 7.7.2. Institutional arrangement

Management of Lukanga Swamp and its resources is multi-sectoral and involves the central government, the private sector, NGOs and the local inhabitants (Chabwela *et al.*, 2010), including:

- Ministry of Lands and Natural Resources; Climate Change and Natural Resources Management Department; Forestry Department;
- Ministry of Water Development, Sanitation and Environmental Protection; Department of Water Resources Development;
- Department of National Parks and Wildlife (DNPW);
- National Heritage Conservation Commission (NHCC);
- Zambia Environmental Management Agency (ZEMA);
- Water Resources Management Authority (WARMA);
- District Councils;
- Ministry of Community Development and Social Welfare;
- Ministry of Fisheries and Livestock;
- Ministry of Local Government;
- Ministry of Housing and Infrastructure Development;
- Ministry of Agriculture; Extension Services for Kafue; Office for Central Zambia;
- Traditional Authorities;
- Local Communities;
- Community Based Organisations (CBOs);
- Non-Governmental Organisations (NGOs), such as BirdWatch Zambia and WWF Zambia (Mapedza *et al.*, 2012);
- Private Sector.

As the promotor of this Conservation Plan for Lukanga Swamp and Upper Kafue Basin, as well as an independent environmental regulator and coordinating agency, mandated to “co-ordinate the implementation of activities of all ministries, appropriate authorities and conservancy authorities in matters relating to the environment” and to “do all such things as are necessary to ensure the sustainable management of natural resources and protection of the environment, and the prevention and control of pollution” (Environmental Management Act No. 12 of 2011), Zambia Environmental Management Agency should **coordinate** the implementation of the Plan, with direct support from the following organs of government:





- The Ministry responsible for Natural Resources – Ministry of Lands and Natural Resources – as the lead institution in overseeing the implementation of the National Policy on Wetlands (2018) and also leading the inter-agency coordination on the management of all wetlands in the Country.
- The Ministry responsible for the Environment – Ministry of Water Development, Sanitation and Environmental Protection – as the responsible for the formulation and for analysing policies on the management of the environment to contribute to better environmental management of the wetlands (MLNR, 2018).
- The Ministry responsible for National Parks and Wildlife – currently the Ministry of Tourism and Arts through the Department of National Parks and Wildlife (DNPW) – as the responsible for the operationalization of the Ramsar Convention on wetlands in the Wildlife Protected Areas, namely for ensuring the protection of wildlife resources, undertaking research and monitoring and conducting restoration of degraded wetland ecosystems within the protected area network (MLNR, 2018).

This governmental arrangement will allow for improved linkages and coordination between relevant institutions in natural resource management (Figure 17), which is missing in Zambia to reduce deforestation, for instance (Vinya *et al.*, 2011). Also, according to Kachali (2008), apart from the local communities, the most important stakeholder in the Lukanga Swamp is the Government of Zambia through its various ministries, departments and agencies.

Of course, there are other governmental institutions very relevant for this Conservation Plan's implementation – such as WARMA and the Ministries of Fisheries and Livestock, Local Government, Housing and Infrastructure Development and Agriculture – but their functions will be harmonised by ZEMA and coordinating ministries.

This Plan also recognises the essential role local institutions play in the management and use of the wetland (and catchment) resources, as demonstrated by the management strategies proposed. As described by McCartney *et al.* (2011), “local communities are the *de facto* managers of the wetland. The traditional authorities (lineage chiefs) (...) administer their areas of jurisdiction through village headmen. They are empowered to allocate land and resolve disputes over natural resource use. (...) The chiefs and headmen are responsible for granting permission to cultivate the land, graze livestock, access water, and collect plants from the wetland”.



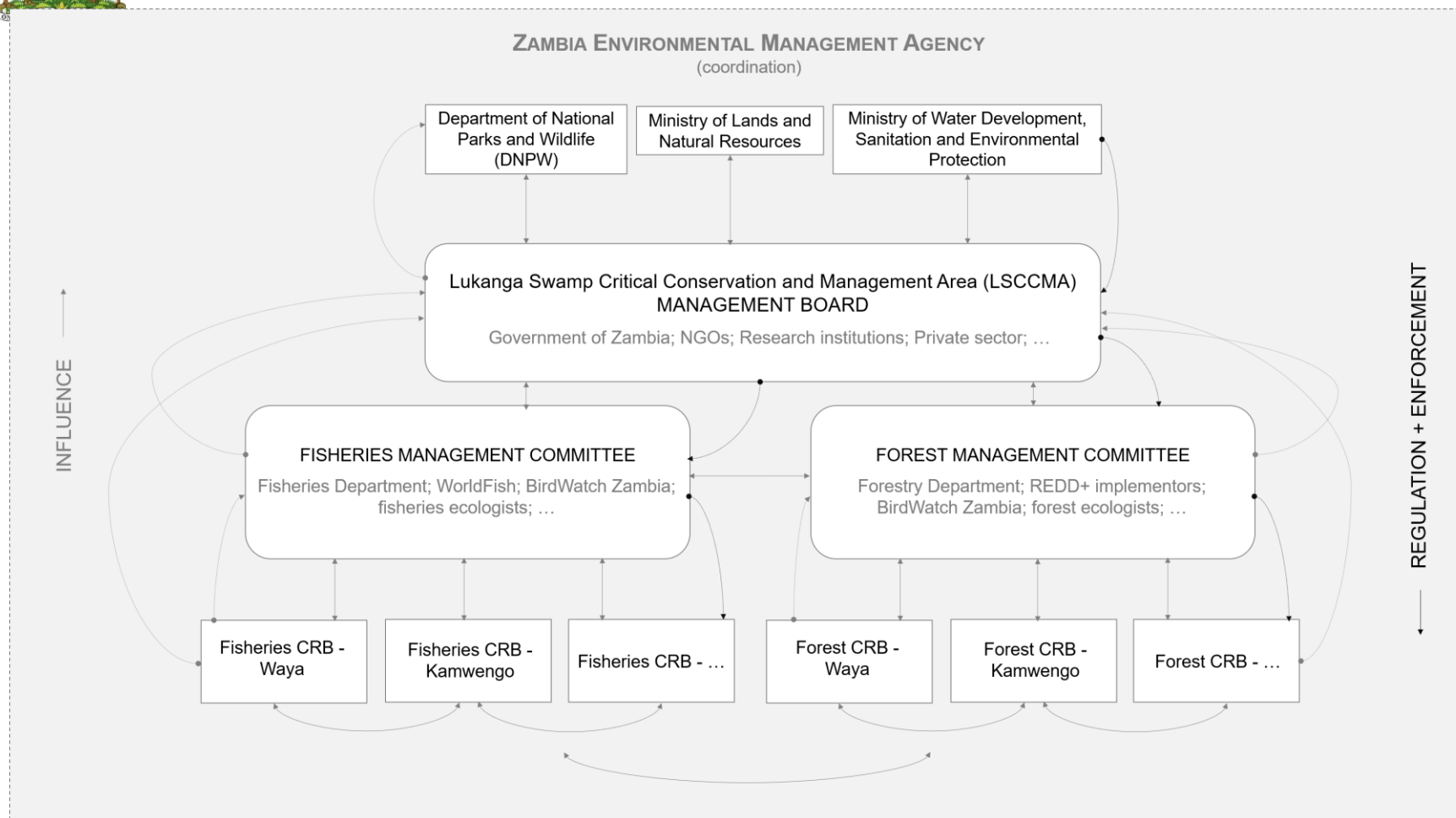
That is why, from the options available for implementation (Chabwela *et al.*, 2010), the present Conservation Plan recommended (cf. section 7.2) a model similar to that proposed by Lukanga Catchment Management Plan, of a Critical Conservation and Management Area (following the multiple use conservation area model, no longer in use by IUCN), managed under Community Resource Boards (CRBs) (section 7.7.2.1). As neither of IUCN's categories compatible with some degree of resource use seems to fit Lukanga's case well enough, this Plan proposes the **creation of a partially protected area** that acknowledges the role of human communities within the system and wider landscape, enabling their continued but sustainable use of natural resources. This way, conservation efforts will focus on systems and communities rather than on particular species and their conservation status, while still forming a wildlife corridor connecting the swamp with the Lunga Luswishi GMA, leading to Kafue National Park.

