EAST AFRICAN COMMUNITY
LAKE VICTORIA BASIN COMMISSION

LAKE VICTORIA BASIN ECOSYSTEM PROFILE ASSESSMENT REPORT

USAID
FROM THE AMERICAN PEOPLE

FEBRUARY 2016

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DISCLAIMER

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COVER PHOTO:

Mara River and swamp, as viewed from the Kirumi Bridge, courtesy of PREPARED Project

Unless otherwise stated, the maps, photos, and illustrations used in this report were obtained from the original sources cited in the accompanying text. Photos from the BSAs in Section 6 were obtained from the PREPARED Project unless cited otherwise.

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ACRONYMS AND ABBREVIATIONS

AKST	Agricultural Knowledge, Science, and Technology
ARCOS	Albertine Rift Conservation Society
AZE	Alliance for Zero Extinction Sites
BMU	Beach Management Unit
BOD	Biological Oxygen Demand
BPS	Best Practices Scenario
BSA	Biologically Significant Area
BTF	Biodiversity Task Force
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CEPF	Critical Ecosystem Partnership Fund
CIP	Conservation Investment Plan
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
CPS	Current-Practices Scenario
DFGFI	Dian Fossey Gorilla Fund International
DPSIR	Drivers – Pressures – State – Impacts – Response
DRC	Democratic Republic of Congo
EAC	East African Community
EFR	Environmental Flow Recommendation
ENSO	El Niño Southern Oscillation
EPA	Ecosystem Profile Assessment
FSSD	Forest Sector Support Department (Uganda)
FZS	Frankfurt Zoological Society
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GIS	Geographic Information Systems
GMA	Game Management Area
HadCM3	Hadley Centre 3rd Generation Coupled Ocean – Atmosphere General Circulation Model
IAASTD	International Assessment of Agriculture Science and Technology for Development
IBA	Important Bird Area
ICRAF	International Centre for Research in Agroforestry – World Agroforestry Centre
ICT	Information and Communication Technology
IGCP	International Gorilla Conservation Programme
INECN	*Institut National pour L'Environnement et la Conservation de la Nature*
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ISABU	*Institut des Siences Agronomique du Burundi*
ITCZ	Intertropical Convergence Zone
ITFC	Institute for Tropical Forest Conservation
IUCN	International Union for Conservation of Nature and Natural Resources – World Conservation Union
IWRM	Integrated Water Resources Management
KBA	Key Biodiversity Area

KEMFRI	Kenya Marine and Fisheries Research Institute
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
LBDA	Lake Basin Development Authority
LPJ	Lund – Potsdam – Jema
LTSA	Land Trees and Sustainability Africa
LVB	Lake Victoria Basin
LVBC	Lake Victoria Basin Commission
LVBWB	Lake Victoria Basin Water Board
LVEMP	Lake Victoria Environment Management Project
LVETF	Lake Victoria Environmental Trust Fund
MA	Millennium Ecosystem Assessment
MALF	Ministry of Agriculture, Livestock, and Fisheries (Tanzania)
MAR	Mean Annual Runoff
MCM	Million Cubic Meters
MENR	Ministry of Environment and Natural Resources
MERECP	Mount Elgon Regional Ecosystem Conservation Program
MINIRENA	Ministry of Natural Resources (Rwanda)
MLHHS	Minister of Lands, Housing, and Human Settlements (Tanzania)
MMWCA	Maasai Mara Wildlife Conservancies Association
MNRT	Ministry of Natural Resources and Tourism (Tanzania)
MOWI	Ministry of Water and Irrigation (Tanzania)
MSE	Mara-Serengeti Ecosystem
MTEF	Medium-Term Expenditure Framework
MWCT	Maasai Wilderness Conservation Trust
NaFFIRI	National Fisheries Resources Research Institute (Uganda)
NBI	Nile Basin Initiative
NBSAP	National Biodiversity Strategy and Action Plan
NCA	Ngorongoro Conservation Area
NDS	No Development Scenario
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NEMA	National Environmental Management Authority (Kenya, Uganda)
NEMC	National Environment Management Council (Tanzania)
NFA	National Forestry Authority (Uganda, Rwanda)
NGO	Nongovernmental Organization
NMK	National Museums of Kenya
NTFP	Non-Timber Forest Products
OBPE	*Office Burundais pour la Protection de l'Environnement*
ORTPN	*Office Rwandaise Du Tourisme Et Des Parcs Nationaux*
PA	Protected Area
PASS	Pan African START Secretariat
PELUM	Participatory Ecological Land Use Management
PES	Payment for Ecosystems Services
PFT	Plant Functional Type
PIN	Project Identification Note

PREPARED	Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development
PRSP	Poverty Reduction Strategy Paper
RDB	Rwanda Development Board
REDD+	Reduction of Emissions from Deforestation and Forest Degradation and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks
REGIDESO	*Régie de Production et de Distribution de l'Eau et de l'Electricité*
REMA	Rwanda Environmental Management Authority
RNRA	Rwanda Natural Resources Authority
RPSC	Regional Policy Steering Committee
RSPB	Royal Society for the Protection of Birds
SAMUKA	Sango Bay – Musambwa Island – Kagera Wetland System
SENAPA	Serengeti National Park
SIDA	Swedish International Development Agency
SGAN	Sub-Global Assessment Network
SOET	Socially Organized Education Team
SORALO	South Rift Association of Landowners
SW-GW	Surface water-Groundwater
TAFIRI	Tanzania Fisheries Research Institute
TAMP	Transboundary Agro-Ecosystem Management Programme
TANAPA	Tanzanian National Parks Authority
TAWA	Tanzania Wildlife Management Authority
TAWIRI	Tanzania Wildlife Research Institute
TFS	Tanzania Forest Service
TWRUF	Transboundary Water Resource Users Forum
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
USAID/EA	United States Agency for International Development/East Africa
UWA	Uganda Wildlife Authority
WCS	Wildlife Conservation Society
WCSC	Worst Case Scenario
WMA	Wildlife Management Area
WRMA	Water Resources Management Authority
WWF	World Wide Fund for Nature
WWF-ESARPO	WWF East and Southern Africa Regional Programme Office

EXECUTIVE SUMMARY

The Lake Victoria Basin (LVB) is internationally recognized for its high levels of species richness and endemism. It is also an area most at risk from human activity and has undergone enormous environmental changes in the last 50 years. The East Africa region faces major challenges in strengthening the resiliency and sustainability of its transboundary freshwater ecosystems, its economies, and its communities. One of the main aims of the Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development (PREPARED) Project is to help address ongoing biodiversity[1] loss and the ability of ecosystems to provide services (e.g., water regulation, water purification) to various beneficiaries in the LVB.

The Lake Victoria Basin Ecosystem Profile Assessment (EPA) was undertaken to provide a broad overview of biodiversity values, the causes of biodiversity loss, and current conservation investments in specific biologically significant areas (BSAs) identified within the LVB. The EPA represents a baseline analysis to guide future conservation planning and investment in the region. It provides technical experts and policy makers with a summary of the terrestrial and freshwater biodiversity resources within the LVB and the most critical threats to these resources. The EPA has also identified a set of priorities for conservation interventions in BSAs that are aimed at supporting policy decision-making in the planning, development and management of the natural resources in the region.

The findings and recommendations of the EPA are presented in seven chapters.

Chapter 1 presents the methodology used in the EPA. The methods are based on years of research on landscape approaches that foster sustainable natural resource management. The EPA employed a two-tier process to engage key stakeholders and identify the BSAs. The first step developed a statement of work that outlined the EPA process, key principles, and a set of deliverables. The next stage gathered and utilized the information generated to prioritize BSAs based on their species, ecological processes, and ecosystem services. Objective criteria to identify the BSAs placed a premium on the endowment of species, ecosystem services, degree of threat, and levels of investment.

A critical element in the EPA process involved extensive stakeholder engagement. To inform the EPA, a Biodiversity Task Force (BTF) was established, comprising country-level experts from the five Partner States (i.e., Burundi, Kenya, Rwanda, Tanzania, and Uganda) of the East African Community (EAC) that also constitute the LVB. The BTF provided the EPA with a point of contact in their respective countries, which was useful in establishing additional contacts in the field.

To select the BSAs, the EPA criteria were agreed upon by the BTF at an EPA-sponsored workshop in Kampala, Uganda on November 13-14, 2013. The selection process identified 10 BSAs based on i) biological criteria, and ii) threats-based criteria. The BSAs were subjected to further review and fact-finding during site visits. Using the information collected in the field, an additional set of criteria was applied to rank them further: iii) regional and partner state priority. The largest two BSAs were subsequently combined based on their underlying ecological similarity (i.e., the Mara-Serengeti Ecosystem in Kenya/Tanzania), which led to nine BSAs as summarized in Table 1.

1 Biodiversity (the shortened form of biological diversity) can be defined as the variety and variability of living organisms along with the interactions they depend on and are part of-broadly including the complexes of animal, plant, and microorganism species; and the communities and ecosystems on Earth. This consists of *genes*, *species*, and *ecological processes* making up terrestrial, marine, and freshwater systems.

Table 1. Biologically Significant Areas studied by the LVB EPA

BSA	COUNTRY LOCATED
1. Nabugabo Lakes Complex	Uganda
2. Mara Wetland	Tanzania
3. Mara–Serengeti Ecosystem	Kenya/Tanzania
4. Nyungwe–Kibira Complex	Rwanda/Burundi
5. Sango Bay–Minziro Swamp Forests	Uganda/Tanzania
6. Yala–Nzoia Wetlands	Kenya
7. Rweru–Mugesera Complex and Northern Aquatic Protected Landscape	Rwanda/Burundi
8. Mount Elgon Ecosystem	Kenya/Uganda
9. Mwanza Gulf	Tanzania

Chapter 2 provides a detailed overview of the LVB ecosystem, including landscape and hydrological scenarios, biological environment, land use changes, and ecosystem services in the Partner States. The EPA found that the LVB has some high conservation value areas[2]. Biodiversity in the basin is characterized by endemism, the presence of endangered species, and habitat refugia for unique species. The location of the basin (at the intersection of five distinct centers of endemism: the Afromontane, Guineo-Congolean, Somali-Maasai, Sudanian, and Zambezian) is a major influence on the characteristic terrestrial and aquatic flora. Other influences include past geology, climate, and centuries of human occupation. Within the LVB are numerous official protected areas (PAs), important wetlands, and forests.

Most of the selected BSAs fit neatly into a regional aquatic ecosystems-landscape context involving a matrix of freshwater and wetland patches that include the main lake, adjoining swamps and satellite lakes, and intervening terrestrial barriers. These are interconnected through flows of water, energy, nutrients, and except for the purely aquatic life forms, a significant exchange of species and genes. In designing conservation interventions, the EPA considered the role played by satellite lakes as faunal refuges for species now extinct in the main lake; a fact widely acknowledged in the scientific world.

The EPA discusses the importance of ecosystem services as it relates to the EAC Partner States, and as an indicator for overall human well-being. The main drivers of ecosystem service loss include population growth, increased agriculture, land conversion, overfishing, and loss of biodiversity. These have various impacts on the biological environment (i.e., rivers, wetlands, terrestrial habitats), which in turn lead to a disruption in the delivery of ecosystem services to various beneficiaries in the LVB.

The EPA found the major ecosystem services impacted are the aquatic regulating services such as water regulation, water purification, and erosion regulation. These have cumulative effects on the timing and magnitude of the delivery of provisioning and cultural services. Among the provisioning services at risk, clean water, food production (i.e., fishing), and wood and fiber harvesting are of most concern. At this scale of analysis, it was difficult to quantify fully the risks posed to cultural services. The most likely to be affected are the recreation and ecotourism services; and as with other complex socioecological systems, spiritual, religious, and cultural values are likely to be linked to ecological infrastructure.

Chapter 3 provides an assessment of climate change impacts. The EAC published the Climate Change Master Plan (2011 to 2031), which contains a comprehensive, country-by-country account of climate, climate trends, and projections from various climate models. This chapter builds off this research and discusses the evidence of species, habitats, and ecosystems responses to climate change. There is a growing body of evidence that rising average temperatures will have an adverse effect on aquatic ecosystems; wetlands are particularly vulnerable. Climate change also results in shifts in the geographical distribution of species and ecosystems.

2 High conservation value areas is a widely recognized term used to describe resources that contain globally, regionally, or nationally significant concentrations of biodiversity values.

Modeling of future climate impacts on ecosystems is presented in this chapter to provide understanding on how climate change and human influences will affect LVB ecosystems.

Chapter 4 describes the direct threats to biodiversity and the principal causes of loss in the LVB, namely:

i) Habitat change through conversion to cropland, urban areas, and other human-dominated landscapes;

ii) Overexploitation or unsustainable harvesting of economically valuable species;

iii) Pollution of the water, land, and air;

iv) Alien invasive species, including pests and disease pathogens; and

v) Environmental change, including shifts in climate, and increases in intensity with the size of human ecological footprints.

In **Chapter 5,** the EPA includes a framework for selecting interventions to mitigate the root causes of biodiversity loss for each BSA. While the EPA does not necessarily prescribe the interventions to be proposed, it was envisaged that a Project Identification Note for each BSA would establish project objectives: rationale, biodiversity importance, relevance to national and international priorities and guidelines, scope and extent, and conservation investment priorities. The intervention framework outlines the following broad categories:

Promote regional aquatic ecosystems landscape conservation. The holistic assessment, protection, and sustainable management of biodiversity in the interconnected main lake, satellite lakes, islands, swamps, and intervening terrestrial enclaves is crucial to LVB's freshwater biodiversity. Particular attention should be placed on the important ecological role of satellite lakes as faunal refuges for species now extinct or near extinct in the main lake. Indicative activities under this might entail evaluating and raising awareness of the key ecological role of the refugia for native species and the use of spatially explicit management approaches for the matrix of wetland habitats.

Support design and review of management plans. Management plans for natural resources in protected and non-protected areas lay a solid foundation for conserving ecosystems, species, and habitats. They are also critical for strengthening the capacity of regional, national, and community-level institutions. Supporting the design and review of management plans would present an opportunity for realizing conservation and community objectives as well as advancing the integration of sustainable resource management approaches within regional and national policies and programs. Indicative activities could include supporting the completion or revision of the existing draft management plans (e.g., in the Mara-Serengeti and Mara Wetland) and supporting dialogue toward aligning them to the conservation needs of the greater ecosystem and basin contexts. This would be done in collaboration with key stakeholders, such as national and local government institutions, the World Wide Fund for Nature, the Wildlife Conservation Society, other nongovernmental organizations and community-based organizations.

Implement site-level interventions for unique habitats. Some of the unique habitats in the LVB are still fairly pristine even outside of the formal PAs; however, many are currently degraded. Identification and implementation of appropriate measures for sustainably managing species and restoring their habitats would be central to interventions in this regard. It should be recognized that in a number of cases, key stakeholders have already identified some priority interventions, notably in the 10-year transboundary strategy for Nyungwe-Kibira.

Strengthen cross-border collaboration. This addresses the priority transboundary issues already identified from previous interventions in the LVB. These issues include i) unsustainable use of water resources; ii) wetland and forest degradation; iii) wildlife and habitat loss; iv) governance, policy, and institutional weaknesses; v) declining fisheries and fish stocks; and vi) increasing sedimentation, pollution, and eutrophication.

Build capacity for sustainable use. Another important category involves influencing agricultural or pastoralist production processes to minimize losses in biological diversity. The social and economic benefits derived from such uses provide incentives for people to conserve natural resources.

Strengthen livelihoods diversification and enhancement. The loss of biodiversity leads to the loss of livelihood strategies and to poverty, which in turn leads to more biodiversity loss. Climate shocks exacerbate the negative impacts on livelihoods. Biodiversity and livelihood strategies, therefore, need to be mutually beneficial.

Design and pilot market-based mechanisms. The LVB has potential for payment for ecosystem services ranging from carbon sequestration, biodiversity protection, microclimate regulation, and watershed protection schemes. It is important to explore ways of establishing a beneficiary system with both the ability to pay and practical interventions, which can secure the delivery of ecosystem services while achieving biodiversity conservation objectives.

Develop and pilot innovative conservation approaches and tools. Illegal or unregulated uses and inadequate law enforcement seriously imperil sustainable biodiversity conservation. There is urgent need to institute measures for protecting the remaining, sometimes relatively small, isolated, and unique species and natural habitats. Indicative initiatives in this area would range from the design and promotion of information communications technology-based anti-poaching platforms, to development of trans-frontier conservation approaches, and the introduction or promotion of product certification schemes. There is also the need for establishing innovative institutional governance structures to support the biodiversity conservation interventions that would be proposed in either the Project Identification Notes or a Conservation Investment Plan.

Chapter 6 provides a description for each of the nine BSAs identified in the EPA. It discusses possible activities to help overcome or mitigate the root causes of biodiversity loss in these areas. The chapter identifies the primary actors responsible for the threats, as well as partners and opportunities for collaboration in ameliorating the threats. It takes into consideration the major efforts in place or previously undertaken for biodiversity conservation by national, bilateral, and international actors, including the public and private sector.

The BSAs represent the areas where future interventions would be the focus of PREPARED, EAC, the LVB Commission, and other partners to have the greatest impact in addressing the challenges facing biodiversity, preventing species and ecosystem declines, ensuring livelihood sustainability, and building resilience.

Finally, in **Chapter 7**, the EPA presents a comprehensive biodiversity investment framework to leverage support for future conservation interventions. The focus is to secure natural capital based on potential levels of funding while meeting the national, regional/transboundary, and international biodiversity conservation goals. The investment framework recognizes the need to explore consistently new ways of meeting funding shortfalls through innovative investment.

Important data gaps that prevent the full realization of biodiversity's economic value and understanding of degradation-related costs are also identified in this chapter. These particularly relate to levels of conservation funding in Partner States, especially as government budgets are rarely aggregated at the appropriate scales for BSAs. The lack of data is critical when important biodiversity occurs outside the network of official PA and when local communities are the key players.

1.0 OVERVIEW OF THE ECOSYSTEM PROFILE ASSESSMENT PROCESS

This chapter presents the methodology used to produce the Ecosystem Profile Assessment (EPA). It discusses key approaches and best practices found in ecosystem-level assessments and describes the process by which the biologically sensitive areas (BSAs) were identified. This section also details the extent of stakeholder consultation throughout the EPA process, which included experts from all East African Community (EAC) Partner States, regional and national conservation nongovernmental organizations (NGOs), and the Lake Victoria Basin Commission (LVBC) Secretariat.

1.1 INTRODUCTION

1.1.1 PREPARED PROJECT

The U.S. Agency for International Development's Kenay and East Africa Regional Mission (USAID K/EA) funds the Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development (PREPARED) Project. PREPARED is a five-year, multi-organization, comprehensive project aimed at mainstreaming climate-resilient development planning and program implementation into the EAC and its Partner States' development agendas.

The overall goal of the PREPARED Project is to strengthen the resiliency and sustainability of East African economies, transboundary freshwater ecosystems, and communities. The PREPARED Project targets three key development challenges facing the EAC region: transboundary freshwater biodiversity conservation, improved access to drinking water supply and sanitation services, and increased resiliency to climate change.

One of the aims of the PREPARED Project is to help address ongoing biodiversity loss and the ability of ecosystems to provide services in the Lake Victoria Basin (LVB). The supply of food, fuel, and water are expected to diminish with declining biodiversity. So, too, will be the ability of ecosystems to provide cultural services such as recreational or non-material benefits; or to mitigate natural hazards, control soil erosion, recycle nutrients, and purify water.

1.1.2 EPA PURPOSE

The purpose of the EPA is to:

- Provide an overview of the key issues around biodiversity values, the threats to biodiversity, and investments in biodiversity conservation.
- Provide a baseline analysis of existing terrestrial and freshwater biodiversity resources in selected LVB BSAs.
- Establish an initial set of priorities for interventions in the selected BSAs.

The key output is an informative, factually accurate, and publishable report documenting the biological wealth, threats, challenges, and opportunities of the LVB. This forms the basis for defining a portfolio for future investment in biodiversity by the PREPARED Project and other stakeholders within the basin.

The EPA process duly accounted for and built upon complementary/ongoing processes relevant to the LVB landscape, such as:

- The Conservation Strategy for the Great Lakes Region (Birdlife International, 2012)
- Basin-Wide Strategy for Sustainable Land Management in the Lake Victoria Basin (LVBC/World Bank/ Swedish International Development Agency (SIDA), 2012)

The EPA also focused on facilitating LVBC's role in coordinating interventions, disseminating information, and promoting appropriate investments in the basin.

1.2 EPA APPROACH

1.2.1 BEST PRACTICES

An EPA ensures that benefits from ecosystem services are taken into consideration in light of the natural sources from which they are derived. EPAs address how changes in the supply of ecosystem services affect people, thereby connecting environmental and development sectors. Assessments play numerous roles in the decision-making process, including responding to the need for information, highlighting trade-offs among decision options, and modeling future prospects to avoid unforeseen long-term consequences. EPAs are also of value throughout the assessment process, by engaging and informing decision makers long before final assessment products are available.

The Sub-Global Assessment Network (SGAN), formed in 2007 after the Millennium Ecosystem Assessment (MA), provides resources and support for ecosystem assessments at the regional, sub-regional, national, and sub-national levels. In 2012, members of the SGAN discussed eight key lessons arising from ecosystem-level assessments (Booth et al., 2012). These include the need to:

- Define clear, policy-relevant research questions in close consultation with key audiences and users that reflect the wider objectives.
- Carefully plan and set clear boundaries of scope and scale, taking into account the context and settings.
- Be inclusive in the analysis of ecological, sociological, and economic data, reflecting the diversity of experience and skills of the people involved.
- Use a clear governance structure, critical for getting the most out of this collective capacity.
- Promote the assessment concept to build ownership from the outset, through well-directed external communication to convey the assessment's value to key users.
- Understand the decision-making context for results to be adopted and put into action.
- Interact with experts and practitioners, who may be able to provide assistance and expert advice.
- Appreciate the need to understand, use, and present different types of information to ensure gaps are handled adequately.

Both policymakers and practitioners increasingly appreciate that the loss of ecosystem services is often more immediate, and apparent, than species loss. Consequently, the value of an ecosystem assessment is more likely to represent biodiversity effectively as a whole than when effort is focused on individual species alone.

The wider effort of compiling an EPA has supported, and often can support, the formulation of "conservation outcomes" that provide guidance for conservation implementation and conservation success. Such outcomes are expressed in terms of probability of reduced or avoided extinctions, amount of area protected, sustainably managed, or connectivity created. There are several assessments that provide examples of good EPA practice (see Box 1-1).

Box 1-1. Examples of ecosystem assessments in practice

Millennium Ecosystem Assessment: The MA, released in 2005, assessed the consequences of ecosystem change for human well-being. The MA consisted of a global assessment and 34 sub-global assessments of current knowledge on the consequences of ecosystem change for people. The MA brought about a new approach to ecosystems assessment: consensus of a large body of social and natural scientists; focus on ecosystem services and their link to human well-being; and development and identification of emergent findings (http://www.unep.org/maweb/en/index.aspx).

International Assessment of Agricultural Science and Technology for Development: The International Assessment of Agriculture Science and Technology for Development (IAASTD), released in 2008, was an intergovernmental process that evaluated the relevance, quality, and effectiveness of agricultural knowledge, science, and technology (AKST) and the effectiveness of public- and private-sector policies as well as institutional arrangements in relation to AKST. The IAASTD consisted of a global assessment and five sub-global assessments using the same assessment framework, focusing on how hunger and poverty can be reduced while improving rural livelihoods; facilitating equitable development that is environmentally, socialy, and economically sustainable; and increasing access to and use of agricultural knowledge, science, and technology (http://www.unep.org/dewa/agassessment/).

Intergovernmental Panel on Climate Change: The Intergovernmental Panel on Climate Change (IPCC) released its fourth report (AR4) in 2007. The IPCC was established to provide decision makers with an objective source about climate change. Similar to the MA, the IPCC does not conduct any research or monitor specific data and parameters; it assesses the latest scientific, technical, and socio-economic literature in an objective, open, and transparent manner. Ecosystem services are addressed in the fourth report of the IPCC by the reports of Working Group II (Impacts, Adaptation, and Vulnerability) and Working Group III (Mitigation of Climate Change) (www.ipcc.ch).

Land Degradation Assessment of Drylands: The Land Degradation Assessment of Drylands is an ongoing assessment that aims to assess causes, status, and impact of land degradation in dry lands to improve decision making for sustainable development at the local, national, sub-regional, and global levels (http://www.fao.org/nr/lada/).

Global Environment Outlook: The Global Environment Outlook (GEO) is the United Nations Environment Program's (UNEP) ongoing assessment of the environment globally. The fourth GEO was released in 2007 and consists of a global assessment and sub-global assessments. GEO-4 provides information for decision makers on environment, development, and human well-being (www.unep.org/geo).

The above assessments broadly applied a Drivers-Pressures-State-Impacts-Response (DPSIR) framework, which provides an overview of the relationship between the environment and humans. According to the framework, "driving forces" are the socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment. "Pressures" are the stresses that human activities place on the environment. The "state" of the environment is the condition of the environment. "Impacts" are the effects of environmental degradation. "Responses" refer to the responses by society to the environmental situation.

1.2.2 KEY CONCEPTS

Biodiversity Hotspots

The EPA-adopted approach recognizes that the "biodiversity hotspots" concept is widely accepted by the international conservation community. The term grew out of work on tropical forest ecosystems in the late 1980s and focused on exceptional levels of plant endemism and habitat loss (Myers, 1988). Later research expanded the concept into non-forested terrestrial, marine, and freshwater ecosystems (Myers, R.A. Mittermeier, C.G. Mittermeier, da Fonseca & Kent, 2000). Despite the later shift in emphasis, the huge appeal of the initial work has tended to bias thinking in favor of forests, or at least the dominant vegetation cover of an area.

The PREPARED Project focuses largely on aquatic biodiversity; therefore, identifying criteria for the BSAs demanded greater emphasis on ecosystem values beyond plant diversity. It was also necessary to find a way of emphasizing even relatively small but remarkably important areas that would be overlooked in a more course-grained approach. The methodology employed in the EPA ensured the development and adoption of a fundamentally more robust, realistic, and objective system for defining biodiversity hotspots or BSAs in the LVB.

Key Biodiversity Areas

A Key Biodiversity Area (KBA) is a site that contributes significantly to the global persistence of biodiversity (International Union for Conservation of Nature and Natural Resources – World Conservation Union [IUCN], Birdlife International, Plantlife International, and Conservation International, 2014). They are identified through national processes using a set of globally agreed-upon scientific criteria. KBAs provide fundamental information for a wide range of decision-making contexts and end-users. KBAs can inform the selection of sites for protection and monitoring global biodiversity targets, help private and financial sectors manage their environmental risks, guide conservation investments, and strengthen conservation actions on the ground.

The identification of KBAs draws from the most current biodiversity information available, including the IUCN Red Lists. KBA criteria also include sites that hold globally significant congregations of animals (e.g., nesting sites, breeding sites, spawning grounds), outstanding intact assemblages, restricted-range species, or outstanding biological processes. Where the site is already under formal protection, the World Database on Protected Areas informs the delineation of boundaries.

The KBA approach extends concepts such as Important Bird Areas (IBA) and Alliance for Zero Extinction (AZE) sites to other taxonomic groups in identifying critical conservation sites by a range of organizations worldwide. These are some of the considerations that heavily influenced the EPA approach.

1.3 THE LVB EPA PROCESS

Development of the LVB EPA was interactive and participatory. Several key pillars of LVBC's operational framework guided the EPA, namely:

- EAC Treaty, Chapter 19, which established the LVBC and decisions of the EAC Council and Summit (The council consists of the ministers/cabinet secretary responsible for regional co-operation of each Partner State, while the Summit comprises heads of state or government);
- LVBC Strategic Plan (2011–2016);

- 4th EAC Development Strategy (2011–2016), Strategic Intervention Areas; and
- LVBC Operational Strategy, especially Developmental Objectives 3 and 6.

1.3.1 GOVERNANCE

In Mwanza, Tanzania on October 19, 2013, the LVBC Sectoral Council approved the formation of a Biodiversity Task Force (BTF) to guide and monitor PREPARED Project's biodiversity conservation activities. The BTF comprised biodiversity experts nominated by the five Partner States, EAC ministerial focal points, and technical advisors from the PREPARED Project. The inaugural meeting of the BTF was held in Kampala, Uganda, on November 14 and 15, 2013. It focused on refining the BTF Terms of Reference, reviewing EPA progress, and developing and agreeing upon criteria for determining BSAs in the region.

Land Trees and Sustainability Africa (LTSA), a subcontractor of the PREPARED Project, provided technical assistance in support of the overall EPA strategy. LTSA contracted a small team of technical experts intimately familiar with the LVB. A statement of work that outlined the EPA process, key principles, and a set of deliverables was adopted by the BTF.

The "EPA team" referred to in this document comprised LTSA technical experts, BTF membership, and wider PREPARED Project counterparts. The LTSA team comprised experts in terrestrial biodiversity, freshwater biodiversity, hydrology, social status and gender, natural resources economics, climate change, and spatial planning.

1.3.2 DATA COLLECTION AND ANALYSIS

The EPA data collection was conducted in two stages to prioritize the BSAs analyzed in the report.

EPA Stage 1: Overview of Ecosystems in the LVB

In the first stage, data was collected to provide a "wide-angle perspective" of ecosystems found in the LVB. The bulk of information was derived from published and unpublished literature, personal interviews, and maps developed by the many key players in the areas of interest. An essential first step to set the scene for subsequent data gathering and monitoring was to characterize the ecosystems in the lake catchment.

The EPA captured information from the best available biodiversity data and metadata, including national species listings; published/unpublished studies; national, regional, and international data sources; the IUCN Red List of Threatened Species; and the Red List of Ecosystems. The Red List categories and criteria have been widely accepted as the most objective and authoritative system available for assessing the global risk of extinction for species (Vié, Hilton-Taylor & Stuart, 2009). The IUCN Red List is the world's most comprehensive information source on the global conservation status of plant and animal species; it is updated annually and freely available online at www.iucnredlist.org.

EPA Stage 2: Selection of BSAs and Field Visits

Based on the ecosystem overview, the next stage used the information gathered to prioritize sites based on their ecosystem and biodiversity importance. This included in-depth analyses of published/unpublished site-specific studies and habitat assessments; national and regional species listings; international data sources such as the KBAs and IUCN Red Lists; interviews with local, regional, and global experts; and information provided by LTSA technical experts with over 30 years of experience in the LVB (and other large lake basins in eastern, southern, and central Africa). The screening and selection of priority BSAs were subjected to further stakeholder validation. Section 1.4 provides further details on BSA selection. Limited data in the BSAs justified the use of a scale-down progression focusing on higher levels, such as ecosystems and habitats in the selection process. Species were perceived to entail the lowest level conceivable under the EPA.

Recognizing the highly intensive land use practices, human population pressure, and human dependence on natural resources within the LVB, a set of conservation targets were developed to address threats and prevent ecosystem and species losses.

Completion of this stage set the scene for the post-EPA steps: utilizing the baseline analyses for identifying and prioritizing conservation interventions and investments. The BSAs were the target areas for focusing future interventions funded by PREPARED and other partners. The investments were captured in management plans, strategies, or Conservation Investment Plans (CIPs), establishing the priorities for addressing the challenges for specific BSAs: preventing species and ecosystem losses, ensuring sustainability of livelihoods, and building resilience to ecological and climate changes.

1.3.3 STAKEHOLDER ENGAGEMENT

An important element in the EPA process involved extensive stakeholder engagement. The creation and mobilization of the EPA team, as described above, provided the necessary technical and administrative support needed to complete the assessment. An initial orientation was held to discuss member's roles and responsibilities, including development and validation of a work plan to guide implementation of the EPA.

The BTF also provided additional technical support and local expertise. The team comprised biodiversity experts and key members from the five EAC Partner States that also constitute the LVB. The BTF provided a point of contact in the respective countries to facilitate in-country engagements, stakeholder consultations, and site-level data collection exercises. At the first BTF meeting, held in Kampala in November 2013, BTF members provided important guidance to the EPA in terms of BSA selection criteria and modus operandi. The BTF provided further guidance and suggestions to improve the report during their second meeting, held in Arusha April 28–29, 2014.

Throughout the EPA process, stakeholders participated in meetings and consultations in the field. The development of supplemental technical papers required ongoing stakeholder input. Stakeholder engagement in the EAC countries included, for example:

- Resource managers (Chief Wardens)-for example, in the Maasai Mara Reserve and Nyungwe National Park;
- Senior research scientists/resource planners-for example, Kenya Wildlife Service (KWS), the Tanzania Wildlife Research Institute (TAWIRI), and the Tanzania Fisheries Research Institute (TAFIRI);
- National/regional program coordinators-Lake Victoria Environment Management Project (LVEMP) II, Tanzania; Nile Basin Initiative, and World Conservation Society (WCS) Rwanda;
- Senior government officers/community leaders-the Uganda Wetlands Department, Rwanda Development Bureau, Rorya, Tarime, and Butiama districts (district commissioners and district executive directors), Tanzania;
- LVBC focal points; and
- Youth groups.

A comprehensive list of the stakeholders consulted is provided in Appendix 1.

1.3.4 VALIDATION OF THE EPA REPORT

The final draft of the EPA report was presented at the Ecosytems Profile Assessment Validation Workshop held on December 10, 2014, in Entebbe, Uganda. The final draft was also presented at the Third Biodiversity Task Force Meeting, held on December 11, 2014, in Entebbe. All of the inputs were incorporated and a final report was produced for consideration and approval by the BTF, the LVBC Regional Policy Steering Committee (RPSC), and the 14th LVB Sectoral Council of Ministers.

1.4 BSA SELECTION PROCESS

1.4.1 SELECTION CRITERIA

Identifying and selecting biodiversity conservation targets, hotspots, or areas of special interest requires clear and objective criteria. These must adequately consider the endowment of species, ecosystem services, degree of threat, and levels of investment, broadly recognizable at varying global and local scales. Therefore, selection of priority sites was targeted at identifying biodiversity at imminent risk. The following is the framework for selection criteria used by the EPA adopted by the BTF in November 2013.

Criteria 1. Biological Criteria

Criteria in this category emphasize the presence of globally, regionally, and locally significant species and/or species aggregations. The criteria roughly follow the considerations for selection of KBAs as discussed above; defined by IUCN as sites that contribute significantly to the global persistence of biodiversity, on land, in freshwater, or in the seas. KBAs are identified using a set of globally agreed-upon scientific criteria that are also used for establishing, for example, IBAs and AZEs.

Habitats are viable indicators as proxies for the biodiversity they represent. They effectively represent fractions of the LVB ecosystem biodiversity as a whole, and the use of GIS to measure/quantify them spatially is both key and achievable.

Some biological criteria are essentially spatial-landscape based, relating to the geographic arrangement of physical units of interest: the KBAs, buffer and transition zones, and biodiversity corridors. From a biodiversity perspective, the spatial distribution of these areas is important to ensure ecosystem functionality and the delivery of ecosystem services. From a natural resources and management perspective, the spatial distribution of these areas is important to connect, for example, areas that are intensively managed to areas with little or no environmental management plans and insufficient operations and budgets. This way, it will be possible to ensure that the benefits of an area with sound environmental management plans and sufficient operations and budget spill over to nearby areas that are less fortunate. It is to be expected that different portions of the total land area will be under different forms of land ownership and tenure and that high levels of cooperation would therefore be required between landowners and occupiers.

Criteria 2. Threats-Based Criteria

These criteria refer primarily to adverse anthropogenic pressures. The criteria in this section are drawn heavily from the principles identified by USAID for effective biodiversity conservation programs. The September 2005 Biodiversity Guide for USAID Staff and Partners emphasizes and ensures integration of a "threats basis" for biodiversity conservation, adaptability, and a focus on priorities, results orientation, sustainability, participation, capacity strengthening, lesson learning, and complementarity (USAID, 2005). Clearly identifying the threats to biodiversity is essential for delineating a threat abatement plan and ensuring that the implementation of activities reduce, eliminate, or mitigate threats and their underlying root causes. Chapter 3 provides an overview of threats to biodiversity in the LVB, and BSA-level threats are summarized in Chapter 4.

Criteria 3. Regional and Partner State Priority Criteria

The third set of criteria involves mainly socio-economic and institutional considerations, focusing more on the geographic and human dimension of biodiversity, and relating to root causes of loss. They underscore the importance attached to particular areas by the EAC and LVBC, as well as to those areas identified as critical to meeting national biodiversity goals in the National Biodiversity Strategies and Action Plans (NBSAPs). They also draw heavily from the experience of the Critical Ecosystem Partnership Fund (CEPF), which recognized that tackling issues in the most important and threatened biological sites would involve a complex interplay of multiple players: private, public, civil society, and relevant institutions.