#### 7.7.2.1. Co-management arrangements

Building on what is said above (for instance, sections 7.7.2, 7.2 and 7.4.4), and throughout this document, the structural arrangement for implementing the Plan should start from the village or chiefdom level, through the CRBs, having their participation in the resources' management assured, though coordinated by the governing agencies (Figure 17). "The functions of a board are to promote and develop an integrated approach to the management of human and natural resources in (...) an open area falling under its jurisdiction" (The Zambia Wildlife Act No. 14 of 2015) and, according to McCartney *et al.* (2011), the creation of CRBs appears to be the primary mechanism for making local communities active stakeholders.

Following the management arrangements up the hierarchical ladder (Figure 17), above CRBs are Resource Committees for fisheries and forests (and, eventually, for fire, grazing and tourism management), joining operational entities, specialized researchers/experts and local stakeholders' representatives. Above these, sits the site's Management Board, tasked with integrating all the knowledge from below, as well as the regulations from above – that is, from the Government of Zambia –, for instance.

NGOs and the private sector's potential to foster the sustainable use of Lukanga Swamp and the Kafue river basin upstream is also documented in the management strategies' operationalization proposed in the section below, as well as in Figure 17.



**Figure 17 – Schematic representation of the co-management arrangements proposed for the Lukanga Swamp Critical Conservation and Management Area**



In the figure above, linkages between different levels of the hierarchical management structure refer to communication, influence or enforcement pathways, and are represented as direct or indirect (if they happen through meetings, or through annual reporting, for instance), vertical (between levels – top-down for enforcement or imposition of particular regulations; or bottom-up, for the sharing of local knowledge and deliberation of communally agreed initiatives) or horizontal (between institutions of the same level, i.e., with analogous responsibilities and roles).

The ways in which these communication links are established need to be clearly detailed, and can include complaint registration mechanisms, monthly discussion forums, monthly meetings, etc. Independent on how these are achieved, the communication links represented need to be implemented and clearly understood by all intervenient governing entities, local groups, NGOs, and other.

Finally, the role (executive, informative, consultative, deliberative, operational, etc.) and the responsibilities (enforcement, surveillance, reporting, data collection, development of a fisheries management plan, communication of news or meetings, etc.) for each entity also needs to be clearly detailed, and provisions must be put in place to ensure each level possesses the technical and human capacity to fulfil its functions adequately.



### 7.7.3. Follow up

To monitor and evaluate the implementation of the Conservation Plan for Lukanga Swamp and Upper Kafue Basin, follow up indicators have been defined to ensure the proposed management strategies and actions achieve the expected objectives.

Table 46 summarizes the proposed management strategies and actions and their respective scales of implementation, responsible institutions and follow up indicators. These will be regularly assessed and reported, with the involvement of relevant stakeholders, so that emerging issues can be taken into account during the plan's schedule for implementation.

The following reports shall be prepared as part of the Plan's monitoring and evaluation process:

- Annual self-assessment reports;
- Independent short-term evaluation report by the third year of implementation (by 2024 – a year before the end of the short-term period of implementation), to prepare a review of the plan for the next ten years;
- Independent medium-term evaluation report (by 2030 – in the middle of the medium-term period of implementation);
- Independent five-year evaluation reports, from then on (by 2035, 2040 and 2045).

Annual self-assessment reports shall reflect the progress achieved in meeting the management objectives, including indicator results, where possible, and clear recommendations for addressing the constraints identified in lack of progress.

The independent evaluation reports shall also include the progress being made towards the achievement of outcomes, but also lessons learned about plan design and management, to be incorporated for enhanced implementation during the next phase.

These reporting requirements and indicative timeline for delivery may also be reviewed in the course of the Plan's monitoring and evaluation process.



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**Table 46 – Summary of the proposed management strategies; scales, time frames, responsibilities and follow up indicators**

| Management strategies                                                                           | Actions                                                                                                                                                                                                                                                 | Scales of implementation | Time-frames for implementation | Responsible institution(s)                                                                      | Management objectives / indicators                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Protection and land use zonation of the Lukanga Swamp critical management and conservation area | Designate the site as the Lukanga Swamp Critical Conservation and Management Area (multiple-use management area)                                                                                                                                        | Lukanga Swamp            | Short-term                     | Zambia Environmental Management Agency (ZEMA)                                                   | <i>De facto</i> integrated management of the site / Official documents – such as Decrees formally creating the management area and publishing the regulations under this designation, as well as institutional responsibilities – and management reports |
| Governance                                                                                      | Create independent Community Resource Boards (CRBs) for the following uses: livestock herding; burning; collection of forest products; and fishing; (or restructuring and capacitation of current ones, such as the Joint Forest Management Committees) | Lukanga Swamp watershed  | Short-term                     | ZEMA; Ministry of Fisheries and Livestock (MFL); Ministry of Lands and Natural Resources (MLNR) | Enabling participative and collaborative management; increase knowledge sharing and compliance / Records of the creation of the CRBs, with member lists, and records of the CRBs activities (meetings, formal training, education initiatives, etc.)     |
| Water and soil management                                                                       | Monitor levels of surface water and groundwater in the area                                                                                                                                                                                             | Lukanga Swamp watershed  | Short, Medium and Long-term    | Water Resources Management Authority                                                            | Ever more realistic diagnostic of the catchment / Monitoring Reports; Interannual trends of water levels and flows                                                                                                                                       |
|                                                                                                 | Actions to decrease the rate of deforestation, and increase areas with forests with native species                                                                                                                                                      | Lukanga Swamp watershed  | Short and Medium-term          | ZEMA                                                                                            | Increase of forested areas / Rates of deforestation in the catchment; area occupied by forests with native species                                                                                                                                       |
|                                                                                                 | Practice climate-smart agriculture: On-farm rainwater harvesting; Enhancement of the soil's capacity to hold moisture; Systematic access to groundwater                                                                                                 | Lukanga Swamp watershed  | Medium and Long-term           | Ministry of Agriculture                                                                         | Sustainable use of soil resources and reduction of deforestation / Produce production per area; rates of deforestation in the catchment                                                                                                                  |
|                                                                                                 | Soil fertility management                                                                                                                                                                                                                               | <i>See below</i>         | <i>See below</i>               | <i>See below</i>                                                                                | <i>See below</i>                                                                                                                                                                                                                                         |
|                                                                                                 | Monitor quality of surface water and groundwater in the catchment                                                                                                                                                                                       | Lukanga Swamp watershed  | Short, Medium and Long-term    | Water Resources Management Authority                                                            | Ever more realistic diagnostic of the catchment / Monitoring Reports; concentration trends of contaminants                                                                                                                                               |
|                                                                                                 | Policies and incentives to reduce land conversion                                                                                                                                                                                                       | Lukanga Swamp watershed  | Medium-term                    | MLNR                                                                                            | Land conversion reduction / Areas occupied by different land uses                                                                                                                                                                                        |
|                                                                                                 | Monitor the quality of soils in the Lukanga Swamp catchment                                                                                                                                                                                             | Lukanga Swamp watershed  | Short, Medium and Long-term    | Ministry of Agriculture                                                                         | Ever more realistic diagnostic of the catchment / Monitoring Reports; Produce production per area                                                                                                                                                        |
|                                                                                                 | Climate-smart agriculture practices: Integrated soil fertility management; Conservation agriculture; Improved grazing management                                                                                                                        | Lukanga Swamp watershed  | Medium-term                    | Ministry of Agriculture                                                                         | Sustainable use of soil resources and reduction of deforestation / Produce production per area; rates of deforestation in the catchment; erosion rates                                                                                                   |
|                                                                                                 | Local people living in the catchment should be trained for best-practices in climate-smart agriculture                                                                                                                                                  |                          | Short-term                     |                                                                                                 |                                                                                                                                                                                                                                                          |





| Management strategies | Actions                                                                                                                                         | Scales of implementation                   | Time-frames for implementation | Responsible institution(s) | Management objectives / indicators                                                                                                                                                                                                                        |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat management    | Submit to Environmental and Social Impact Assessment all development projects suspected to impact the hydrology of the sub-catchment and swamp. | Lukanga Swamp watershed; Upper Kafue River | Short, Medium and Long-term    | ZEMA                       | Mitigate impacts of projects on hydrology-dependent habitats / number of EIA studies developed in relation to projects proposed                                                                                                                           |
|                       | Monitor the impacts of development projects within the sub-catchment with potential impacts on the swamp's seasonal hydrological regime         | Lukanga Swamp watershed; Upper Kafue River | Short, Medium and Long-term    | ZEMA                       | Monitor impacts of projects on the hydrology-dependent habitats, for the adaptation of management / monitoring reports                                                                                                                                    |
|                       | Actions to decrease the rate of deforestation                                                                                                   | Lukanga Swamp watershed                    | Short and Medium-term          | ZEMA                       | Halt deforestation completely in the Ramsar site and the 10 km buffer, and reduce deforestation by 2/3 in the subcatchment (10% deforestation – reduction from the expected scenario of 15% deforestation) / Area occupied by forests with native species |
|                       | Develop a reforestation programme (including the creation of community-led tree nurseries)                                                      | Lukanga Swamp watershed                    | Short and Medium-term          | ZEMA                       | - / Area of reforested patches; number of community-led nurseries                                                                                                                                                                                         |
|                       | Develop a river restoration programme                                                                                                           | Lukanga Swamp watershed                    | Short and Medium-term          | ZEMA                       | Increase the cover of riparian vegetation in the Lukanga and Mushingashi rivers upstream of the swamp / Area occupied by riparian vegetation                                                                                                              |
|                       | Monitor swamp and seasonally inundated grasslands                                                                                               | Lukanga Swamp                              | Short, Medium and Long-term    | ZEMA                       | Assess the current state and future evolution of priority ecological values for which information is lacking / Monitoring reports                                                                                                                         |