The design of an effective investment strategy must also acknowledge the fact that any investment is likely to be small in the light of limited public investments from developing countries.

The criteria (see Table 2) were presented to BTF and adopted at the first BTF meeting. Application of the above criteria was based on knowledge determined from existing and available literature and through field work involving rapid assessments. The selected BSAs were mapped based on the dominant land cover, regional importance, and location in a transboundary context.

Table 2. BSA selection criteria and rationale for site selection

CATEGORY	CRITERIA	INDICATORS/EXAMPLES/EXPLANATION
Biological: Globally, regionally, locally significant species and/or species aggregations	• Holding globally/ regionally/locally significant species and/or species aggregations	Including one or more of the following: • Endemic species • Scarce, rare, or threatened species • Seasonal large migrations • Breeding/spawning or nesting sites • Unique plant and animal communities in a relatively pristine natural habitat
	• Presence of restricted-range biological diversity	• Occurrence of one or several unique species (e.g., primates) in a single forest or forest patch • Rare mammal/bird/reptile/amphibian or fish species restricted to a wetland • Specialized plant communities in a small part of the catchment
	• Performing a unique biological function or regulating ecosystem service	• A small patch of land or water serving as refuge for species known or believed to be locally extinct elsewhere • Intact natural vegetation providing habitat for pollinators or disease regulation to surrounding farming and pastoralist activities • Effluent clean-up or sediment trapping in a wetland • Water purification by riparian plants temporary habitat for migratory birds • Climate moderation by a mountaintop or hilltop forest • KBAs, buffer and transition zones, biodiversity corridors

CATEGORY	CRITERIA	INDICATORS/EXAMPLES/EXPLANATION
Threats-based: Adverse anthropogenic pressures	• Loss of natural habitats	• Population growth • Immigration, intrinsic population growth • Climate change-extreme weather events such as droughts and floods, or fires, water impoundments, land conversion • Transformation for agricultural expansion • Land use change for urbanization and rural settlement • Desertification or land degradation
	• Degradation through overexploitation and pollution	• Poaching • Overfishing • Illegal logging • Excessive collection of food and/or medicinal plants • Waste deposition • Accumulation of harmful substances • Inappropriate farming techniques
	• Invasive species	• Weeds • Pests • Disease agents (pathogens and parasites of both animals and plants)
Regional and partner state priority Socio-economic and institutional considerations	• Documented policy and NBSAP	• Has it been identified by national or sub-national government? • Existence or non-existence of supportive public policy and governance structures • Direct public-private land ownership (e.g., voluntary conservation, private reserves, stewardship arrangements)

1.4.2 TWO-TIERED APPROXIMATION

First-level Approximation

An initial selection of BSAs within the LVB was derived from the IUCN List of KBAs, the list of IBAs, selected Ramsar Wetlands sites and expert knowledge of the LVB. It was decided that the general concept of KBAs was adequate as a basis for selecting around 100 sites, which would then be reduced to fewer sites when other characteristics (or additional biodiversity characteristics) were relevant. As mentioned above, the KBA approach has become a globally accepted way to categorize places where important biodiversity is to be found; biodiversity in its widest sense, i.e., using the Convention on Biological Diversity (CBD) standards of species, populations, genes, and ecosystems/habitats, along with the interactions that they are part of and depend on.

After further review of the general literature concerning LVB and its biodiversity, it was decided to include known KBAs, especially those designated by the CEPF for the Great Lakes of Africa in the LVB, and other areas that fit the same type of definition (i.e., "BSAs"). These include IBAs based primarily on special species and groups; Ramsar sites; protected areas (PAs) due to both important biodiversity and livelihood and cultural aspects; notable small satellite lakes for Lake Victoria that have aquatic species of ecological value; and the river mouths, bays, and estuaries entering Lake Victoria for livelihoods, special aquatic species, and habitat considerations. These areas, when considered across the LVB and after consulting experts and literature, yielded 95 BSA sites for future consideration. Table 3 lists potential BSAs by country.

The total number of sites listed using these categories exceeded 90 as shown in Table 3. Those qualifying in three or more categories was 21- regarded as too many as the target was subjectively set at around 10.

Several other categories were added to narrow the results, and the same sites were evaluated again. The new categories included zero extinction sites, world heritage sites, man and the biosphere sites, transboundary sites, special species groups, rare species, sites with known endemic species of animals or plants, sites with species listed in the IUCN Red List of Endangered Species, and sites with species or habitats with special local or regional uses or threats. This produced 14 categories. No site qualified under all of these categories; in fact, the highest number any site qualified for was 11.

Second-level Approximation

Based on the methodology described in preceding sections and the criteria agreed upon at the BTF meeting, the identified BSAs were scored in terms of i) their biodiversity importance (biological criteria); ii) the pressures they are facing (threats-based criteria); and later ranked by iii) regional and partner state priority to determine and prioritize future interventions. All sites were subjected to further review and fact finding during field visits.

Ten BSAs were initially identified; however, the largest two were subsequently combined (i.e., Mara–Serengeti Ecosystem [MSE] in Kenya/Tanzania) based on their underlying ecological similarity, leading to nine BSAs as shown in Table 4. Chapter 6 presents details on the nine BSAs.

Table 3. Sites judged to be possible candidates for Biologically Significant Areas based on application of EPA criteria

SITE	CE	IB	PA	LK	RS	RM	ZE WH MB	TB	SP	RA	EN	RL	SS	KC	SCORE
BURUNDI															
Bururi Forest Reserve			+												
Cyohoha Lakes				+				+							
Kibira National Park (same as Nyungwe Transboundary area)		+	+					++	+	+		+	+	++	**10**
Kirundu Protected Landscape					+										
Nyamugari	+		+												
Ruvubu National Park	+	+	+		+										
Rweru Lake & downstream				+				++					++++	++	**9**
Rwihinda Lake Managed National Reserve	+	+	+												
RWANDA															
Akagera National Park	+	+	+						+			+			
Akanyaru Wetlands	+	+										+			
Cyohoha Lakes				+				+							
Gishwati Forest Reserve			+												
"Lower Lakes"				+											
Mukura Forest Reserve	+		+												
Mutara Forest Reserve			+												
Nyabarongo Wetlands	+	+							+			+			
Nyungwe Forest National Park		+	+					++	+	+			+	++	**9**
Rugezi Marsh and Lakes	+	+	+		+				+			+	+		
Rweru Lake (see Burundi)				+				+							
"Upper lakes"				+											
Volcanoes National Park (S. East)		+	+				+		+			+			
KENYA															
Asembo Bay						+									
Awach River Mouth						+									
Busia Grasslands	+	+								+		+			

SITE	CE	IB	PA	LK	RS	RM	ZE WH MB	TB	SP	RA	EN	RL	SS	KC	SCORE
Dunga Swamp		+								+		+			
Kadimo Bay						+									
Kakamega Forest Reserve	+	+	+						+	+	+	+			
Kanyaboli Lake			+	+							+	+	++		
Kisat River Mouth						+									
Koguta Swamp	+	+								+		+			
Koriga Lake (reservoir)				+											
Kuja River Mouth						+									
Kusa Swamp	+	+								+		+			
Maasai Mara National Reserve	+	+	+					(+)	+	+	+	++		+	**10**
Mau Forest Complex Forest Reserves	+	+	+							+					
Mau-Narok Molo Grasslands	+	+							+	+		+			
Migowa Lake (reservoir)				+											
Mirundu Bay						+									
Mount Elgon National Park(not primarily freshwater)	+	+	+				++	(+)		+	+	+			**9**
Namboyo Lake (reservoir)				+											
Ndere Island National Park			+												
Ngothe Bay						+									
North Nandi Forest Reserve	+	+	+						+			+			
Nyakatch Bay						+									
Nyango Bay						+									
Nzoia River Mouth						+				+	+		+		
Oluch River Mouth						+									
Ruma National Park		+	+						+	+		+	+		
Samunyi River Mouth						+									
Sare Lake				+											
Simbi Lake				+											
Sio Port Swamp	+	+				+				+		+			
Sondu Miriu River Delta						+							+		

SITE	CE	IB	PA	LK	RS	RM	ZE WH MB	TB	SP	RA	EN	RL	SS	KC	SCORE
South Nandi Forest Reserve	+	+	+							+		+			
Ufinya Lake (reservoir)				+											
Ulanda Lake (reservoir)				+											
Yala Swamp Complex, with Lake Kanyaboli	+	+		+		+				+	+	+	++		**9**
TANZANIA															
Bisongo				+											
Bumbire Islands, L. Vic.	+	+													
Bunda Bay, L. Vic.	+	+													
Burigi-Biharamulo Game Reserve	+	+	+	+						+		+			
Emin Pasha Gulf						+			++	++	+++				8
Grumeti Game Reserve			+												
Ibanda Game Reserve			+												
Ikimbi Lake				+											
Ikona WMA			+												
Kagera Swamps	+														
Kajumbura Lake				+											
Kikuru Forest Reserve			+												
Korongo Game Reserve			+												
Lwelo Lake				+											
Majita Bay						+									
Mara Bay & Masurura/Mara Swamp (Mara Wetland)	+	+				+		+	+	+	+		++	+	**10**
Maswa Game Reserve	+	+	+						+			+			
Minziro Forest Reserve (see Uganda)	+	+	+					+	+			+			
Mujunju Lake				+											
Mwanza Gulf	+	+				+			+	+	+++	+	+		**10**
Rubondo Island National Park	+	+								+					
Rumanyika-Orugundu Game Reserve			+												
Rushwa Lake				+											
Serengeti National Park	+	+	+				+	(+)	+	+	+	+			**9**

SITE	CE	IB	PA	LK	RS	RM	ZE WH MB	TB	SP	RA	EN	RL	SS	KC	SCORE
UGANDA															
Bulera lake				+				+	+						
Buswahili Lake				+											
Itabugamba Lake				+											
Kachera Lake				+											
Kijanibalora Lake				+											
Koki Lake				+											
Lutembe Bay, L. Vic.	+	+			+	+						+			
Lutoboka Point (Ssese Isles)	+	+													
Mabamba Bay, L. Vic.	+	+			+	+			+			+			
Mburo Lake National Park	+	+	+	+	+				+			+			
Musambwa Islands, L. Vic.	+	+													
Nabajjuzi Wetland	+				+										
Nabugabo Lake complex	+	+		+	+				++	++	+	+	+		**11**
Nakivubo Swamp			+											++	
Sango Bay-Minziro swamp forests	+	+	+		+	+		+	+		+		+	+	**9**

CE, CEPF sites; IB, IBAs; PA, protected areas; LK, notable satellite lakes; RS, Ramsar sites; RM, river mouths and sheltered bays; ZE, zero extinction sites; WH, world heritage sites; MB, man and the biosphere sites; TB, transboundary sites; SP, special species groups; RA, rare species (e.g., native fish no longer in the main lake); EN, known endemics; RL, Red List species; SS, special uses, special threats; KC, known choices of others.

Plus (+) signs signify how strongly a site met a particular criterion. Pluses in parentheses signify a site meeting the criterion has been weighted up or down by proximity to transboundary or another adjacent site. The weighted scores are only shown for sites selected for further analysis.

Table 4. BSA priorities for development of investment packages

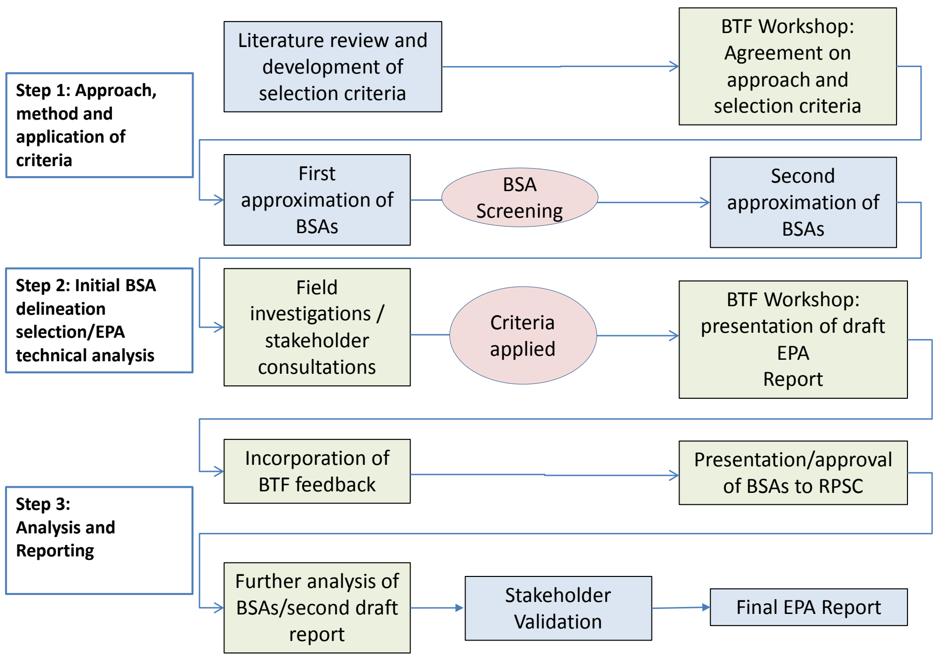
BIOLOGICALLY SIGNIFICANT AREA	SCORE
1. Nabugabo Lake Complex, Uganda	11 pts
2. Mara Wetland, Tanzania 3. Mara–Serengeti Ecosystem, Kenya/Tanzania 4. Mwanza Gulf, Tanzania	10 pts
5. Nyungwe–Kibira Complex, Rwanda/Burundi 6. Rweru–Mugesera Complex and Northern Aquatic Protected Landscape, Rwanda/Burundi 7. Sango Bay–Minziro Swamp Forests, Uganda/Tanzania 8. Yala–Nzoia Wetlands, Kenya 9. Mount Elgon Ecosystem, Kenya/Uganda	9 pts

During the ranking of BSAs, special care was taken to ensure BSAs were in at least two of the lake basin countries to further transboundary conservation and management within the region. Furthermore, the EPA employed a "landscape-scale" approach to ensure the sustainability of species, ecosystems, and their goods and services benefit local people and institutions.

Field work was conducted in the various sites during January and February of 2014, follow-up visits in March 2014, and further ground checks requested by the BTF in June and July of 2014. During some of the site visits, BTF members and/or experts from local natural resource management/ research institutions assisted with data collection. The BTF was also involved in data collection from their respective member states to the extent possible.

Several iterations of the report were produced to include input provided by the BTF and EPA team. The EPA preparation process is summarized in Figure 1 below.

Figure 1. Summary of the EPA preparation process



2.0 THE BIODIVERSITY CONSERVATION CONTEXT IN THE LVB

This chapter presents a review of the LVB landscape and hydrological scenario; surface and ground water (SW-GW) dynamics; and the impacts of land cover, land use change, and climate change on water quality and quantity. It also addresses the socio-economic aspects in the LVB relative to biodiversity and climate change, institutional and policy issues, and livelihood and gender aspects. Recommendations are suggested to strengthen livelihoods with respect to biodiversity resources and climate change.

2.1 THE PHYSICAL ENVIRONMENT

2.1.1 LOCATION

Lake Victoria straddles the equator extending between latitudes 0°30' N and 2°30' S and longitudes 31°50' E 34°10' E. It occupies approximately 68,870 km^2 with a maximum depth of about 70 meters and a surface altitude of 1,134 meters above sea level (Witte, Wanink & Kishe-Machumu, 2007). Lake waters are shared by Tanzania (51%), Uganda (43%), and Kenya (6%) (Balirwa et al., 2003). The shoreline is highly indented and estimated to be about 3,460 km long (Kayombo & Jorgensen, 2005). Combined with the lake itself, the basin has a spatial coverage of 249,820 km^2. Of the 180,950 km^2 that comprise the terrestrial component, 44% is in Tanzania, 22% in Kenya, and 16% in Uganda. Rwanda and Burundi contain 11% and 7%, respectively.

2.1.2 TOPOGRAPHY AND GEOLOGY

The lake occupies a relatively young and shallow depression, generally characterized by plains, a series of plateaus, and highly eroded surfaces that expose granitic hills and rock outcrops. The eastern and western sides slope gently, culminating in the highlands associated with the two arms of the Great Rift Valley, formed about 400,000 years ago.

The lake basin and its present topography are the outcome of tectonic movements and regional back-tilting that led to the formation of the Great Rift Valley. Most of the basin drained from east to west prior to the onset of rifting in the late Miocene and the Pliocene (Danley et al., 2012; Ebinger, 1989). A slow uplifting of the western divide blocked the westward-flowing rivers, notably the Katonga and Kagera (Kaufman, L.J. Chapman, and C.A. Chapman, 1997). The flow of these rivers was then reversed into the basin that finally became Lake Victoria.

Recent seismic reflection profiles have confirmed that the basin was previously occupied by a series of much smaller lakes, supporting the estimated geological age of 400,000 years (Johnson et al., 2000). Geological cores taken from the lake bottom indicate that it has dried up completely at least three times-probably related to past ice ages, when precipitation declined globally. It last dried out 17,300 years ago and refilled beginning about 14,600 or 14,700 years ago. The three major desiccation events may reflect the 100,000-year cycle of climate forcing (Johnson, Kelts & Odada, 2000). The Victoria Nile (a contributory to the White Nile) flows out of the northern shoreline at a natural outlet, a narrow opening formerly referred to as Ripon Falls until it was submerged after the construction of Owen Falls Dam in 1954. The approximate geographic limits of the LVB are shown in Figure 2 below.