| Management strategies           | Actions                                                                                                                                                                                                                                    | Scales of implementation | Time-frames for implementation | Responsible institution(s)                                      | Management objectives / indicators                                                                                                   |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Biodiversity/species management | Monitor aquatic macrophytes and phytoplankton                                                                                                                                                                                              | Lukanga Swamp            | Short, Medium and Long-term    | ZEMA; MFL                                                       | Assess the current state and future evolution of priority ecological values for which information is lacking / Monitoring reports    |
|                                 | Monitor ichthyofauna and zooplankton                                                                                                                                                                                                       | Lukanga Swamp            | Short, Medium and Long-term    | MFL                                                             | Assess the current state and future evolution of priority ecological values for which information is lacking / Monitoring reports    |
|                                 | Monitor waterbirds                                                                                                                                                                                                                         | Lukanga Swamp            | Short, Medium and Long-term    | Zambia Wildlife Authority, with the support of BirdWatch Zambia | Assess the current state and future evolution of priority ecological values for which information is lacking / Monitoring reports    |
|                                 | Monitor wild ungulates                                                                                                                                                                                                                     | Lukanga Swamp            | Short, Medium and Long-term    | Zambia Wildlife Authority                                       | Assess the current state and future evolution of priority ecological values for which information is lacking / Monitoring reports    |
|                                 | Implement a system for early detection and alert on alien species introduction                                                                                                                                                             | Lukanga Swamp watershed  | Short, Medium and Long-term    | ZEMA                                                            | Detect infestations on time, for a more cost-effective control / Documents on the system's processes and reports                     |
|                                 | Implement best-practices for preventing the (re)introduction of the Kariba weed, the water hyacinth, the giant sensitive plant, the Nile tilapia, and the red claw crayfish                                                                | Lukanga Swamp watershed  | Short, Medium and Long-term    | ZEMA                                                            | Prevent the introduction of alien species / Presence/absence data for each species                                                   |
|                                 | Control active infestations; ideally, a combination of different methods should be employed (integrated control – manual + biological + chemical), depending on the species, the status of the invasion and the nature of the invaded site | Lukanga Swamp watershed  | Short, Medium and Long-term    | ZEMA                                                            | Prevent infestations from establishing, and keep them in controlled levels / Implementation and success of control programs; reports |
|                                 | Monitor the status of invasive alien species infestations                                                                                                                                                                                  | Lukanga Swamp watershed  | Short, Medium and Long-term    | ZEMA                                                            | Prevent infestations from establishing, and keep them in controlled levels / Monitoring reports                                      |



| Management strategies                 | Actions                                                                                                                                                                                                                                      | Scales of implementation        | Time-frames for implementation | Responsible institution(s)                              | Management objectives / indicators                                                                                                                                                         |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Socio-economic development: fisheries | Declare the Swamp as a Fisheries Management Area, under Article 26 of Part IV of the Fisheries Act of 2011, through the publication of a decree/act/gazette                                                                                  | Lukanga Swamp                   | Short term                     | MFL; Community Resource Boards for Fisheries Management | Framework for the management of the fisheries / legal documents                                                                                                                            |
|                                       | Appoint a Fisheries Management Committee and local level fisheries decision groups                                                                                                                                                           | Lukanga Swamp                   | Short term                     | MFL                                                     | Institutional arrangement to support management / legal documents and meeting reports                                                                                                      |
|                                       | Develop – in a participatory way – fishing concession zones within the Fisheries Management Area, for each fishing village or chiefdom                                                                                                       | Lukanga Swamp                   | Short term                     | MFL; Community Resource Boards for Fisheries Management | <i>De facto</i> participatory management of the fishery / legal documents and meeting reports                                                                                              |
|                                       | Update the licencing system to fit this model of local property rights                                                                                                                                                                       | Lukanga Swamp                   | Short term                     | MFL; Community Resource Boards for Fisheries Management | Assignment of property rights and protection of local users / legal documents and licencing records                                                                                        |
|                                       | Develop clear regulations for the Lukanga Swamp Fisheries Management Area                                                                                                                                                                    | Lukanga Swamp                   | Short term                     | MFL; Community Resource Boards for Fisheries Management | Improved management and legitimacy of management actions / legal documents                                                                                                                 |
|                                       | Build the capacity of regulatory and enforcement agencies                                                                                                                                                                                    | Lukanga Swamp                   | Short term                     | MFL                                                     | Support management / records for the implementation of training actions and equipment inventories                                                                                          |
|                                       | Establish mechanisms for setting trading strategies – such as fixed fish prices (independent of species), if and when deemed appropriate, as was done in the Bangweulu swamps (Imai, 1998), as a buffer against external market fluctuations | Lukanga Swamp                   | Medium term                    | MFL; Community Resource Boards for Fisheries Management | Protection of local communities from market fluctuations / pricing system                                                                                                                  |
|                                       | Establish mechanisms for conflict resolution                                                                                                                                                                                                 | Lukanga Swamp                   | Short and medium term          | MFL                                                     | Increase participation platforms, to increase the legitimacy of managing institutions                                                                                                      |
|                                       | Establish appropriate fines for non-compliance                                                                                                                                                                                               | Lukanga Swamp                   | Short and medium term          | MFL                                                     | Deter non-compliance / legal documents and reports for enforcement actions                                                                                                                 |
|                                       | Establish a system for locating, registering (e.g., with the help of handheld GPS devices) and organizing fishing camps within the swamp                                                                                                     | Lukanga Swamp                   | Medium and long term           | MFL                                                     | Increase the knowledge on the current system, for the development of tailored measures / existence of this system, and of a database of geographic information concerning this information |
|                                       | Define the rules for proper utilization of fishing camps                                                                                                                                                                                     | Lukanga Swamp                   | Medium and long term           | MFL                                                     | Increase the safety, living conditions and environmental cleanliness in fishing camps                                                                                                      |
|                                       | Implement the utilization of improved post-harvest processing technologies (such as smoking kilns, solar drying tents and salting)                                                                                                           | Lukanga Swamp and sub-catchment | Medium and long term           | MFL                                                     | Optimize processing method to reduce waste / Reports form implementation programs                                                                                                          |



| Management strategies                   | Actions                                                                                                                                                                                                                                                                                                                            | Scales of implementation          | Time-frames for implementation | Responsible institution(s)                            | Management objectives / indicators                                                                                                |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|--------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Socio-economic development: grazing     | Collect updated information regarding local pastoralists and their practices, including the creation of a community-led registry system                                                                                                                                                                                            | Lukanga Swamp                     | Short, Medium and Long-term    | MFL                                                   | To acquire updated information on the system, for future development of tailored measures / Documents of the Registry System      |
|                                         | Develop Grazing Management Plans                                                                                                                                                                                                                                                                                                   | Lukanga Swamp (by chiefdom)       | Short-term                     | MFL; Community Resource Boards for Grazing Management | To support management in a spatially-specific and organized way / Documents of the Grazing Management Plan                        |
|                                         | Improve extension services for grazing management                                                                                                                                                                                                                                                                                  | Lukanga Swamp (covered Districts) | Medium and Long-term           | MFL                                                   | To increase local users' understanding of sustainable practices and their good implementation / Reports on extension actions      |
| Socio-economic development: use of fire | Establish a system for the collection of updated information regarding traditional and current burning practices                                                                                                                                                                                                                   | Lukanga Swamp                     | Short-term                     | MLNR                                                  | Effectively characterize burning regimes and practices, to be shared with fire managers and researchers / Data collection reports |
|                                         | Develop Fire Management Plans                                                                                                                                                                                                                                                                                                      | Lukanga Swamp (by chiefdom)       | Short-term                     | MLNR; Community Resource Boards for Fire Management   | Maintain traditional use of fire practices in a sustainable and safe way / Planning documents                                     |
|                                         | Introduce incentives to increase compliance to fire restrictions, and to substitute fire as a tool (e.g., shift to less fire-dependent farming practices; promotion of hunting methods that do not involve burning; clarification of land tenure), possibly through the implementation of a Payments for Ecosystem Services scheme | Lukanga Swamp                     | Medium and Long-term           | MLNR                                                  | Decrease the need to use fire as a tool / Reports from enforcement/surveillance actions                                           |
|                                         | Implement best-practices to reduce the impact of fire on ecological systems                                                                                                                                                                                                                                                        | Lukanga Swamp                     | Short, Medium and Long-term    | MLNR                                                  | Maintain traditional use of fire practices in a sustainable and safe way / Reports from enforcement/surveillance actions          |
|                                         | Capacity building of government officials in fire management                                                                                                                                                                                                                                                                       | Lukanga Swamp                     | Short-term                     | MLNR                                                  | Support management / Records/reports of training actions                                                                          |
|                                         | Implement an education and awareness raising campaign for local populations                                                                                                                                                                                                                                                        | Lukanga Swamp                     | Short-term                     | MLNR                                                  | Foster a sense of responsibility and stewardship; and to increase compliance / Records/reports of awareness raising actions       |



| Management strategies                               | Actions                                                                                                                                                                                                        | Scales of implementation                                    | Time-frames for implementation | Responsible institution(s)                            | Management objectives / indicators                                                                                                                                                    |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Socio-economic development: use of forest resources | Define clear, long-term, forest tenure through the assignment of exclusive exploitation rights to local communities; the licencing system should be re-designed to fit this model of local ownership           | Lukanga Swamp                                               | Short-term                     | MLNR                                                  | Planned forest production and conservation; sustainable resource use / Legal documents assigning property rights to local communities; licencing systems and records                  |
|                                                     | Develop community-level Forest Management Plans                                                                                                                                                                | Lukanga Swamp (by chiefdom or village, as more appropriate) | Short-term                     | MLNR; Community Resource Boards for Forest Management | Planned forest production and conservation; sustainable resource use / Planning and implementation documents                                                                          |
|                                                     | Allocate exclusive trading rights for wood-based fuel and/or products to local communities; and development clear marketing rules and arrangements to protect local users                                      | Lukanga Swamp                                               | Medium and Long-term           | MLNR                                                  | Protection of local communities against market fluctuations and against the reduction of their income due to the introduction of restrictions / Planning and implementation documents |
|                                                     | Develop a Lukanga Swamp brand for improving the marketability of its products (wood, charcoal, honey, etc.), based on the adhesion to effective sustainable practices                                          | Lukanga Swamp                                               | Long-term                      | MLNR                                                  | Protection of local communities against market fluctuations and against the reduction of their income due to the introduction of restrictions / Planning and implementation documents |
|                                                     | Actions to increase the cover of indigenous fruit trees around cultivated land and household gardens                                                                                                           | Lukanga Swamp                                               | Short, Medium and Long-term    | MLNR                                                  | Increase food security / reports from surveillance actions                                                                                                                            |
|                                                     | Implement best-practices to reduce the negative impacts of resource extraction from forests and improve post-harvest natural regeneration (bark harvesting, mushroom harvesting, regenerative practices, etc.) | Lukanga Swamp watershed                                     | Short, Medium and Long-term    | MLNR                                                  | Achieve sustainable harvesting / Reports from enforcement/surveillance actions                                                                                                        |
|                                                     | Promote improved kiln technologies                                                                                                                                                                             | Lukanga Swamp watershed                                     | Medium and Long-term           | MLNR                                                  | Optimize charcoal production for the reduction of wood harvesting / Reports from enforcement/surveillance actions                                                                     |
|                                                     | Introduce alternative energy sources, such as household-level solar equipment                                                                                                                                  | Lukanga Swamp watershed                                     | Medium and Long-term           | MLNR                                                  | Reduce the use of wood as energy source/ Reports from enforcement/surveillance actions                                                                                                |
|                                                     | Build the capacity of government institutions and officials concerning sustainable forest management and ecology; improve extension services for the area                                                      | Lukanga Swamp                                               | Short, Medium and Long-term    | MLNR                                                  | Support management / Records/reports of training actions                                                                                                                              |
|                                                     | Implement an awareness raising and education campaign for local populations concerning forest ecosystems, their values, services, and the impact of different activities, do's and don'ts                      | Lukanga Swamp                                               | Short, Medium and Long-term    | MLNR                                                  | Foster a sense of responsibility and stewardship; and to increase compliance / Records/reports of awareness raising actions                                                           |



| Management strategies                       | Actions                                                                                                                                          | Scales of implementation | Time-frames for implementation | Responsible institution(s)                                             | Management objectives / indicators                                                                                                                                |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strategies concerning the Upper Kafue Basin | Kafue River Management Plan                                                                                                                      | Kafue River Basin        | Short-term                     | Ministry of Water Development, Sanitation and Environmental Protection | Sustainable use of water resources / Enough water quantities for the different uses, Good water quality for the different uses, Maintenance of ecosystem services |
|                                             | Guarantee that water needs in the Upper Kafue River are met without considering the regulation of the main river upstream from the Lukanga Swamp | Upper Kafue River        | Short, Medium and Long-term    | Ministry of Water Development, Sanitation and Environmental Protection |                                                                                                                                                                   |





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## 8. Conclusion

Part II of the Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin was presented in this document, comprising the Action Plan: wetland conservation approach; Conservation Plan zonation; strategies for Lukanga Swamp watershed; strategies concerning the upper Kafue basin; environmental monitoring plan; implementation and follow up.

### **Wetland conservation approach**

The strategy of the Conservation Plan, to combine different management tools (e.g., from the creation of zones to species or habitat management), and the principles that guided that strategy and the whole conservation plan development and implementation: wise-use and sustainability; adaptive management; equity and transparency; cross-sectoral articulation and the “nexus approach”; public involvement, participation and accountability; education and capacity building.

Introduced the proposal of the creation of a managed area like the 2010 Lukanga Management Plan proposed model of a Multiple-Use Management Area.

### **Conservation Plan zonation**

The Lukanga Swamp critical conservation and management area was divided into three protection categories:

- Total Protection Areas – dominated by habitats of moderate to high ecological relevance, in a more favourable status, and that are known to support important ecological values and services;
- Partial Protection Areas – areas without (or with very few) human settlements, but which serve important ecosystem services and/or direct uses such as being grazing grounds or fishing areas; these serve as a buffer between total protection areas and areas of stronger human influence;
- Complementary Protection Areas – areas essentially covered by semi-natural and artificial land covers (settlements, cropland, etc.); management here focuses on empowering sustainable practices and implementing restorative actions; forested land is also included in this category.



The appropriate uses and the permanently or temporarily prohibited uses for the different zones were also specified.

### **Strategies for Lukanga Swamp watershed**

Strategies for Lukanga Swamp watershed conservation focus on several types of actions and recommendations: Conservation and management strategies – Water and soil management, Habitat management, Biodiversity/species management; Research and monitoring – Surface water and groundwater, Soil, Habitats, Biodiversity/species, Grazing, Burning practices; Capacity building – Training, Awareness-raising and education campaigns; Socioeconomic development – agriculture, fisheries, grazing, use of fire, use of forest resources; Climate change resilience – Regional-scale; Local-scale.

### **Strategies concerning the Upper Kafue Basin**

A holistic view of water governance, considering all uses present upstream of the Lukanga Swamp.

Activities that should be restricted and need to be regulated in the Upper Kafue river basin, such as interventions that alter water and flood levels across the basin, degradation of forest and riparian habitats, industrial and domestic waste discharges and invasive weed introduction.

### **Environmental monitoring plan**

The goal of the monitoring plan is to build up a database on the different media in the Lukanga Swamp catchment and Upper Kafue Basin, to gradually picture a more accurate diagnosis on the area and allow continuously more focused management. Its results will also allow understanding if the strategies proposed are assuring their purpose or if adaptation of these or new ones are needed.

The monitoring activities proposed (parameters, sampling stations and frequency, data collection and analysis methods and criteria) focus on surface water, groundwater, soil, sediment, habitats and biological communities.



## Implementation and follow up

The Conservation Plan for Lukanga Swamp and Upper Kafue Basin has been developed for implementation covering approximately 30 years from 2021 to 2050, phased between short-term (2021-2025), medium-term (2026-2035) and long term (2036-2050).