Figure 2. Geographic delineation of the LVB

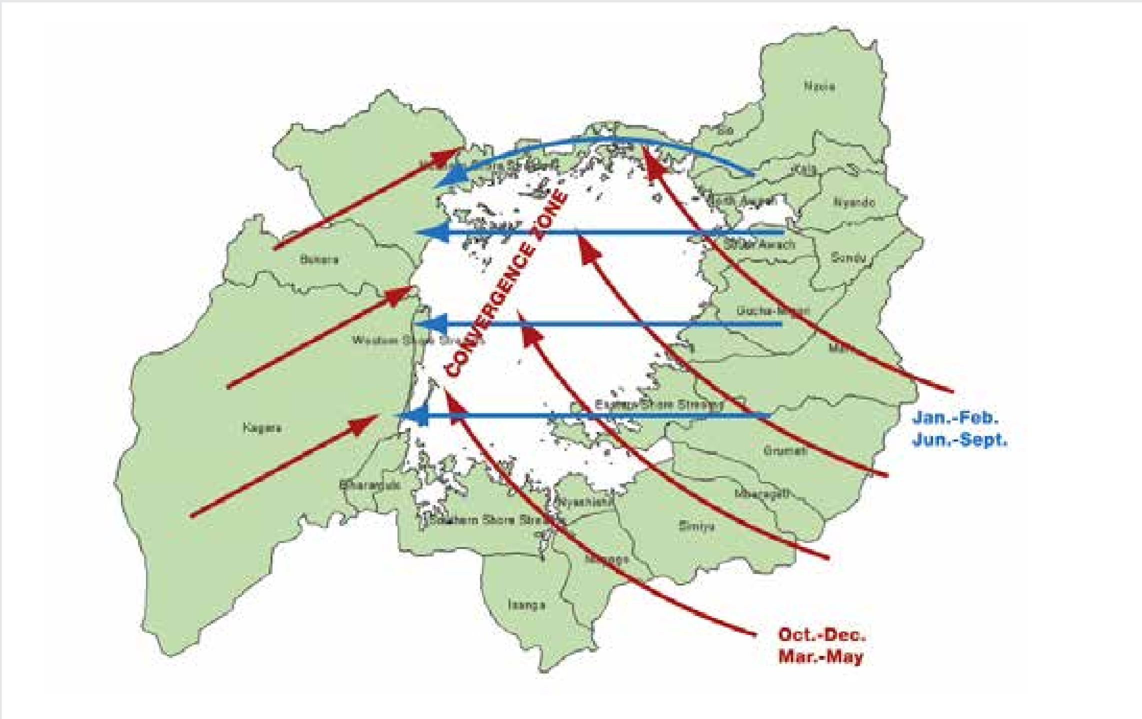
Source: LVBC, 2007; adopted from the International Lake Environmental Committee (ILEC), 2005

2.1.3 SURFACE HYDROLOGY

The basin has a biannual rainfall pattern, with the long rains from March to May and short rains from October to December. July is the coolest month of the year; the warmest month is variable and fluctuates during the period from October to February. Rainfall varies considerably from one part of the basin to another. There is a contrast between the heavy rainfall in the west and northwest of the lake, at Bukoba and Kalangala, and the lower rainfall in the southeast, at Musoma, where the dry seasons in June to August and January to February are more marked. Refer to Chapter 3 for a more detailed discussion on the average annual rainfall patterns in the LVB.

Flohn & Burkhardt (1985) reported that the true source of the Nile is neither the Ripon Falls, where the river leaves Lake Victoria, nor the headwaters of the Kagera tributary draining the highlands of Rwanda and Burundi, but rather the nocturnal cloud above the lake itself, which provides 85% of the water supply to the lake. In the months of January to February and June to September, the wind pattern is predominantly east-west, parallel to the equator, with origins from the western parts of Kenya and Tanzania. These dry winds pick up moisture while crossing the lake, subsequently depositing it to the western catchments, especially the Bukora catchment in Uganda. During the March to May and October to December rainy seasons, the wind pattern changes toward the northern parts of the Lake (Figure 3). There is also a diurnal element to the lake/land breeze system, which interacts with the mountain/valley breezes and the large-scale winds in such a way that strong wind convergence occurs over the western half of the lake at night but over the eastern half of the lake during the day. Consequently, precipitation and cloudiness are common over the western half of the lake at night, but during the day in the east. There is a very sharp transition between these two seasons through the center of the lake.

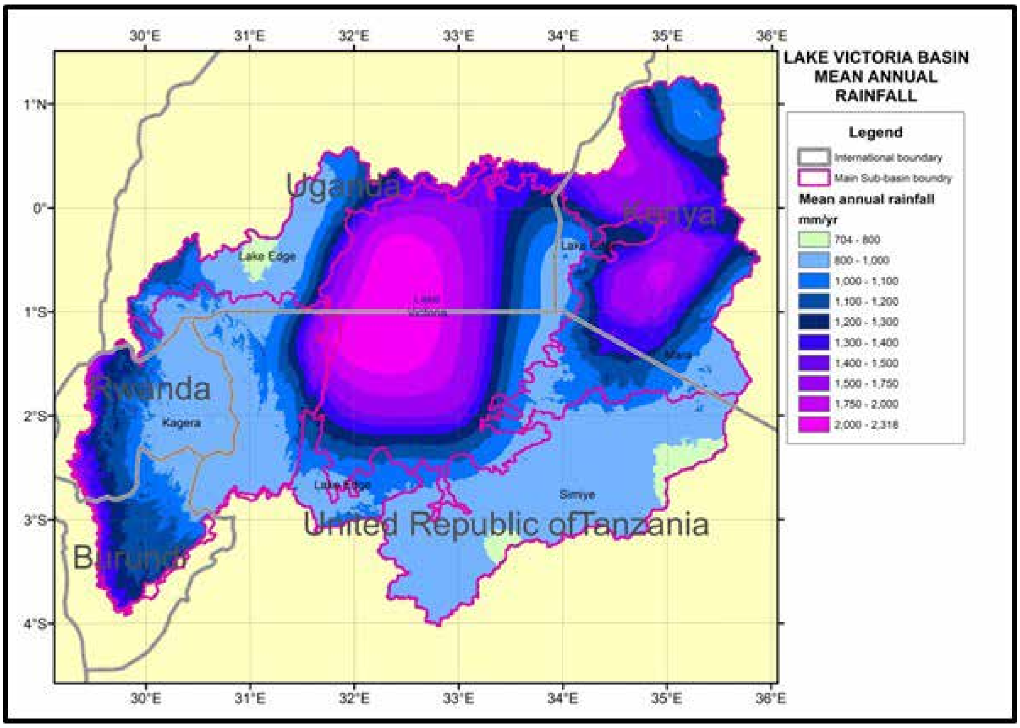
Figure 3. Seasonal wind patterns over Lake Victoria



Source: LVEMP, 2007

The diurnal effect is greatest in the north and during the March to May rainy season, although the effect is still quite evident in the "short rains" of October to December. While over the catchment, mean annual rainfall is approximately 1,200 to 1,400 mm, it exceeds 3,000 mm at the tiny Nabuyonge Island, in the center of the lake. The distribution of mean annual rainfall across the basin is shown in Figure 4.

Figure 4. Lake Victoria Basin: Mean Annual Rainfall (mm/yr)



Source: Map provided by EPA consultant (Hydrologist)-unsourced

Evaporation is also a key element of the water balance of the lake (Piper et al., 1986. Combined rainfall and evaporation far exceed inflow and outflow from the catchment. Rainfall over the lake exceeds evaporation by a factor of 0.1, whereas outflow exceeds inflow by a factor of 0.27 (Sewagudde, 2009).

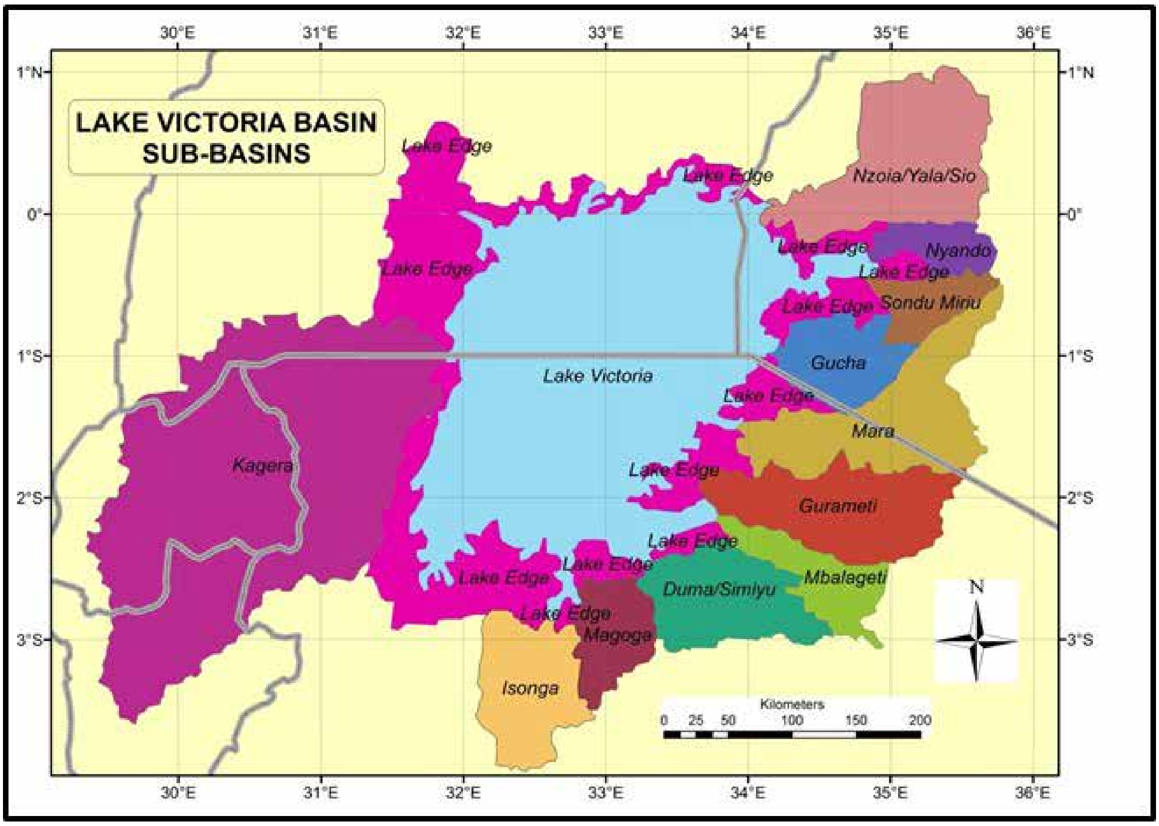
2.1.4 SUB-BASIN FLOWS

Annual Flow

The basin comprises 11 defined sub-basins with a fringing lake edge catchment of variable width (Figure 5). The two sub-basins with the largest flows are the Kagera and the Nzoia with 32.7% and 14.6% of total inflows (Table 5). Streams on the lake edge constitute some 11.1% of inflows. The two transboundary rivers are the Kagera (Burundi, Rwanda, Tanzania, and Uganda) and the Mara (Kenya and Uganda).

However, several tributaries, especially in Uganda, enter the lake through swamps, with estimated areas totaling 2,600 km^2 (Brown, Ribeny, Wolanski & Codner, 1979). In recent years, many of the bays around the shore have been invaded by water hyacinth (***Eichhornia crassipes***); the influence on the lake water balance will depend on the extent of invasion by this noxious weed.

Figure 5. Sub-basins of the Lake Victoria catchment



Source: Map provided by EPA consultant (Hydrologist)-unsourced

Table 5. River flows by sub-basin (1950–2000, 2001–2004, 1950–2004)

COUNTRY	RIVER BASIN	FLOW IN CUMECS 1950–2000	%	FLOW IN CUMECS 2001–2004	%	FLOW IN CUMECS 1950–2004	%
Kenya	Sio	11.4	1.4	9.8	1.4	11.3	1.4
	Nzoia	116.7	14.5	107.4	15.7	116.1	14.6
	Yala	37.7	4.7	47.9	7	38.4	4.8
	North Awach	3.8	0.5	3.3	0.5	3.7	0.5
	South Awach	5.9	0.7	5.5	0.8	5.9	0.7
	Nyando	18.5	2.3	41.9	6.1	20.3	2.6
	Sondu	42.2	5.2	43.9	6.4	42.4	5.3
	Gucha–Migori	58	7.2	39.9	5.8	56.6	7.1
Tanzania	Grumeti	11.5	1.4	4.6	0.7	11	1.4
	Mbalageti	4.3	0.5	3.5	0.5	4.2	0.5
	Eastern Shore Streams	18.6	2.3	11.3	1.6	18.1	2.3
	Simiyu	39.0	4.8	12.2	1.8	37	4.6
	Magogo–Maome	8.4	1.0	1.6	0.2	7.8	1.0
	Issanga	31.0	3.9	4.3	0.6	29.0	3.6
	Nyashishi	1.6	0.2	0.3	0	1.5	0.2
	Southern Shore Streams	25.7	3.2	3.5	0.5	24.1	3.0
	Western Shore Streams	20.7	2.6	18.9	2.7	20.6	2.6
	Biharamulo	17.8	2.2	18.3	2.7	17.9	2.2
Uganda	Katonga	51	0.6	2.1	0.3	4.9	0.6
	Bukora	3.1	0.4	2.0	0.3	3.0	0.4
	Northern Shore Streams	25.6	3.2	28.2	4.1	25.8	3.2
Shared Rivers	Kagera	261.1	32.4	252.5	36.8	260.5	32.7
	Mara	37.5	4.7	23.1	3.4	36.5	4.6
TOTAL		805.3	100	686.2	100	796.6	100

Source: Integrated Water Quality and Limnology Study of Lake Victoria LVEMP, 2005.

Monthly Flows

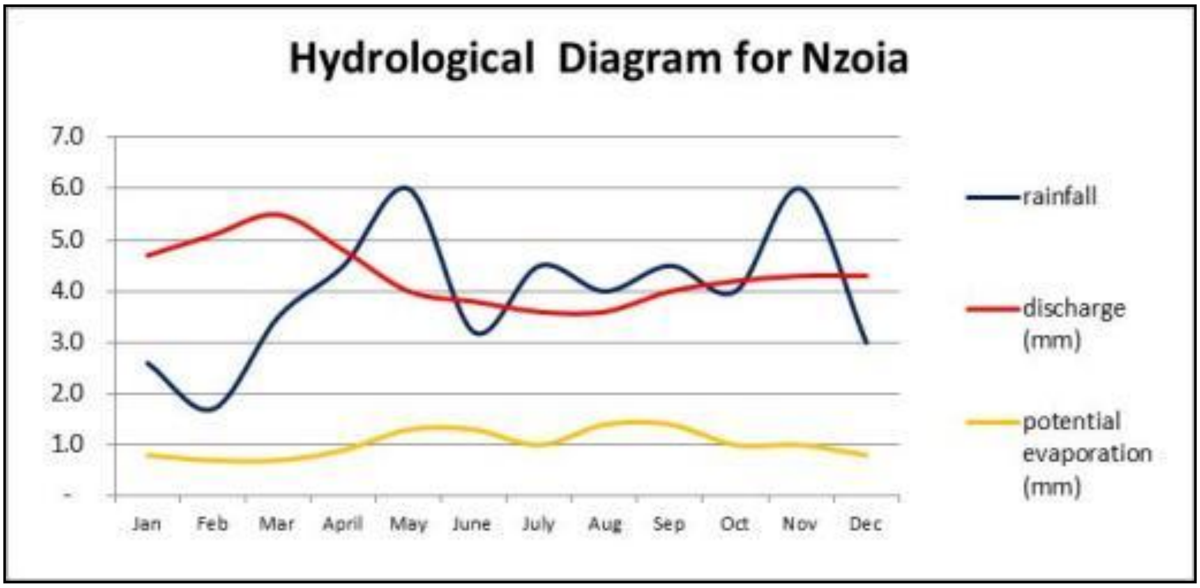
The river flows reflect the rainfall distribution; the runoff patterns are highly seasonal and accentuate the seasonal rainfall. These are summarized briefly for the three major rivers in the sections below.

Nzoia River

More clearly than the other rivers, the flows of the Nzoia reflect the July-August rainfall to the northeast of the lake, superimposed on the effect of the other seasonal variations. According to Mutua & Al-Weshah (2010), the Nzoia River basin receives rainfall in three main rain seasons: March to May, July to September, and October to December. The seasons are not exactly concurrent in all parts of the basin. Rainfall is most intense in the March to May season and often causes serious flooding in the lower parts of the basin. The evaporation over the basin is almost constant over the year. The peak discharge of the river shows a strong lag behind the peak rainfall. Figure 6 shows the hydrologic diagram for a station located near the mouth of the Nzoia River.

The Yala and the Sondu reveal a greater proportion of base flow; to the south, the Gucha shows much greater variability of flow and the dominant influence of the March to April rainfall season.

Figure 6. Hydrological diagram for the Nzoia River basin

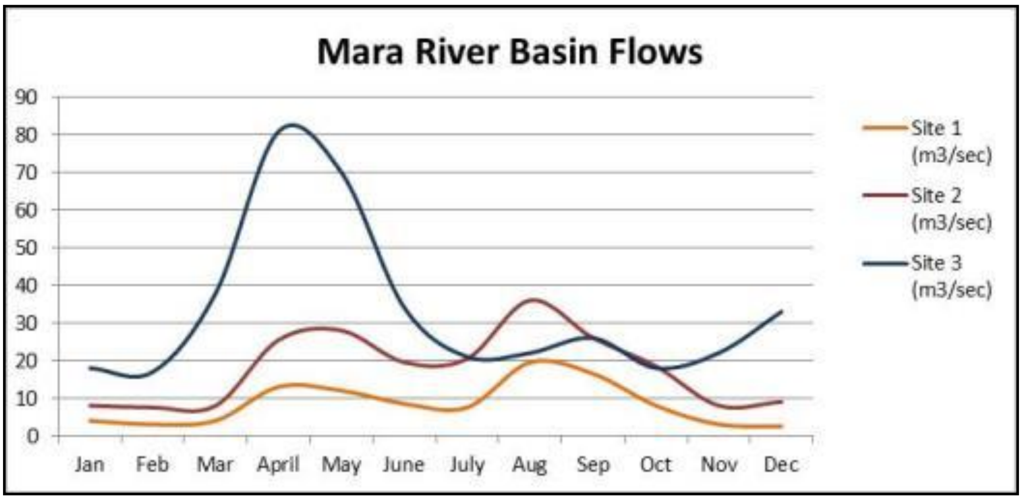


Source: Mutua & Al-Weshah, 2010. Note: Left axis depicts depth in mm in the original publication.