Zambia Environmental Management Agency is indicated as the coordinator of the implementation of the Plan, with direct support from the Ministry responsible for Natural Resources – Ministry of Lands and Natural Resources; the Ministry responsible for the Environment – Ministry of Water Development, Sanitation and Environmental Protection; the Ministry responsible for National Parks and Wildlife – currently the Ministry of Tourism and Arts through the Department of National Parks and Wildlife (DNPW). The Plan also recognises the essential role local institutions play in the management and use of the wetland (and catchment) resources, by proposing the structural arrangement for implementing the Plan to start from the village or chiefdom level, through the CRBs, having their participation in the resources' management assured, though coordinated by the governing agencies.

To monitor and evaluate the implementation of the Conservation Plan for Lukanga Swamp and Upper Kafue Basin, follow up indicators and reporting requirements and frequency were defined.

## Final considerations

Regarding the overall objective of the Conservation Plan for Lukanga Swamp – generate both qualitative and quantitative data and tools to support the participatory management of the area –, a relevant amount of data has already been compiled and collected; also, its analysis allowed the selection or development of tools (e.g., Environmental Cost-Benefit Analysis, Co\$ting Nature, the Lukanga Conservation Plan *website, including a "Participation form" for the reception of inputs*) that will support the participatory management of the area.

The body of information collected and analysed, as well as these tools, allowed the assessment of different conservation scenarios and the definition of the strategies here proposed to maximize the benefits provided by the swamp and thus improve the quality of life of the populations that depend upon these resources while protecting existing natural ecosystems.



The next steps include:

- Stakeholder consultation workshop W3, for presentation and discussion of Parts I and II of the Draft Plan, presented in Progress Reports No. 4 (D5) and No. 5 (D6), respectively;
- Draft Conservation Plan for Lukanga Swamp and Upper Kafue Basin, integrating, reviewing and updating Parts I and II according to comments from ZEMA and other relevant stakeholders, as well as stakeholder consultation actions conducted thus far, which will be the object of the Draft Report (D7).



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## Appendixes



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## **Appendix 1 – Maps**

**Map 1: Overview of Lukanga Swamp and Upper Kafue Basin; Conservation Plan areas**

**Map 2: Conservation Plan areas' administrative and hydrographic frameworks**

**Map 3a: Environmental and social constraints – Areas of conservation interest**

**Map 3b: Environmental and social constraints – Areas subject to greater anthropogenic pressure**

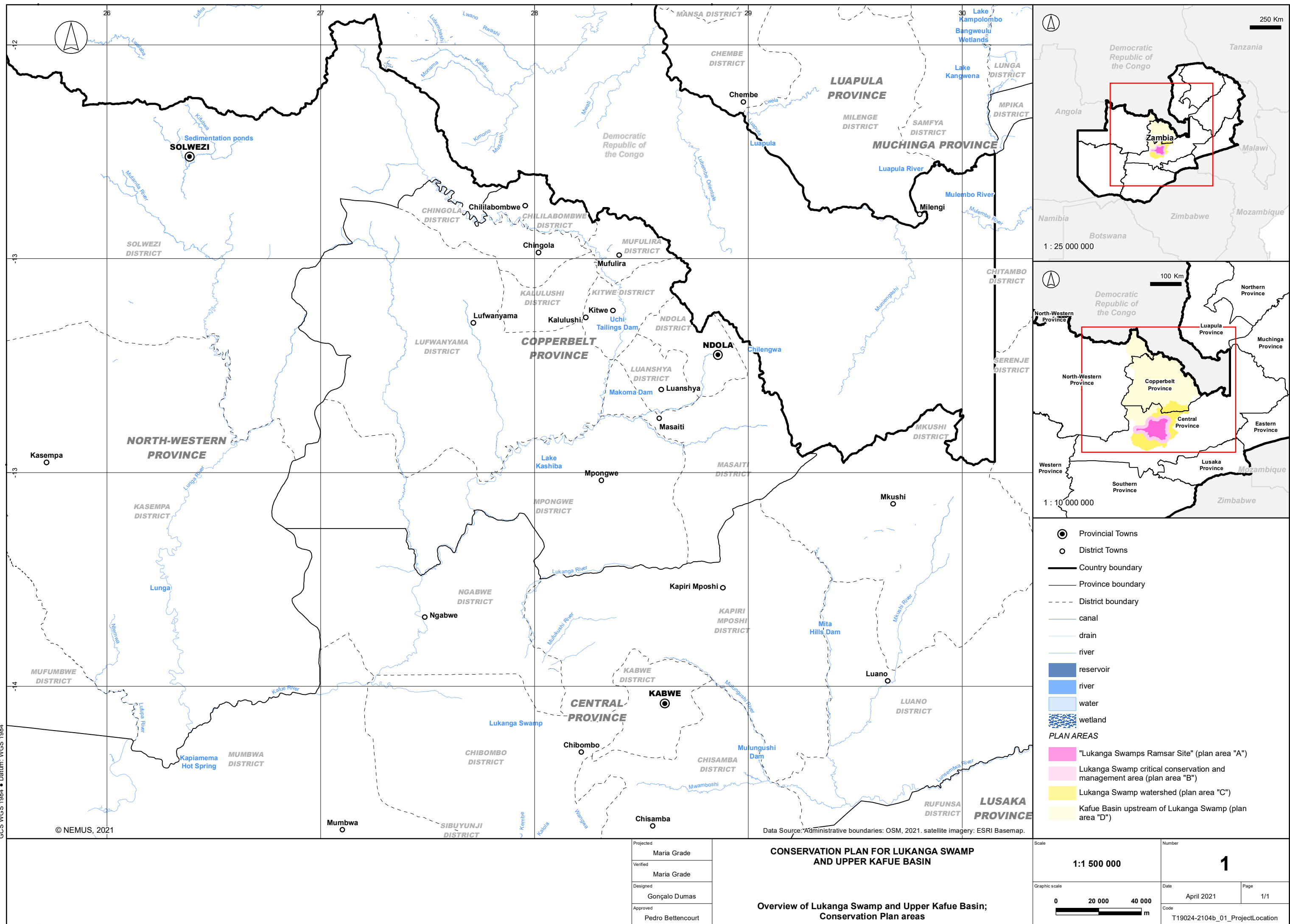
**Map 4: Protection and land use zonation of the Lukanga Swamp critical conservation and management area**