Mara River

Farther south, the Mara and Simiyu show similar seasonal patterns but even less flow in the dry season. The flows for the Mara are shown (Figure 7) for three points in the basin. There are two annual peaks in flow levels in the Mara River. One occurs from March to June, and the second occurs from November to December. Peak flows increase the farther one goes downstream in the basin. At Site 1, in the upper reaches of the basin on the Amala River, these peak flows reach approximately 30 m^3/s in an average year. During a dry year, peak flows may reach only 8 m^3/s, while during a wet year peak flows may extend over 150 m^3/s. At Site 3, in the lower Mara straddling the Kenya-Tanzania border, peak flows can reach 300 m^3/s in an average year, but may vary from 90 to over 400 m^3/s, depending on whether it is a dry or wet year. Along the entire length of the river, low flows can approach 1 m^3/s or less in both wet and dry years, although the river has not dried up completely at the study sites in the past 50 years of monitoring. Many other tributaries, however, such as the Sand and Talek Rivers, do stop flowing during the dry season.

Figure 7. Average monthly flows (m^3/second) for three points in the Mara Basin

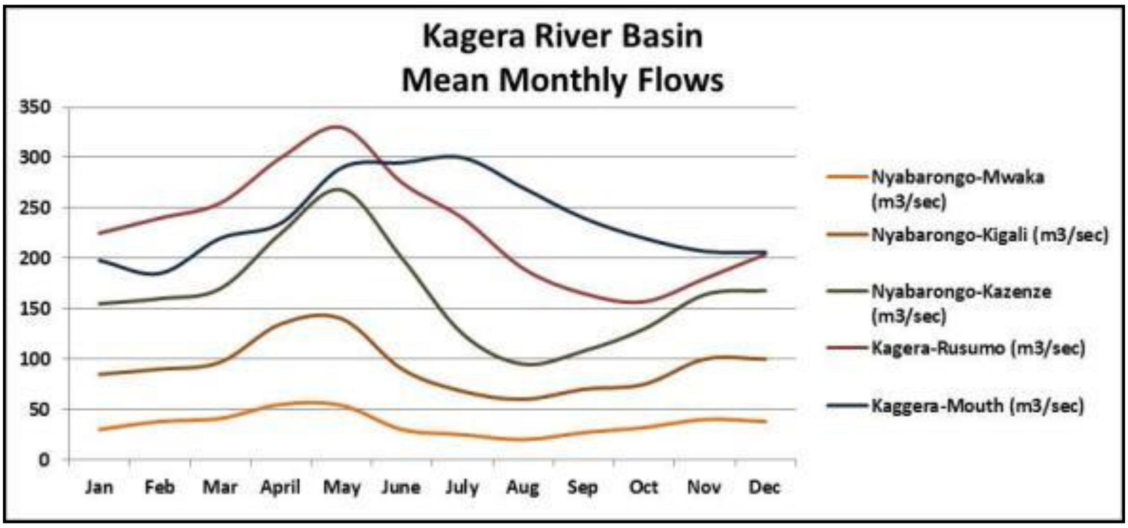


Source: LVBC and WWF-ESARPO, 2010

Kagera River

Three main tributaries feed the Kagera River: the Nyabarongo, Akanyaru, and the Ruvubu. Numerous lakes and wetlands attenuate the flow regime for the Kagera River. The runoff in the Kagera River basin responds to seasonal rainfall. The peak flow occurs in April in the upper tributaries; in May at Kigali and Rusumo Falls, where the stream flow is the result of half of the total catchment area; and is delayed to July at Kyaka Ferry on the lower Kagera, close to the outlet into Lake Victoria. A comparison of mean monthly flows at Rusumo Falls (which marks the boundary between the upper and lower reach of the swamp and lake area) and Kyaka Ferry shows a difference in timing in the peak flow at Kigali of about one month, whereas the period of the peak increases from one to three months. The Kagera River flow tributaries to Lake Victoria are different from others, mainly because of this wetland attenuation. The monthly flow series of the Kagera River at Kyaka Ferry (Figure 8) shows the high base flow component, resulting from the storage in lakes and swamps (Sutcliffe & Parks, 1999).

Figure 8. Average monthly flows (m^3/second) for five points in the Kagera Basin



Source: Bas Rhône et du Languedoc (BRL), 2008

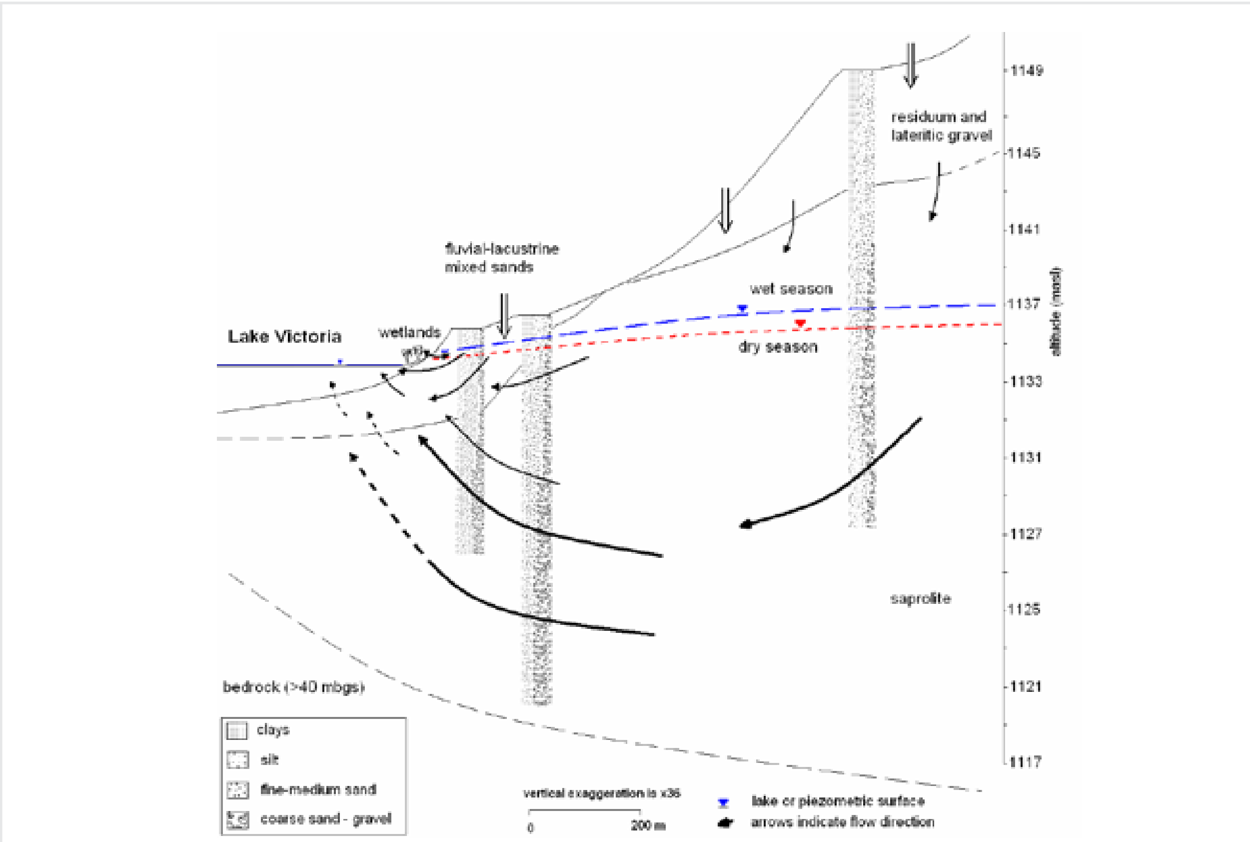
2.1.5 GROUNDWATER HYDROLOGY

Groundwater-Surface Water Interactions

The data on groundwater in the LVB is sparse. Owor (2010) studied SW-GW interactions on the shores of Lake Victoria and found SW-GW interactions are strongly influenced by changing drainage base (lake) levels that are controlled, in part, by regional climate variability and dam releases from the lake at Jinja. The direction of fluxes within the lithologic interface with the lake at Jinja is as presented in Figure 9. Darcy throughflow calculations suggested that direct contributions from groundwater to Lake Victoria make up less than 1% of total inflows to the lake (Owor et al., 2011). At Jinja, the lithostratigraphy was as follows:

- Fluvial-lacustrine sands (~5 m thick),
- Lateritic gravel and sands (15 m thick), and
- GW saprolite (>17 m thick).

Figure 9. Hydrodynamic conceptual model showing the direction of fluxes within the lithologic interface with Lake Victoria at Jinja



Source: Owor, 2010

Khisa et al. (2012) studied GW-SW interactions in the Nyando Papyrus wetland in Kenya. They found that the river, lake, alluvial aquifer, and wetland were hydraulically connected and that wind direction was the main influence of lake level fluctuations. They concluded that the main factors influencing soil moisture content were rainfall, river overtopping, backwater effects, and groundwater.

The International Atomic Energy Agency is using isotope studies to investigate the role of groundwater in the water balance of Lake Victoria. They found that the water balance is dominated by direct precipitation and evaporation. Isotopic data show that no significant lake water is lost due to flow into the adjacent shallow aquifer system. Furthermore, the wetlands at the fringes of Lake Victoria are sustained by groundwater and not lateral flow from the lake.

Threats to the Groundwater System

In Kenya, most of the problems affecting groundwater are associated with human development. The most common problem is degradation of the groundwater quality due to surface-level pollution or saline intrusion and environmental degradation because of over-abstraction in areas where demand far outstrips supply. Causes of groundwater pollution include unregulated waste disposal in industrial areas and informal housing areas; abandoned waste disposal, especially in peri-urban areas; agricultural chemical loading; and domestic sewers.

In Uganda, heavy groundwater abstraction has been observed in some towns, resulting in the lowering of groundwater levels and sometimes competitive pumping among water providers. The lack of sewerage systems in many urban areas has also led to construction of onsite sanitation systems in the form of septic tanks and pit latrines. This, combined with poor solid disposal practices, has caused contamination of groundwater resources in isolated areas.

In Tanzania, threats to groundwater include pollution from human settlements and industrial waste, farming activities, and groundwater depletion because of declining rainfalls.

2.1.6 SURFACE WATER QUALITY

Table 6 summarizes the sources and relative pollutant loads for Lake Victoria. Atmospheric deposition is considered to be the major pollutant source to the lake. The results indicate that total atmospheric deposition (wet and dry deposition) contributes about 49.07% and 63.70%, respectively, to the total nitrogen and total phosphorus load.

Table 6. Annual external pollution load to Lake Victoria

POLLUTION SOURCE	LOADING TO LAKE VICTORIA		
	BOD	TOTAL NITROGEN	TOTAL PHOSPHORUS
Domestic Waste (including urban runoff)	17,938	3,505 (1.68%)	1,624 (4.24%)
Industrial Sources	5,606	414 (0.21%)	342 (0.89%)
River Basin	25,122	49,509 (23.78%)	5,693 (14.86%)
Runoff from Cultivated Land	...	22,966 (11.03%	2,297 (6.00%)
Runoff from Non cultivated Land	...	29,615 (14.23%)	3,949 (10.31%
Atmospheric Wet Deposition	...	62,601 (30.08%)	11,831 (30.89%)
Atmospheric Dry Deposition	...	39,550 (18.99%	12,567 (32.81%)
Total	**48,666**	**208,160 (100%)**	**38,303 (100%)**

BOD, Biological Oxygen Demand

It is important to note however, that some local scientists dispute the high nutrient loadings attributed to atmospheric deposition.

Impacts of Land Use Pollutants on Loading to the Lake

While perennial horticultural areas are generally well managed with perennial cover and runoff control, many other areas with annual crops (e.g., maize) do not maintain ground cover. Thus Majaliwa, Magunda, Teya & Musitwa (2001) reported that soil erosion losses are highest for annual crops, and lowest for coffee and bananas. In addition, cropping areas often extend down to streams and lake edges, eliminating riparian buffering vegetation found in wetlands.

Further, forested areas surrounding the lake have been cleared for settlement and agricultural activities. These poor land management practices have resulted in large areas being subjected to severe soil erosion (Scheren, Mirambo, Lemmens, Katima & Jansse, 2001). This study indicated that land utilization has a high impact on nutrient loading to the lake, thereby contributing to eutrophication. The annual increase in cultivated land is estimated at 2.2%; 1.5 million cattle and 1 million goats exceeds the sustainable grazing rate by a factor of 5. The resulting influence of these factors on eutrophication of Lake Victoria reveals itself through two main pathways: i) increasing soil erosion, nutrient runoff, and leakage to surface waters; and ii) increasing nutrient release to the atmosphere from animal and biomass burning and their consequent deposition to surface water (Scheren et al., 2001).

Siltation not only causes the turbidity observed in Winam Gulf in the northeast (and possibly other semi-enclosed areas), but also transports nutrients (e.g., phosphorus) and contaminants (e.g., agricultural chemicals). It should be noted that, whereas high turbidity in areas like Winam Gulf is caused primarily by increased siltation from rivers, the increased turbidity in the main body of the lake is caused by high chlorophyll-a concentrations. This distinction has significant ecological consequences, and requires different management strategies. Some rivers are also the likely source of mercury from mining activities observed nearshore in Mwanza Gulf.

The current annual sedimentation rates for Lake Victoria are the same as projected in 1978, and comparison with calculated net deposition rates shows that 4% of the phosphorus, 8% of the nitrogen, and 10% of the silicon is permanently buried (COWI Consulting Engineers, 2002). The burial rates represent an annual accretion of 1 mm/y. However, Swallow et al. (2001) showed that the settling rate at the river inlets in the catchment area was 1 cm/y, indicating a high accumulation of sediments at the lakeshore.

2.1.7 ECOLOGICAL CHANGES IN LAKE VICTORIA

Ecological transformations with far-reaching implications have occurred in Lake Victoria in recent decades. Azza (2006) conducted a detailed study of the ecological changes in Lake Victoria and examined some of the factors behind these changes. These changes are also recorded in the works of Talling (1966) and Worthington (1930), and are summarized as follows:

- Warmer temperatures and more stable thermal stratification (Hecky, 1993; Lehman, 1998);
- Increased hypolimnetic anoxia, affecting nearly half of the lake's bottom and persisting for extended periods (Hecky, 1993; Hecky et al., 1994; Bugenyi & Magumba, 1996);
- An increase in the incidence of catastrophic fish kills (Ochumba, 1987; Ochumba & Kibara, 1989; Ochumba, 1990);
- A twofold increase in pelagic primary productivity and a threefold increase in chlorophyll-a concentrations (Lehman & Branstrator, 1993; Mugidde, 1993);
- A tenfold decrease in soluble reactive silica concentrations and a twofold to fivefold increase in the concentrations of other plant nutrients (Hecky & Bugenyi, 1992; Hecky, 1993; Gophen, Ochumba, Pollinger & Kaufman, 1993; Bugenyi & Magumba, 1996; Verschuren, Edgington, Kling & Johnson, 1998);
- A replacement of diatoms as the dominant phytoplankton group by blue-green algae (Hecky, 1993; Mugidde, 1993; Balirwa, 1998); and
- A sharp rise in the population of Nile perch coinciding with a dramatic decline in other fish stocks and modification of pelagic food webs (Ogutu-Ohwayo, 1990, 1992; Ogutu-Ohwayo & Hecky, 1991; Goldschmidt & Witte, 1992; Kaufman, 1992; Witte et al., 1992a, b; Witte, Goldschmidt & Wanink, 1995; Cohen, Kaufman & Ogutu-Ohwayo, 1996; Witte et al., 1999).

2.1.8 FACTORS CAUSING ECOLOGICAL CHANGE

While descriptions in literature on the ecological changes in Lake Victoria commonly go into great detail among scientists, there is fluctuant conviction, and often disagreement, over the causative factors of change. Three competing hypotheses have been tendered to explain the changes:

(1) Trophic alterations caused by a cascade of predator-prey interactions triggered by introduction of the predatory Nile perch eliminated endemic herbivores and permitted the unrestrained growth of nuisance algae (Witte et al., 1992a, b; Gophen et al., 1993; Goldschmidt, Witte & Wanink, 1993).

(2) Progressive anthropogenic disturbance of the lake's catchment has increased nutrient inflows to the lake and spurred the emergence of cyanobacteria dominance and expansion of areas affected by acute hypolimnetic anoxia (Ochumba, 1990; Bootsma & Hecky, 1993; Hecky, 1993; Muggide, 1993; Hecky et al., 1994; Bugenyi & Magumba, 1996).

(3) A warming trend in the climate of East Africa accompanied by a decrease in the duration of strong winds has altered the lake's water column structure and mixing patterns, and triggered changes in the phytoplankton community structure (Hecky & Kling, 1987; Talling, 1987; Ochumba and Kibaara, 1989; Lehman, 1998).

Over time, consensus has formed among scientists on eutrophication and climate change being the leading causes of the ecological transformations in Lake Victoria (Lehman, 1998; Johnson et al., 2000; Verschuren et al., 2002). The case for cascading trophic interactions has been significantly weakened by careful examination of fish capture statistics (Ogutu-Ohwayo, 1990) and by recent paleolimnological evidence (Hecky, 1993; Lipiatou et al., 1996) that together have demonstrated changes in lake biota preceded Nile perch introduction; therefore, the predator could not have caused the ecosystem changes in the lake. Further examination of trophic relations in the lake did not generate clear evidence of the suggested simplification in food webs (Wanink & Witte, 1998; Wanink et al., 2002).

Moreover, paloelimnological work established strong chronological linkage between land use change in the catchment and limnological transformations in the lake (Johnson et al., 2000; Verschuren et al. 2002). Thus, this view has effectively been discarded (Lehman, 1998). Notwithstanding, it is widely accepted that the voracious Nile perch is responsible for the extinction of several hundred species of endemic cichlid fishes.

Eutrophication is the most widely cited cause of Lake Victoria's problems. The export of nutrients from the catchment is believed to have increased tremendously, from as early as the 1920s, through man's clearing of savannah and virgin forests, burning of bushes, practicing intensive agriculture and animal husbandry, and occupying lake shorelines for access to fish (Hamilton, 1984; Cohen, Kaufman & Ogutu-Ohwayo, 1996; Crul, 1998). Direct verification of this hypothesis has been rendered difficult by the absence of historical measurements of nutrient exports from the catchment. However, Verschuren et al. (2002) circumvent this problem by using human population size as a proxy indicator of anthropogenic soil and forest/savannah disturbance and its effect on nutrient fluxes. They showed that the timing and progress of lacustrine productivity increase matched human population growth and associated agricultural and nutrient export activities within the catchment.