**Map 5: Environmental monitoring plan – spatial scope**



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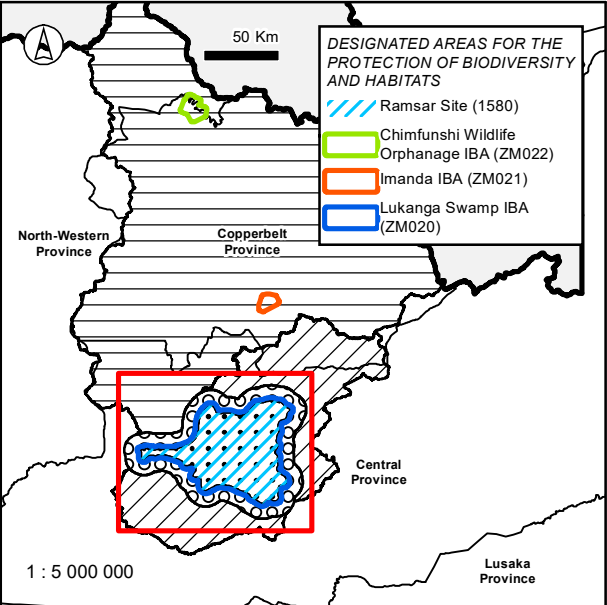
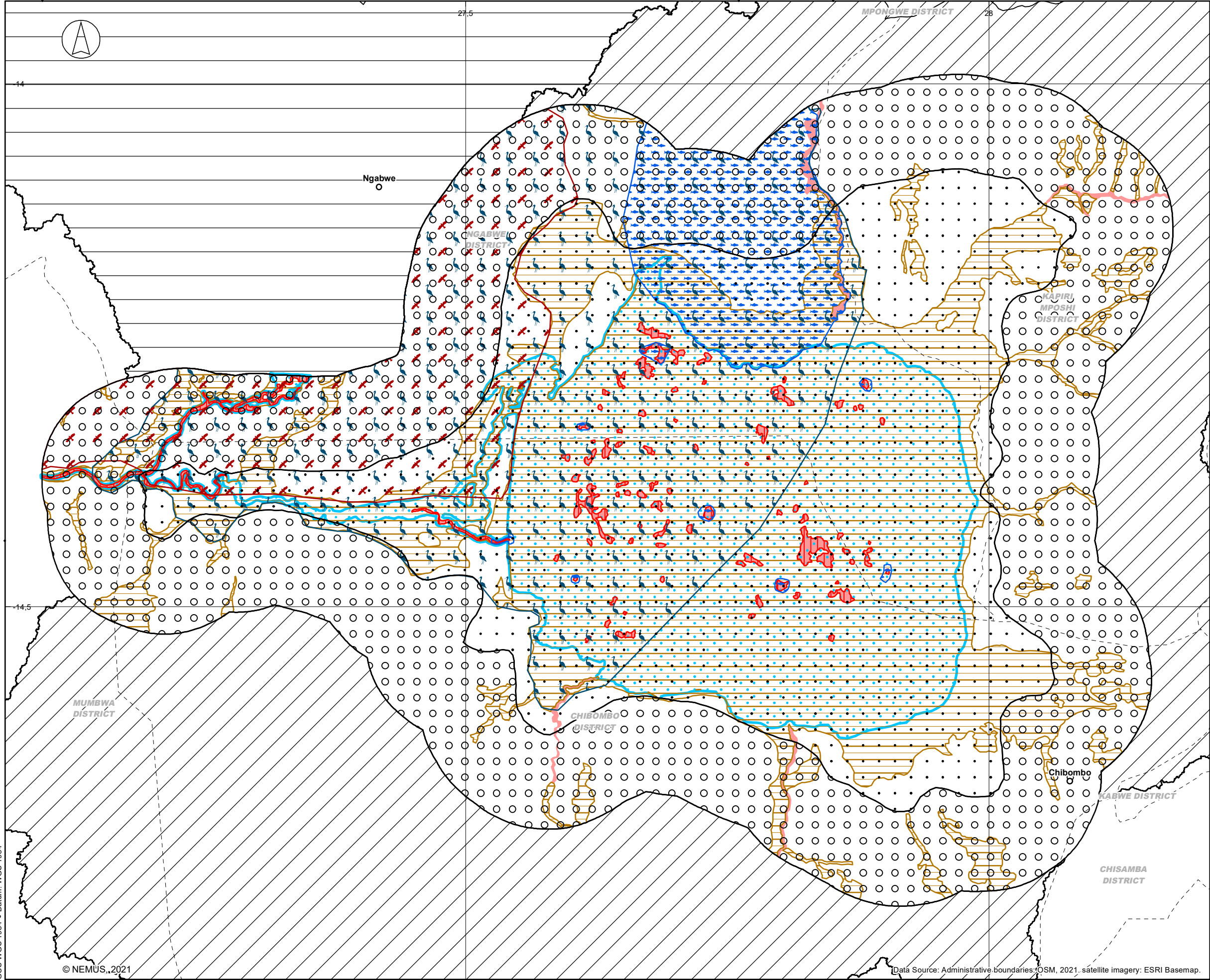












- District Towns  
— Province boundary  
--- District boundary
- PLAN AREAS**
- "Lukanga Swamps Ramsar Site" (plan area "A")
  - Lukanga Swamp critical conservation and management area (plan area "B")
  - Lukanga Swamp watershed (plan area "C")
  - Kafue Basin upstream of Lukanga Swamp (plan area "D")
- AREAS OF CONSERVATION INTEREST**
- Fish breeding area
  - High (west) to moderate (east) value habitats (classes 4 and 3 of 5)
  - High value habitats (class 4 of 5)
  - Most suitable habitat for *Lobogenes michaelis* (endangered)
  - Most suitable habitat for the yellow-belly bream (critically endangered)
  - Very high value biological communities (class 5 of 5)
  - Very high value habitats (class 5 of 5)
  - Most suitable habitat for endangered and critically endangered birds of prey
  - Most suitable habitat for waterbirds and ungulates

GCS WGS 1984 • Datum: WGS 1984

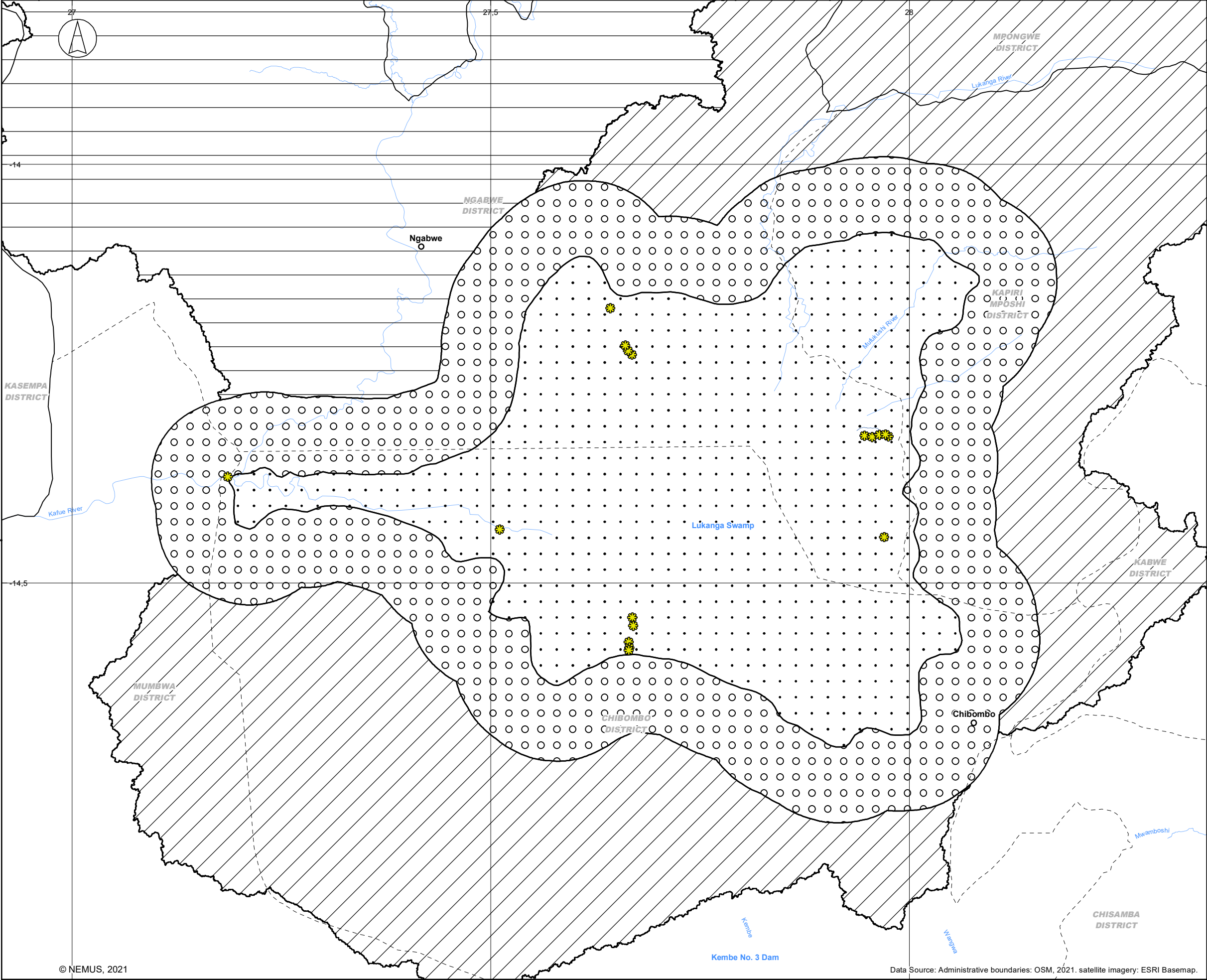
© NEMUS, 2021

Data Source: Administrative boundaries: OSM, 2021; satellite imagery: ESRI Basemap.

|          |                      |                                                                          |                                                           |               |      |
|----------|----------------------|--------------------------------------------------------------------------|-----------------------------------------------------------|---------------|------|
|          | Projected            | CONSERVATION PLAN FOR LUKANGA SWAMP<br>AND UPPER KAFUE BASIN             | Scale                                                     | Number        |      |
|          | Maria Espírito Santo |                                                                          | <div>1:400 000</div>                                      | <div>3a</div> |      |
|          | Verified             |                                                                          |                                                           |               |      |
|          | Maria Espírito Santo |                                                                          |                                                           |               |      |
| Designed | Gonçalo Dumas        | Environmental and social constraints - Areas of<br>conservation interest | Graphic scale                                             | Date          | Page |
| Approved | Pedro Bettencourt    |                                                                          | <div><div>05 00010 000</div><div><div></div></div>m</div> | April 2021    | 1/1  |
|          |                      |                                                                          | Code<br>T19024-2104b_03a_ConservationInterest             |               |      |