Burgeoning population growth is regarded as the underlying cause of aquatic impacts in the catchment (Hecky, 1993). The explosion in human and livestock populations started around 1930 with completion of the Uganda railroad, which stimulated plantation agriculture for the export of cash crops, and opened up the Lake Victoria region to settlement. Continued population growth through immigration and improved health conditions initiated the pattern of large-scale deforestation and agricultural conversion that has continued to the present day. Commissioning the hydropower station at Owen Falls Dam in 1954 further catalyzed economic growth and saw the emergence of new activities with a potential to further increase nutrient exports. These include the rapid expansion of towns and cities, increasing road construction, discharge of untreated municipal and industrial effluents, and encroachment on wetlands (Hecky, 1993; Cohen et al., 1996; Bugenyi & Balirwa, 1998; Crul, 1998; Kairu, 2001). Intensity of this growth is rising and driven by the growing population and struggle of riparian areas for greater economic prosperity (World Bank, 1996).

The export of nutrients from the catchment may have been aggravated by the sudden rise in lake levels in the early 1960s that followed unusually heavy rains (Flohn, 1987; Sene & Plinston, 1994). The rise in lake levels caused extensive flooding of the shoreline, drowning of shoreline swamps, and possible release of plant nutrients from flooded soils and drowned decomposing plant biomass.

Eutrophication had seemed most plausible and sufficient as an explanation because the ecosystem changes of 1960–1990 were widely viewed as being unique (Hecky, 1993). Recent reconstructions of past conditions in the lake, however, have indicated that modern events are not unique. This discovery raised the potential of climate change being a co-driver of the change process. Climate variation is linked to lake condition through mechanisms of heat budget and mixing patterns, which are the consequences of atmosphere-lake interactions. Detailed fossil stratigraphy of diatoms during the last 10,000 years indicated that dominance of heavily silicified diatoms, proxy indicators of deep and sustained lake mixing conditions, rose and fell repeatedly and episodically over time periods of centuries or less (Stager et al., 1997). Elemental and isotopic analysis of sedimentary organic matter also suggested that the Late Pleistocene to Holocene history of the lake was characterized by alternating periods of deep mixing and relative water column stability (Talbot & Lærdal, 2000). In a recent effort to set up a hydrodynamic model for Lake Victoria (World Bank, 1999), it was realized that the lake's temperature structure and mixing regime were extremely sensitive to variations in meteorological forcing factors.

Climate change-particularly change producing lower wind speeds and higher humidity-has a strong potential to increase stratification and cause major alterations in the chemical and biological condition of the lake. Refer to Chapter 3 for a more detailed assessment of climate change impacts in the LVB.

2.1.9 RIVERS

Rivers carry soil eroded from the catchment area to the lake. Thus, the water is more turbid and shallow at the inlets than in other parts of the lake. For example, Winam Gulf is comparatively shallow, having a maximum depth of 35 m and a mean depth of 6 m. The input of nutrient loads from the rivers located in the catchment area is 49,509 t/y T-N and 5,693 t/y T-P (Table 7).

Table 7. Pollution loadings to Lake Victoria due to rivers

COUNTRY	BASIN	AREA (KM²)	DISCHARGE (M/S)	TOTAL-N (T/Y)	TOTAL-P (T/Y)
Kenya	Sio	1,450	12.1	248	47
	Nzoia	12,676	118	3,340	946
	Yala	3,351	27.4	999	102
	Nyando	3,652	14.7	520	175
	North Awach	1,985	3.8	112	15
	South Awach	3,156	6	322	39
	Sondu	3,508	40.3	1,374	318
	Gucha-Migori	6,600	62.7	2,849	283
	Subtotal	**36,378**	**285**	**9,764**	**1,925**
Tanzania	Mara	13,393	38.5	1,701	304
	Grumeti	13,363	12.7	561	185
	Mbalageti	3,591	4.9	216	50
	E. shorestream	6,644	20.2	892	159
	Simiyu	11,577	34.1	1,507	435
	Magogo moame	5,207	6.3	278	50
	Nyashishi	1,565	1.4	62	11
	Issanga	6,812	5.1	225	40
	S. shore stream	8,681	27	1,193	213
	Biharamulo	1,928	21.5	950	170
	W. shore stream	733	21.1	932	166
	Kagera	59,682	265.3	29,303	1,892
	Subtotal	**253,176**	**458.1**	**37,820**	**3,675**
Uganda	Bukora	8,392	2.9	575	30
	Katonga	15,244	4.7	1,023	47
	N. shore stream	4,288	1.5	327	15
	Subtotal	**27,924**	**9.1**	**1,925**	**92**
Total Average Load		**197,478**	**752.2**	**49,509**	**5,693**

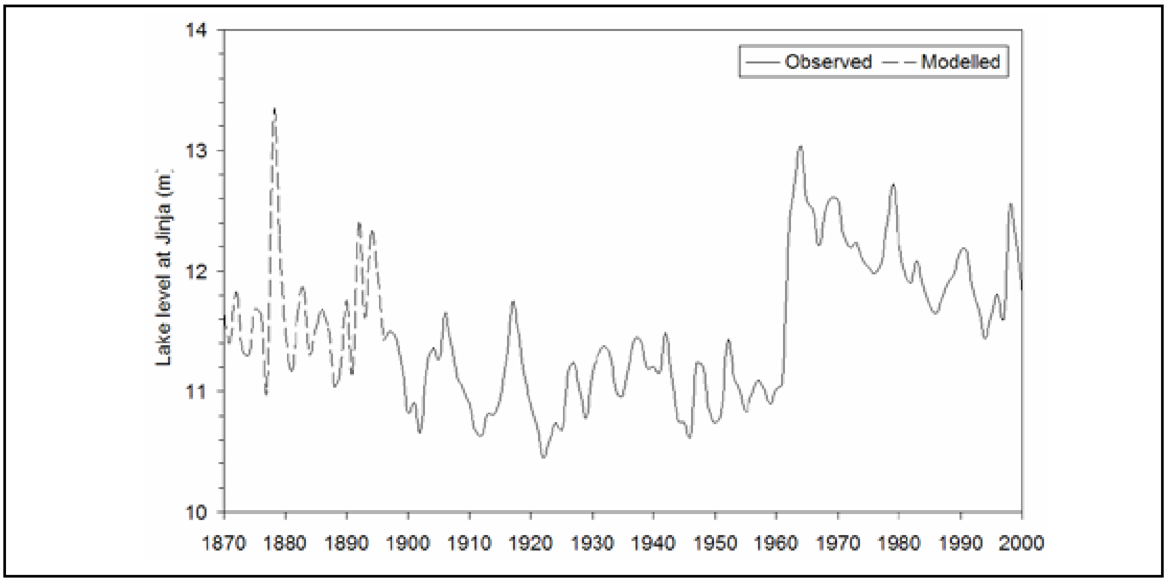
t/y = tonnes per year; N = Nitrogen; P = Phosphorus

2.1.10 WATER BALANCE

Lake Levels

Lake levels have been recorded since 1895, with considerable variation shown since then. Figure 10 shows the variation in levels from 1870 to 2000. Between 1961 and1962, heavy rains drove up the lake level by two meters to a historic high. Thereafter, levels gradually declined.

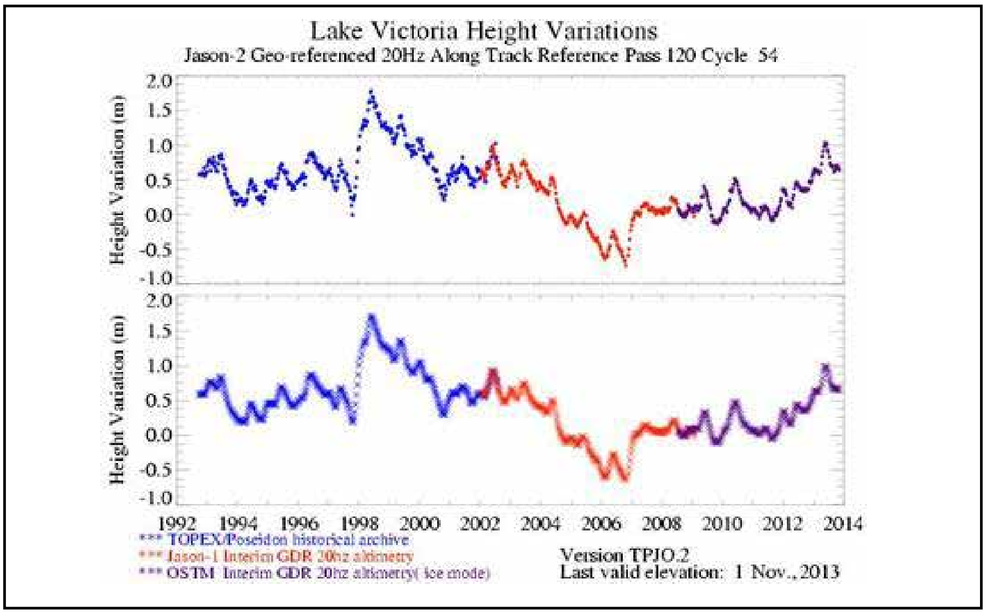
Figure 10. Lake Victoria levels, modeled (1870–1895) and observed (1896–2000)



Source: (Tate et al., 2004)

The TOPEX-Poseidon, Jason 1, and Jason 2/OSTM satellites measure water surface levels. Their data is available from the United States Department of Agriculture Foreign Agricultural Service website. Figure 11 shows the raw and smoothed variations relative to the 10-year average from September 1992. There was a sharp rise in levels from the 2007 low to a new high in 2013.

Figure 11. Lake Victoria height variation 1992–2013 relative to 10-year average from September 1992



Source: USDA: http://www.pecad.fas.usda.gov

Current Water Balance

The water balance has been studied in some detail by Piper et al. (1986), by Sene & Plinston (1994), by Sutcliffe & Parkes (1999), by Tate et al. (2004), and Sutcliffe & Petersen (2007).

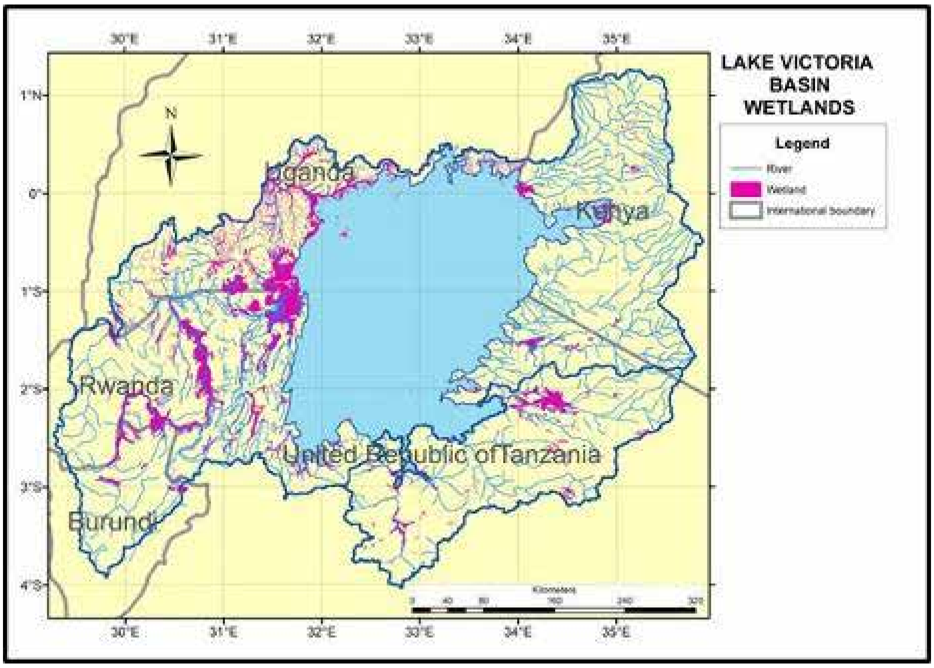
The inflow to the lake is dominated by the enhanced rainfall on the lake surface estimated at 67,000 km^2, which accounts for roughly 84% of the total inflow. An important contribution is the inflow from a large number of tributaries, draining some 190,000 km^2 from six countries, which makes up the remaining 16% of the total; that is subject to a greater variability of about 30% from year to year, compared with 10% for rainfall. The outflow from the lake includes evaporation from the lake surface, which is less variable from year to year, and the outflow down the Victoria Nile. Because the average lake rainfall and evaporation are almost in balance, the lake outflow is very sensitive to variations in rainfall and tributary inflow and has been highly variable.

2.1.11 WETLANDS

Wetland ecosystems are particularly rich in biodiversity. Permanent and seasonal swamps are important year-round habitats for many indigenous birds and fish and are important seasonally for other species' feeding and reproduction (Chapman et al. 2001). Swamplands and ponds around Lake Victoria serve as refugia for species from predators, for example the Nile perch, an indigenous predatory fish introduced in the 1950s (Reid et al., 2013; Schofield & Chapman, 1999).

The distribution of major wetlands in the LVB is shown in Figure 12. Many of the smallest wetlands (e.g., narrow valley wetlands in Burundi and Rwanda) are too small to be shown on a map of this scale.

Figure 12. Distribution of major wetlands in the Lake Victoria Basin



Source: Map provided by EPA consultant (Hydrologist)-unsourced

2.1.12 ENVIRONMENTAL FLOWS

Natural flow regimes of rivers are often quite variable over the course of a year and between years. Plants and animals living in river corridors adapt to predictable inter-annual and seasonal base flows, as well as to less-predictable, extreme events, such as floods and droughts. Adaptations are expressed in the life histories of organisms, their behavioral characteristics, and morphology (Lytle & Poff, 2004). Life history adaptations, such as the timing of reproduction, are linked to long-term averages in the seasonal occurrence of high and low base flows (Bonada et al., 2007; Naiman et al., 2008). This synchronization of life history events and average flow conditions allow organisms to access key habitats and resources when they are most likely to be available. Behavioral adaptations-such as seeking shelter in the event of large floods or delaying spawning when unexpected low flows signal drought-enable organisms to cope with and recover from extreme events. Morphological adaptations, such as animal body form or the relative allocation of above- and below-ground biomass in riparian plants, also impart advantages to organisms in coping with both predictable and unpredictable characteristics of river flow regimes.

The most ecologically relevant components of flow regimes are the magnitude, frequency, duration, timing, and rates of change of different flow levels. These basic flow components have been subdivided into more than 150 quantifiable indices, which capture the fine details of the regime, but a subset of 33 indices is more commonly applied (Richter et al., 1996; Olden & Poff, 2003). Common indices include magnitude of mean or median flows for each month of the year and of maximum and minimum flows extending over select periods from 1 to 90 days; the timing of maximum and minimum flows during the year; the frequency and duration of high and low pulses; and the rates and number of reversals of rising and falling water levels. Analysis of these indices helps to identify and quantify environmental flow recommendations (Mathews & Richter, 2007).

As river flow regimes are being modified across the globe, special research emphasis is now to measure and quantify ecological responses to flow alterations. While relatively few quantitative relationships have been described thus far, there is clear evidence that altering flow regimes leads to ecological changes in rivers, and the majority of these changes result in declining ecological status as expressed by reductions in the abundance and diversity of fish, macro invertebrates, and native riparian plant species (Mantel et al., 2010; Poff & Zimmerman, 2010; Greet et al., 2011; Mimms & Olden, 2012). New research activities are needed to investigate changing ecological characteristics across gradients of flow alteration and during pre- and post-alteration periods (Poff & Zimmerman, 2010).

Dyson et al. (2003) have presented in detail the reasons and requirements for establishing "environmental flows" in river systems. An environmental flow is the pattern of water flow provided within a river, wetland, or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated. Environmental flows provide critical contributions to river health, economic development, and poverty alleviation. They ensure the continued availability of the many benefits that healthy river and groundwater systems bring to society.

Beginning with environmental flows, all aspects of the river and drainage system need to be considered from their perspective. This means looking at the basin from its headwaters to the estuarine and coastal environments and including its wetlands, floodplains, and associated groundwater systems. It also means considering environmental, economic, and social and cultural values in relation to the entire system. A wide range of outcomes-from environmental protection to serving the needs of industries and people-are to be considered for the setting of an environmental flow.

To set an environmental flow, one needs to identify clear objectives as well as water abstraction and use scenarios. Objectives should have measurable indicators that can form the basis for water allocations. The Mara sub-basin is the only BSA area in the LVB to have conducted an environmental flows analysis, refer to the case study synopsis below.

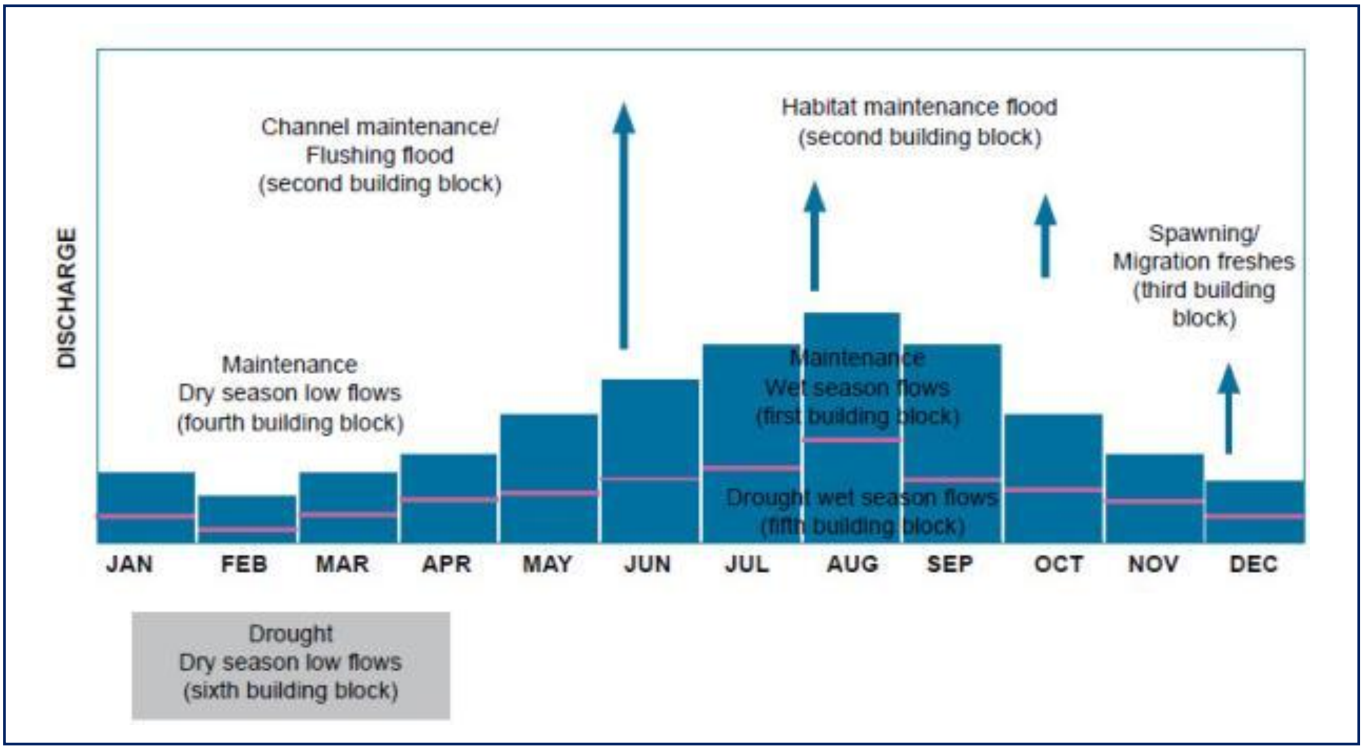
Case Study of Environmental Flows in the Mara Sub-basin

LVBC and WWF-ESARPO Study

In 2007, the LVBC and WWF-East and Southern Africa Regional Programme Office (ESARPO) assessed the reserve flow in the Mara sub-basin (LVBC & WWF-ESARPO, 2010). The assessment team, including a geomorphologist, hydrologist, hydraulic engineer, aquatic ecologist, riparian ecologist, water quality specialist, and socio-economist, identified three appropriate study sites in distinct geomorphological reaches of the basin and conducted site assessments of physical, biological, and social indicators during low and medium flows. The status of critical indicators was related to in-stream flow levels using hydrological and hydraulic analysis. The findings of each technical specialist were used to determine a modified flow regime for the river that would serve as the reserve.