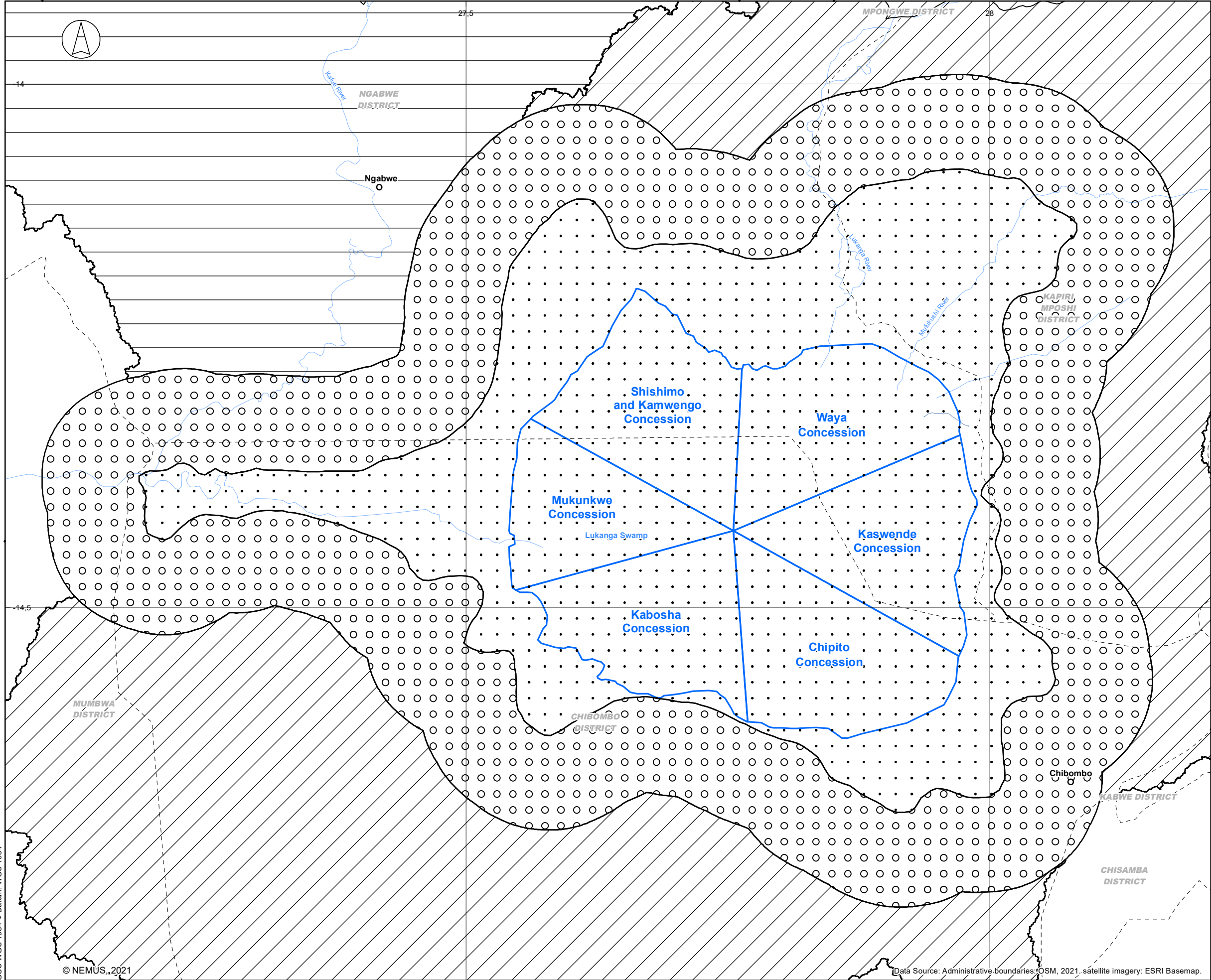












- District Towns
  - Province boundary
  - - - District boundary
- PLAN AREAS**
- "Lukanga Swamps Ramsar Site" (plan area "A")
  - Lukanga Swamp critical conservation and management area (plan area "B")
  - Lukanga Swamp watershed (plan area "C")
  - Kafue Basin upstream of Lukanga Swamp (plan area "D")
- COMPLEMENTARY PROTECTION AREAS**
- COMMUNITY FORESTS**
- 
- SETTLEMENT**
- high population density
- SETTLEMENT AND CROPLAND MOSAIC**
- moderate population density
  - low population density
- PARTIAL PROTECTION AREAS**
- FISHERIES MANAGEMENT AREA**
- Fishing Concession Zones
  - No-take zones
- GRAZING MANAGEMENT AREA**
- Open zones
  - Riparian protection
- FISHERIES MANAGEMENT AREA/GRAZING MANAGEMENT AREA**
- 
- TOTAL PROTECTION AREAS**
- WILDLIFE RESERVE**
- 

GCS WGS 1984 • Datum: WGS 1984

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Data Source: Administrative boundaries: OSM, 2021; satellite imagery: ESRI Basemap.

|                                                                                                                                     |                                                                                                            |  |                           |  |                                |             |
|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--|---------------------------|--|--------------------------------|-------------|
| Projected<br>Maria Espírito Santo<br>Verified<br>Maria Espírito Santo<br>Designed<br>Gonçalo Dumas<br>Approved<br>Pedro Bettencourt | <b>CONSERVATION PLAN FOR LUKANGA SWAMP<br/>AND UPPER KAFUE BASIN</b>                                       |  | Scale<br><b>1:400 000</b> |  | Number<br><b>4</b>             |             |
|                                                                                                                                     | <b>Protection and land use zonation of the Lukanga Swamp<br/>critical conservation and management area</b> |  | Graphic scale<br>         |  | Date<br>April 2021             | Page<br>1/1 |
|                                                                                                                                     |                                                                                                            |  |                           |  | Code<br>T19024-2104b_04_Zoning |             |
|                                                                                                                                     |                                                                                                            |  |                           |  |                                |             |









## Appendix 2 – Capacity Building Action Plan



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## A2.1. Introduction

Capacity building is a process of strengthening or developing human resources, institutions, organisations, or networks, also referred to as capacity development or capacity enhancement.

Stakeholder capacity/consensus building is one of the tasks expected in the development of the present Conservation Plan since the establishment of its terms by ZEMA, including:

- The development of training materials on the supporting resources, including the application of the modelling tool and training of relevant national and project area staff/stakeholders on the use of the materials and the modelling tool; building capacity in cross-sectoral governmental staff in indicator data collection;
- Develop public awareness resources for distribution to national and local stakeholders to support the initiative.

Aiming to meet these goals, a Capacity Building Action Plan (CBAP) is proposed, detailing the following:

- The target stakeholders (section A2.2);
- A training course on the implementation and follow-up of the Conservation Plan (T1 – section A2.3);
- A training course on the application of cost-benefit analysis and the modelling tool (T2 – section A2.4);
- A training course on the implementation of the monitoring plan (T3 – section A2.5);
- The training material to be developed (A2.6);
- The awareness raising resources to be produced (A2.7).



## A2.2. Target stakeholders

Given the main actors responsible for implementing the conservation plan (section 7.7.2) the training courses proposed in sections A2.3, A2.4 and A2.5 will target Zambia Environmental Management Agency, the Ministry of Lands and Natural Resources, the Ministry of Water Development, Sanitation and Environmental Protection and the Department of National Parks and Wildlife's officers with responsibilities in environmental information management.

Each of the training courses are designed for an expected number of attendants of 20, including central and regional/local management and planning officers.

The awareness-raising resources to be developed target a broader audience, comprising the central government, the private sector, NGOs and the local inhabitants involved in Lukanga Swamp management (section 7.7.2).



### A2.3. Course on the development and implementation of the Conservation Plan (T1)

The proposed training courses start with an overview of the whole Plan (development and implementation) and of Lukanga Swamp's ecosystems and biodiversity – at the heart of the conservation objectives established for the region. The modules and corresponding contents proposed for the first training course (T1) are presented in the table below.