The building block methodology was used as a basis for determining the recommended environmental flows for the Mara River (Figure 13). River-building blocks classify the most critical elements of the flow regime needed to maintain physical and biological processes. Both habitat maintenance and channel maintenance floods compose the second building block.

Figure 13. Monthly environmental flows for the Mara River



Source: LVBC and WWF-ESARPO, 2010

The assessment found that during years of normal rainfall, the reserve is easily met and ample river water is available for extractive uses at all three sites. At Site 1 on the Amala River, the recommended reserve flow levels account for 18% on average of recorded flows during maintenance years. It is important to note, however, that the percent of flow held in the reserve varies over the course of a year, mirroring the natural highs and lows of the system. The percent of reserve flows for Site 2 is 35%. At Site 3 on the border between Kenya and Tanzania, the reserve accounts for, on average, 46% of the average monthly flow based on 26 years of available flow data for the river near that site.

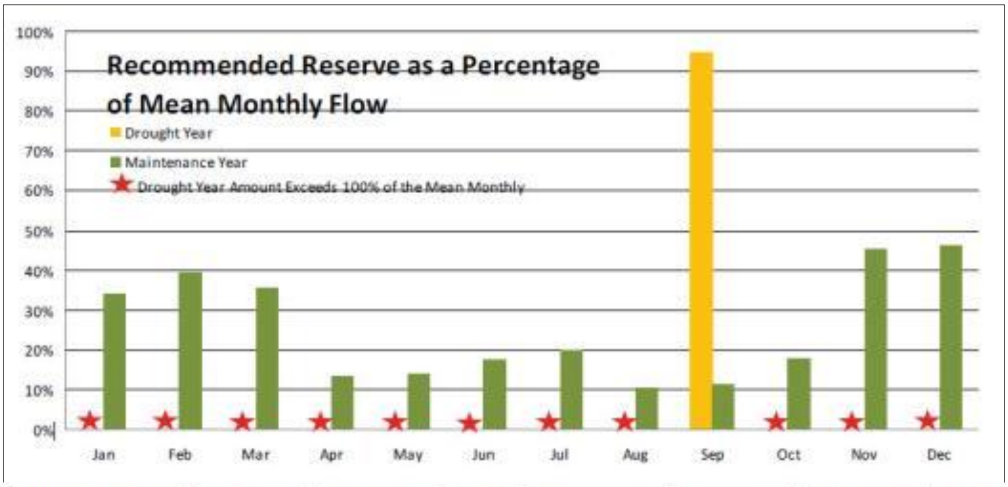
The majority of water available for abstraction is therefore mainly accessible within a few months when flows are high. Far less water is available for abstraction during dry season months. The situation during drought years is quite different, as the assessment found that, presently, the reserve is not being met during several months of the year at Sites 1 and 2. The observation that drought year reserve flows are not being met in the upper and middle reaches of the Mara may be the first clear evidence of a trend toward unacceptable alterations of the Mara River's flow regime.

Upstream impacts are necessarily linked to downstream resources, and poorly managed water abstraction above the wildlife reserves will ultimately affect the downstream reaches as well. The Mara River currently has no major dams acting to modify its flow regime significantly. Thus, reserve flow prescriptions must be achieved by improving management of the catchment and controlling permits for abstractions. The unequal distribution of flows throughout the year also poses the challenge of developing and implementing sustainable technologies for harvesting and storing wet season runoff for consumptive use during dry months. Monitoring of flows and abstraction levels will be critical to determine the current state of the reserve and the amount available for further consumptive use. Because the Mara is a transboundary river, these efforts must be closely coordinated between responsible institutions in the two countries.

The reserve estimates in the assessment have not taken into account the environmental flow requirements of the Mara Swamp, which may be different. The reserve also does not include flow volumes necessary to meet the extractive water needs of Tanzanian communities and industries between the Serengeti National Park and the Mara Swamp. Thus, flow levels reaching Tanzania must be high enough not only to sustain the reserve but also to meet Tanzanian extractive water needs.

The LVBC-WWF-ESARPO assessment for the Mara River applied a structured and scientifically sound process for determining the requirements of the reserve flow, and thus the process is an essential step toward estimating the amount of water available for consumptive use. It is important to note that this was the first assessment of the reserve based on the best available data and expertise of the scientific team. Continued monitoring of the river's flow levels and ecological status will be critical to determine if the prescribed flow regime is sufficient, if more water needs to be set aside for the reserve, or if more water can be permitted for consumptive use.The recommended average monthly reserve flows and flood events for both maintenance and drought years for each of the three sampling sites are shown graphically below in comparison with average monthly flow recorded over the length of record (Figures 14 to 16 and accompanying environmental flow requirement tables areal obtained from LVBC and WWF-ESARPO, 2010).

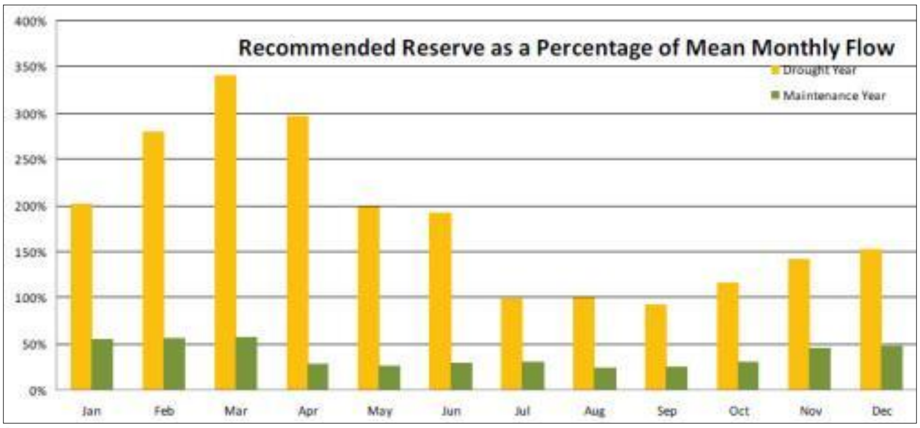
Figure 14. Recommended average monthly reserve for Site 1 in the upper Mara



Maintenance EFR	Base Flows	Higher Flows	Total	Drought EFR	Base Flows	Higher Flows	Total
Volume (MCM)	47.6	12.8	60.4		13.6	0.4	14.0
as % of MAR	17.8%	4.8%	22.6%		5.1%	0.1%	5.2%
MAR (MCM)	266.9						

EFR, environmental flow recommendation; MCM, million cubic meters; MAR, mean annual runoff

Figure 15. Recommended average monthly reserve for Site 2 in the middle Mara



Maintenance EFR	Base Flows	Higher Flows	Total	Drought EFR	Base Flows	Higher Flows	Total
Volume (MCM)	198.6	23.6	222.2		72.6	4.3	76.9
as % of MAR	35.2%	4.2%	39.4%		12.9%	0.8%	13.7%
MAR (MCM)	563.5						

EFR, Environmental Flow Recommendation; MCM, Million Cubic Meters; MAR, Mean Annual Runoff

Figure 16. Recommended average monthly reserve for Site 3 in the lower Mara

Maintenance EFR	Base Flows	Higher Flows	Total	Drought EFR	Base Flows	Higher Flows	Total
Volume (MCM)	260.9	36.3	297.2		111.5	3.5	115.0
as % of MAR	46.2%	6.4%	52.6%		19.7%	0.6%	20.3%
MAR (MCM)	564.92						

EFR, Environmental Flow Recommendation; MCM, Million Cubic Meters; MAR, Mean Annual Runoff

Other Assessments

A second paper by Melesse et al. (2008), ***Modeling the Impact of Land Cover and Rainfall Regime Change Scenarios on the Flow of Mara River, Kenya,*** reported that hydro-meteorological analysis of the basin has shown a decline in the dry season flow and increase peak flood frequency in recent years. Identified issues include changes in the precipitation pattern (distribution and volume), deforestation in the upper basin, and increased water use activity in the large-scale agricultural areas upstream.

Another report, ***Consulting Services for the Assessment and Design of Hydrometric Network and Guidance of Water Quality Survey for Mara River,*** notes that at present there are only two operational hydrometric stations out of seven on the Kenyan side of the Mara River Basin (Nile Basin Initiative, 2008). On the Tanzania side, there are only two operational stations. This gives a network density of 3,500 km^2 per station, which is below the range of norms for a minimum network. In view of the anticipated development in the Mara River Basin, 10 river-gauging stations are proposed to constitute the hydrometric network on the Kenyan side, while seven river-gauging stations are proposed to constitute a network on the Tanzanian side of the Mara River Basin. This report also provides a detailed assessment of the water quality in the basin from a general integrated water resources management (IWRM) point of view and not specifically from an environmental flow point of view.

The thesis by Hoffman (2007), published by Florida International University, concluded that the total current water demand within the basin does not appear to eclipse water supply during periods of mean flow. However, the current water demand does pose a threat to water resources within the basin during periods of minimum flow. Most of this report, however, was based on the demands for water resources in the basin linked to its availability. This work was done before any estimate of the environmental flow for the Mara was developed, and thus environmental flow principles were only considered in rough terms.

Gereta et al. (2009) noted that as a result of various land based activities in Kenya, with business-as-usual, the Mara River may dry out for at least one month when a severe drought such as that of 1972–1973 next occurs, and as a result the Serengeti ecosystem may collapse-more precisely, the wildebeest population would drop 80%, from about 1,000,000 to about 200,000. They recommend that remedial measures are urgently needed in Kenya to restore the flow in the Mara River during low-flow conditions. If this does not occur, disaster-prevention measures are needed, they say, to preserve this ecosystem: providing water in weirs, dams, and artificial wetlands along the Mara River, as well as extending by 5 km the western edge of the park to reach Lake Victoria and provide access to permanent water. The report indicates that daily flow rates of the Mara River at Mara Mines during exceptional droughts may have been smaller than 1 cubic meter per second. Nevertheless, all eyewitnesses (e.g., park rangers) state that the Mara River has never stopped flowing, though the flow apparently reduced to a trickle during the October to November droughts in 1972, 1973, 1992, 1993, and 1997.

The overall conclusions of the hydrological condition of the river in relation to environmental flows is that during years of normal rainfall, the environmental flow is met and ample water is available for extractive uses. During drought, the situation may be quite different, with a trend toward unacceptable alterations of the Mara River's flow regime. There is thus cause for much concern if the system is not to degrade to a point where the services from the river begin to fail.

McClain et al. (2014) have carried out an investigation into the flow regime characteristics and ecological status of the Mara River, which drains the Mara-Serengeti eco-region of Kenya and Tanzania. The Mara River is largely free-flowing at this time, but three dams are proposed, two on the river's principal headwater tributaries and one on its main channel just downstream of Serengeti National Park. As part of an initial environmental flow assessment to protect the river's ecological status, the river's flow regime over the past 40 years was analyzed using discharge data; hydraulic cross-sections at points along the river corridor were examined; and fish, macro invertebrates, and riparian vegetation in the same locations were sampled during both low and high flows. The research objectives were to characterize the river's flow regime, identify biological communities inhabiting the river corridor, and consider the potential linkages between the past and present flow regime and ecological condition.

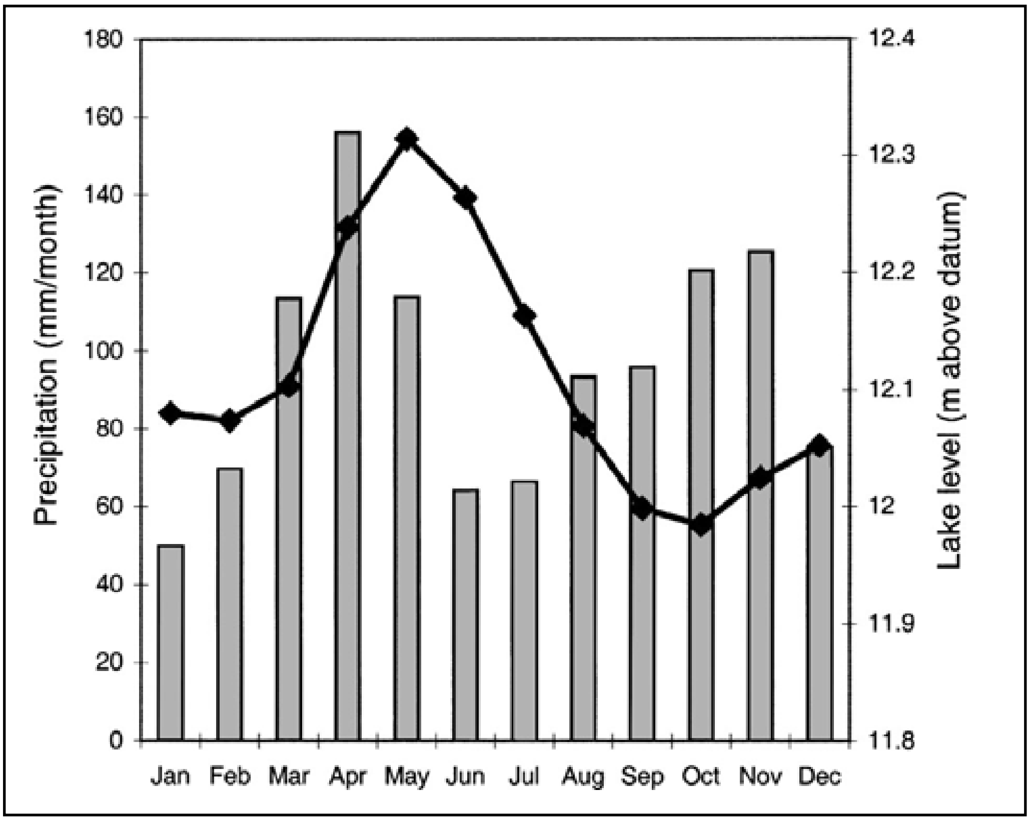
Their findings emphasize the importance of flow variability in maintaining fish diversity in the Mara. Although species numbers are fairly low in this system, two species recorded in this study, ***Synodontis victoriae*** and ***Labeo victorianus***, are native to the LVB. ***S. victoriae*** is also listed as near threatened by the IUCN Red List, and three more species recorded from other studies in the lower Mara are listed as endangered (***Brycinus jacksonii***) and critically endangered (***Oreochromis variabilis*** and ***Oreochromis esculentus***) (Wandera et al., 2006; Chitamwebwa, 2007; IUCN, 2013). Furthermore, reaches of the Mara River near Lake Victoria have been documented to provide critical refugia to native species of fish suffering severe population declines in Lake Victoria due to introduction of non-native species, overfishing, and eutrophication (Rosenberger & Chapman, 1999; Chapman et al., 2002). Thus, the fish species of the Mara River, while limited in number, are important.

2.2 CLIMATE OF THE LVB

The current or "normal" climate regime of the LVB is based on measurements from 1960 to approximately the turn of the century. The water level of the lake is strongly affected by rainfall. Precipitation may contribute as much as 87% to the lake level (Nicholson, 1998). The El Niño Southern Oscillation (ENSO) and Indian Ocean sea-surface temperatures influence weather. The rainfall pattern in the basin is bimodal, and temperatures average around 26°C.

Extreme precipitation events thus strongly influence the lake volume (Sutcliffe & Parks, 1999). For example, a large rise in water level resulted from exceptionally high rains in 1961 to 1964 (Mistry & Conway, 2003). Figure 17 shows the annual change in water level in relation to rainfall.

Figure 17. Annual Lake Victoria precipitation (bars) and water level (points)



Source: Mistry & Conway (2003)

In recent years, there has been an observed increase in extreme precipitation events and a warming trend. Evidence for both average drying and wetting has been put forward. Projections of future rainfall are still uncertain. From recent scenarios, it seems likely that the October to December rains will increase and that variability will increase.