**Table 47 – Training course on the development and implementation of the Conservation Plan; modules and contents**

| Modules                                                                   | Contents                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>T1.1 – Conservation Plan set-up: context; development; action plan</b> | <ul style="list-style-type: none"> <li>• Conservation Plan's background and framework</li> <li>• Baseline &amp; evaluation</li> <li>• Trends &amp; drivers of change</li> <li>• Assessment of future scenarios</li> <li>• Action Plan: vision &amp; approach; zonation; strategies; implementation and follow up</li> </ul> |
| <b>T1.2 – Ecosystems and biodiversity</b>                                 | <ul style="list-style-type: none"> <li>• Ecological assessment; habitats' classification and mapping</li> <li>• Ecosystem services: provisioning, regulating, supporting and cultural services</li> <li>• Ecological values and conservation objectives</li> <li>• Conservation plan zonation</li> </ul>                    |

The training course will have the following basic structure:

- Presentation – structure, contents, logistics;
- Technical modules – theoretical and practical approaches;
  - Theoretical – dominantly lecture approach, with theoretical and practical concepts to be orally transmitted; supported by a multimedia presentation projection; each theoretical component should take at least forty-five minutes (45min) to one hour (maximum) depending on the module;
  - Practical – two main methods will be applied, depending on the module; one method consists of group discussions in which the trainees will be encouraged to exchange opinions on specific consultation documents provided; the other approach consists of working exercises designed to illustrate how the theoretical concepts



are applicable; the practical component should take at least forty-five minutes (45min) to one hour (maximum) depending on the module;

- Participatory moments – daily practical exercises, questions and inputs from participants;
- Evaluation – final evaluation of the training course.

The training course will be 2 (two) days long, from 8.30 to 15.30, which includes time for coffee breaks and lunch break. The following schedule is proposed.

**Table 48 – Proposed schedule for the training course on the development and implementation of the Conservation Plan**

|              | <b>Day 1</b>                                                                     | <b>Day 2</b>                                                                      |
|--------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <b>8.30</b>  | <b>Registry; Introduction</b>                                                    | <b>Registry; Introduction</b>                                                     |
| <b>8.45</b>  | T1.1 – Conservation Plan set-up: background and framework                        | T1.2 – Ecosystems and biodiversity: ecological assessment                         |
| <b>9.45</b>  | T1.1 – Conservation Plan set-up: baseline & evaluation                           | T1.2 – Ecosystems and biodiversity: ecosystem services                            |
| <b>10.45</b> | Coffee Break                                                                     | Coffee Break                                                                      |
| <b>11.00</b> | T1.1 – Conservation Plan set-up: trends & drivers of change; scenario assessment | T1.2 – Ecosystems and biodiversity: ecological values and conservation objectives |
| <b>12.00</b> | Lunch                                                                            | Lunch                                                                             |
| <b>13.30</b> | T1.1 – Conservation Plan set-up: action plan                                     | T1.2 – Ecosystems and biodiversity: conservation plan zonation                    |
| <b>14.30</b> | Participatory moment 1                                                           | Participatory moment 2                                                            |
| <b>15.30</b> | Closing                                                                          | Closing                                                                           |

This training course will be conducted through online video conferencing and incorporate the participation of international consultants. For the video conference, the Cisco Webex Meetings platform is recommended.



#### A2.4. Course on the application of cost-benefit analysis and the modelling tool (T2)

Given the main capacity-building needs established by ZEMA since the requirements for this Conservation Plan, the second training course focuses on the (environmental) cost-benefit analysis and scenario assessment, including the (modelling) tool used to implement both: Co\$ting Nature. The modules and corresponding contents proposed for the second training course (T2) are presented in the table below.

**Table 49 – Training course on the application of cost-benefit analysis and the modelling tool; modules and contents**

| Modules                                                             | Contents                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>T2.1 – Cost-Benefit Analysis</b>                                 | <ul style="list-style-type: none"> <li>• Problem definition</li> <li>• Identification of relevant impacts</li> <li>• Physical quantification of relevant impacts (general)</li> <li>• Monetary valuation of relevant impacts (general)</li> <li>• Discounting costs and benefit flows</li> <li>• Sensitivity analysis</li> </ul>                        |
| <b>T2.2 – Assessing development scenarios; Co\$ting Nature tool</b> | <ul style="list-style-type: none"> <li>• Ecosystem services in Co\$ting Nature</li> <li>• Physical quantification of ecosystem services in Co\$ting Nature</li> <li>• Monetary valuation of ecosystem services in Co\$ting Nature</li> <li>• Co\$ting Nature's scenarios and policy options</li> <li>• Results and decision-making framework</li> </ul> |

This training course's basic structure will be similar to that described for the first training course.

The training course will be less than 1 (um) day long, from 8.30 to 14.30, which includes time for coffee breaks and lunch break. The following schedule is proposed.



**Table 50 – Proposed schedule for the training course on the application of cost-benefit analysis and the modelling tool**

|              | <b>Day 1</b>                                                         |
|--------------|----------------------------------------------------------------------|
| <b>8.30</b>  | <b>Registry; Introduction</b>                                        |
| <b>8.45</b>  | T2.1 – Cost-Benefit Analysis                                         |
| <b>9.45</b>  | T2.2 – Assessing development scenarios; Costing Nature tool (Part 1) |
| <b>10.45</b> | Coffee Break                                                         |
| <b>11.00</b> | T2.2 – Assessing development scenarios; Costing Nature tool (Part 2) |
| <b>12.00</b> | Lunch                                                                |
| <b>13.30</b> | Participatory moment                                                 |
| <b>14.30</b> | Closing                                                              |

This training course will also be conducted through online video conferencing, incorporating the participation of international consultants. For the video conference, again, the Cisco Webex Meetings platform is recommended.



## A2.5. Course on the implementation of the monitoring plan (T3)

Given again the capacity-building needs established by ZEMA since the requirements for this Conservation Plan, the third and last training course focuses on the monitoring plan, including some of the assessments made during the conservation plan's development, that supported the monitoring activities proposed. The modules and corresponding contents proposed for the third training course (T3) are presented in the table below.

**Table 51 – Training course on the implementation of the monitoring plan; modules and contents**

| Modules                                                   | Contents                                                                                                                                                                                                            |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>T3.1 – Basin information systems and monitoring</b>    | <ul style="list-style-type: none"> <li>• Organising collaborative basin information systems</li> <li>• Technical aspects and practical implementation</li> <li>• Monitoring and evaluation</li> </ul>               |
| <b>T3.2 – Water, sediment and soil monitoring</b>         | <ul style="list-style-type: none"> <li>• Surface water monitoring</li> <li>• Groundwater monitoring</li> <li>• Sediment monitoring</li> <li>• Soil monitoring</li> </ul>                                            |
| <b>T3.3 – Habitat and biodiversity/species monitoring</b> | <ul style="list-style-type: none"> <li>• Habitat monitoring</li> <li>• Biodiversity/species monitoring: swamp and edaphic grassland flora; swamp and edaphic grassland fauna; waterbirds; wild ungulates</li> </ul> |

This training course's basic structure will be similar to that described for the first training course.

The training course will be 2 (two) half-days long, from 8.30 to 12.00, which includes time for coffee breaks. The following schedule is proposed.





**Table 52 – Proposed schedule for the training course on the implementation of the monitoring plan**

|              | <b>Day 1</b>                                    | <b>Day 2</b>                           |
|--------------|-------------------------------------------------|----------------------------------------|
| <b>8.30</b>  | <b>Registry; Introduction</b>                   | <b>Registry; Introduction</b>          |
| <b>8.45</b>  | T3.1 – Basin information systems and monitoring | T3.3 – Habitat monitoring              |
| <b>9.45</b>  | T3.2 – Water, sediment and soil monitoring      | T3.3 – Biodiversity/species monitoring |
| <b>10.45</b> | Coffee Break                                    | Coffee Break                           |
| <b>11.00</b> | Participatory moment 1                          | Participatory moment 2                 |
| <b>12.00</b> | Closing                                         | Closing                                |

This training course will also be conducted through online video conferencing, incorporating the participation of international consultants and using, preferably, the Cisco Webex Meetings platform.



## **A2.6. Training material**

Training material to support the training course and to be left behind with the target stakeholders will be developed, including the contents to be presented in the theoretical modules and the modelling tool (Co\$ting Nature) manual.

## **A2.7. Awareness raising resources**

Aiming to raise awareness for the Conservation Plan's implementation among key stakeholders and the general public, a brochure will be designed with synthesized information about Lukanga Swamp catchment's values, services and benefits, conservation objectives, scenario assessment and the road map for implementation of the Conservation Plan, including user-relevant strategies and actions.



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# Conservation Plan for Lukanga Swamp and Upper Kafue Basin

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