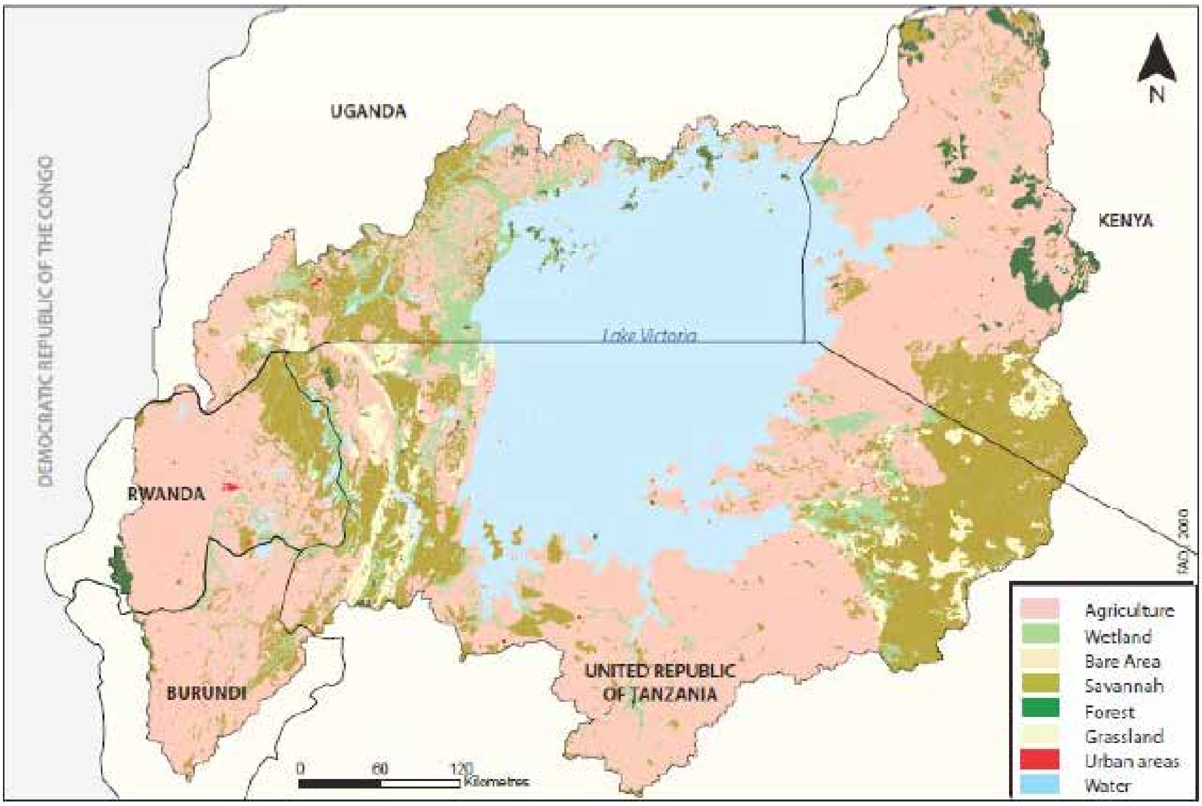
There is much less uncertainty over projections of future temperature rises. The impacts of higher average (and maximum) temperatures-and a possible increase in frequency of drought and intensity of rainfall events-needs to be put in the context of an increasing annual average rainfall. It is possible that climate change will increase lake levels by the end of the 21st Century (Tate et al., 2004).

A detailed assessment of climate change scenarios and potential impacts on humans, ecosystems, and biodiversity can be found in the next chapter.

2.3 THE BIOLOGICAL ENVIRONMENT

In the context of this EPA, the main ecosystems of the LVB are considered in broad terms based on the dominant land cover (see Figure 18). This is in part because knowledge of the location of more specific floral and faunal associations is lacking, and in part, because there is insufficient data on climate impacts to merit a more detailed breakdown.

Figure 18. Ecosystems of LVB (based on Globcover data from 2009)



Source: Globcover, 2009

There is no doubt that the LVB has some High Conservation Value Areas. One of the main influences of the characteristic flora and fauna is the location of the basin at the intersection of five distinct Centers of Endemism- the Afromontane, Guineo-Congolean, Somali-Maasai, Sudanian, and Zambezian. These have also been shaped by past geology, climate, and centuries of human occupation. Within the lake basin are numerous official PAs, important wetlands, and forest reserves. It is currently estimated to be home to 223 fish species (13% of the African total), 263 odonates (37%), 81 mollusks (14%), and 15 crabs (13%). Out of these, 51 fish (9% of African Red-Listed species), 3 odonates (12%), and 12 mollusks (8%) are globally threatened (Birdlife International, 2012). It hosts 52 KBAs (41 terrestrial, 11 freshwater).

2.3.1 TERRESTRIAL BIODIVERSITY

The sheer extent of the basin renders it an important reservoir of terrestrial biodiversity. Some of the biodiversity is partially dependent on the wetlands and is therefore more accurately described as semi-terrestrial. A few examples include mammals such as the sitatunga (***Tragelaphus spekii***, Sclater, 1863), spot-necked otter (***Hydrictis maculicolis***), and cane rat, (***Thyronomys gregorianus***), as well as the hippos that are ubiquitous around the lakeshores. Birdlife within the immediate vicinity of the lake has been described as staggering—huge nesting colonies of egrets, cormorants, gannets, and fish eagles. Kingfishers, herons, storks, and spoonbills proliferate in the swampy lake fringes, supplemented by thousands of seasonal migrants during the European winter. There are also large flocks of the threatened African grey parrot (***Psittacus erithacus***). The herpetofauna is relatively less known, but the inshore waters and fringing wetlands support up to 28 species of reptiles, including the

Nile crocodile (***Crocodylus niloticus***), monitor lizards (***Varanus niloticus***), chelonids (e.g., the African helmeted turtle-***Pelomedusa subrufa***) and snakes such as the African rock python (***Python sebae***) and water cobra (***Naja melanoleuca***). At least 30 species of amphibians are known to occur in the basin represented only by the order Anura (frogs and toads). Amphibian diversity, however, can still be remarkable, and up to 24 species have been recorded at one small site in Uganda (Behangana & Arusi, 2004).

Most of the basin lies in what White (1983) described as the Lake Victoria Mosaic, a meeting point of the five distinct floral associations outlined below. The ambient vegetation depends mainly on precipitation and human activities (Lejju, 2012). The basin notably includes some of the world famous tropical grasslands—land on which the dominant plant forms are primarily graminoids (grasses, sedges, and rushes) and forbs (broad-leaved herbaceous flowering plants). In their various combinations with trees and shrubs, grasslands and woodlands occupy more than half of the basin. They support exceptional faunal diversity of large grazing and browsing mammals and high herbivore biomass density directly linked to their high spatial heterogeneity. In addition, they represent a major stock of terrestrial carbon, provide habitat for a wide array of smaller animal species, and protect soils and water.

Varying intensities and duration of human pressure have led to increased cultivation and livestock grazing resulting in fragmenting of broad-leafed forests. A large and increasing percentage of land is now under agricultural production. Many economically important non-timber forest products (NTFPs) come from plant species that are widespread in the woodlands, including products for ecotourism, bioenergy, meat, traditional medicine, and the conventional pharmaceutical industry.

Acacia-Commiphora Associations

The Acacia-Commiphora is the main natural vegetation on the eastern and southeastern part of the basin. Woody canopy cover consists of a single open stratum of deciduous bush lands and thickets. ***Acacia*** or ***Commiphora*** are the main genera, mostly 3–7 meters high, but they can grow to 9–20 meters. These are interspersed with wide swathes of open grasslands, with trees usually covering less than 40%.

Most features of vegetation structure mirror the rainfall gradients, with more heavily wooded and taller grasses in the western part of the Serengeti. Short-grass and almost treeless plains occur to the south, giving way to taller grasses and woodlands in the north. Areas with hardpans are covered by perennial grasses and some scattered shrubs, which gradually give way to thorn bush typified by ***Commiphora africana, C. schimperi***, ***Acacia drepanolobium*****,** and ***A. mellifera*** (Sinclair et al., 2009). Other common acacias are ***A. gerrardii, A. hockii, A. nilotica, A. robusta, A. senegal, A. seyal, A. sieberiana, A. tortilis, A. polyacantha and A. xanthophloea*** (White, 1983). The baobab (***Adansonia digitata***), tamarind (***Tamarindus indica***), and figs (***Ficus spp***) may be found where soils are deep. The grass layer is often 0.5–1.5 meters high and is dominated by ***Digitaria macroblephara*****,** ***Eustachys paspaloides*****,** ***Pennisetum mezianum***, and ***Themeda triandra.***

Miombo Woodlands

Miambo woodlands dominate the central and southwestern parts of the basin, representing the northern-most extremity of the extensive wooded and grass savannah mosaic that spans the continent from east to west and stretches from near the equator southwards into Mozambique. The ***miombo*** are a dense vegetation type dominated by deciduous broad-leaved trees of the legume subfamily Caesalpinioideae (***Brachystegia, Julbernardia,*** and ***Isoberlinia),*** which includes trees 15–20 meters high. The trees form a single-story, light canopy that rises over a broadleaf-scattered, shrub-and-grass undergrowth that may reach a height of about 1 meter. The common grasses are composed of ***Hyparrhenia spp***., ***Themeda triandra*****,** and ***Panicum maximum*****.** The vegetation is often associated with contrasting topography, edaphic changes, drainage patterns and levels of burning. More than half of the estimated 8,500 plant species in this eco-region are found nowhere else on Earth (Timberlake & Chidumayo, 2001). As the rainfall decreases in both amount and duration, Acacia, Combretum, and Commiphora woodland associations gradually replace the miombo.

Volcanic Grasslands

These form a distinct vegetation type, in equilibrium with the edaphic and climatic conditions. They occur just south of the Tanzanian-Kenyan border, where the underlying soils contain volcanic ash. Characterized by plant communities belonging to the Somali-Maasai regional center of plant endemism (White 1983), they are almost denuded of vegetation during periods of severe drought. Common grass species are ***Sporobolus spp.***, ***Pennisetum mezianum***, ***Eragrostis tenuifolia***, ***Andropogon greenwayi***, ***Panicum coloratum***, ***Cynodon dactylon***, ***Chloris gayana***, and ***Digitaria spp***. The grasslands dominate the virtually tree-less undulating plains of Serengeti interrupted by scattered rock outcrops (kopjes) that project from the Precambrian basement rocks.

Mixed Forest-Savannah Associations

Forest-savannah associations also dominate in the west, north and northwest, extending into the Sudanian center of endemism. The mixed forest-savannah associations in the north and northwest are characterized by ***Albizia-Combretum-Terminalia*** associations and are replaced by grasslands dominated by ***Hyparrhenia*** in the drier areas (Langdale-Brown, 1964).

Previously covered mostly by forest, woodland, and open savannah grasslands, the native vegetation in the southwestern part has been greatly modified by human activities. There are three broad land use types: pasture, rangeland, and sub-tropical cultivation. The latter mainly involves perennials (plantains, banana and coffee), as well as annuals. The most extensive natural landforms characteristic of the vegetation association is the undulating extensive plateau and wetlands around major water bodies such as Lakes Mburo and Kjanebalola. Similarly, forest-savannah woodland mosaics occur on the rolling hills and plateaus beyond the lake shores.

Guineo-Congolian and Afromontane Forests

Two types of transitional rain forest exist, mostly in Central and West Africa. These are associated with the genera ***Albizia*** and ***Celtis***, among others. White (1983) described these as:

(i) High-altitude forests occurring in western Burundi, western Rwanda, and the eastern Democratic Republic of Congo (DRC)
(ii) Lowland rain forest occurring in Kakamega in Kenya (1,520-1,680 meters above sea level), where Guineo-Congolian forest species reach their easternmost limits but contain fewer Afromontane species than the other Lake Victoria transitional rainforests (White, 1983).

Vast stretches of Afromontane rainforest occur farther to the west of the basin, on the Congo-Nile divide at altitudes occupied by few other forested areas in Africa. These have been characterized into four strata based on altitudinal ranges, each identified with dominant tree species. They have been summarized by Gapusi (2007) and other authors. Trees of the species ***Parinari excelsa***, ***Newtonia buchananii***, ***Symphonia globulifera***, ***Entandrophragma excelsum***, and ***Albizia gummifera*** are common between 1,600 and 2,000 meters above sea level, reaching 35-40 meters in height. Orchids and ferns are also abundant.

The dominant canopy between 2,000-2,300 meters above sea level comprises ***Entandrophragma excelsum***, ***Parinari excelsa***, ***Prunus africana***, ***Ocotea usambarensis***, ***Ficalhoa laurifolia***, and ***Chrysophyllum gorungosanum***. Ferns dominate the undergrowth here. ***Podocarpus latifolius*** dominates above 2,300-2,500 meters above sea level, where mosses and lichens often occur, but the grass layer is poor and discontinuous. Shrubs and herbs, mosses, lichens, and epiphytes dominate the altitude range 2,500-2,700 meters above sea level. The main tree species at these altitudes include ***Philippia benguelensis***, ***Agauria salicifolia***, ***Faurea saligna***, and ***Hagenia abyssinica***.

Typically found higher than 2,000 meters above sea level, Afromontane forests are a source of great curiosity and speculation of their non-contiguous nature. They consist of mountain "islands" that are widely distributed over Africa. Many of these mountain massifs are of volcanic origin, attributed mainly to the seismic activity that led to the separation of the African and Arabian tectonic plates about 35 million years ago. Despite this isolation, they comprise a remarkably species-rich floristic region of about 4,000 plant species, about 75% of which are believed to be endemic (Ramdhani et al., 2008). Many common tree species are of the genera ***Podocarpus*** and ***Juniperus***. The floral composition varies with increasing altitude, with a zone of bamboo and shrubby heathers often found as the altitude increases up to 3,000 meters above sea level. Many unusual plants adapted to the high altitudes: For example, ***Hagenia,*** giant dendrosenecios, and lobelias are often present up to 3,600 meters above sea level.

A few remnants of the Guineo-Congolian rainforest exist to the northeast of the basin, at Kakamega and on the Nandi highlands, as small patches in an intensely cultivated region. These represent the easternmost extent of this type of forest that once stretched all across to Central and West Africa, but today exists at altitudes of 1,500–1,850 meters above sea level. Reports indicate that these remnants were contiguous until about 1895 (Solomon et al., 2007).

2.3.2 FRESHWATER BIODIVERSITY

The freshwater biodiversity (species, habitats, and ecosystems) of the LVB is varied and vast with many special aspects, some of which are listed in the available literature. Thus, a preliminary assessment was made of the breadth of that biodiversity using global-level sources (e.g., Sritharan & Burgess, 2011; Thieme et al., 2005; Fishpool & Evans, 2001; WWF & IUCN, 1994) which, surprisingly, revealed that there were few "globally important" accumulations of biodiversity and a wide range of species and ecosystems of importance in the LVB region. Exceptions include the extensive biodiversity of Mount Elgon (4,320 meters) and the fish and invertebrate fauna of the extensive main and subsidiary lakes, with many species yet to be named. This is not to say that there are not globally important species and habitats. However, when comparing faunas and floras of the LVB with other global freshwater areas, there are many others with greater diversity and higher endemism.

The characterization of aquatic fauna and flora was based on knowledge from more recent literature and attempts to summarize situations and to seek what are usually thought of as "important species"—meaning that they play special roles that none other can or that they are unique in the region. They may also be endemic to the lake region or in some aspect that is common in the lake basin such as "papyrus endemics," species endemic to habitats dominated by ***Cyperus papyrus***, which is a vegetation type dominant in some parts of LVB but also present elsewhere.

A literature review and field records search revealed that there are many special species, but many do not have traceable or precise localities that could be further examined as "special areas." Other programs and organizations have designated special areas for their own interests, which can often be pointers to areas of general interest—such as IBAs (e.g., Bennun & Njoroge, 1999; Baker & Baker, 2002; Birdlife International, 2012)- or mention interesting and important species of other groups apart from birds.

The search included the purely aquatic species (phytoplankton, zooplankton, mollusks, crustaceans, aquatic insects, and fish) from the main lake, subsidiary lakes, and wetlands. Other freshwater-associated vertebrates were included where appropriate, as well as aquatic macrophytes and wetland-associated plants. The criteria used for selection of species as a first step included endemism to the lake basin; endemism to special ecosystems; rare & endangered species (the latter from the IUCN Red List of threatened species where this list had been used); species that are special because of some noteworthy characteristic; & unique associations of species. A more detailed assessment of freshwater biodiversity is presented for the various BSAs in Chapter 6.

The search did not result in any microscopic species-partly due to a paucity of literature but also because none were found that actually mentioned any of these criteria. This does not indicate there is no endemism in these groups; it means that none was detected. Identification of main groups of microscopic organisms need special experts, & a search for such expertise was not possible in the time available. In addition, the area occupied by microscopic organisms is not possible to compare with macroscopic species due to sampling limitations.

Searches for freshwater plants (macrophytes) did not reveal any endemism apart from two species of wetland plants-***Senecio nabugabensis*** and ***Xyris ednae***, both known only from the edge of the swamps in the Lake

Nabugabo complex in Uganda. This area is also renowned for hosting several species of carnivorous wetland plants: one species of ***Aldovandra*** **(*A. vesiculosa,*** classified as "endangered" in the IUCN Red List of Threatened Species); two species of ***Drosera*** **(*D. burkeana*** and ***D. madagascarensis***); and 10 species of mostly submerged ***Utricularia.*** This complex of wetlands and small lakes associated with Lake Nabugabo in southern Uganda also has a total of wetland-related plants that far exceeds any other place in the LVB: approximately 300 species (Busulwa et al., 2005).

There are several endemic terrestrial plant species on Mount Elgon in the Lake Victoria catchment, mostly orchids, but no freshwater species were found. The same was true of the parts of Kakamega Forest that are in the LVB.

Among freshwater invertebrates, one endemic gastropod mollusk (***Ferrissia kavirondica***) is restricted to the Lake Victoria basin and is rated "endangered" in the IUCN Red List, while a rare relative, ***Ferrissia clessiniana*****,** is not rated ("data deficient") but, together with ***F. kavirondica,*** is found in the Winam Gulf in the innermost part of the lake in Kenya. One bivalve mollusk is also known to be endemic to the lake (***Sphaerium nyanzae***) and was of least concern when tested for Red List status. Winam Gulf can be regarded as a KBA, although it covers quite a few river mouths and other habitats.

When considering fish, the situation is very different, with several large species being endemic to the main lake, and several extinct in the main lake but present and under threat in subsidiary lakes and rivers. The main form of endemism in the LVB catchment is that of hundreds of species of small fish in the subfamily Haplochrominae (family Cichlidae). At least 300 species of haplochromines have been recorded, and almost all were endemic-but some are now thought to be extinct due to various pressures, including increased predation by the alien species of Nile Perch (***Lates niloticus***). Some species persist in the satellite lakes of the LVB and in the protected bays and gulfs, especially the Mwanza and Emin Pasha Gulfs in the Tanzanian sector of the lake.

The most notable papyrus endemic bird is the shoebill ***Balaeniceps rex*****,** which is Red Listed as "vulnerable" and is present in a number of satellite lakes and in the Kagera Swamps, located in the Tanzanian sector of the LVB. Other papyrus endemics like the greater swamp warbler, white-winged warbler, papyrus gonolek, Caruther's cisticola, northern brown-throated weaver, papyrus yellow warbler and papyrus canary persist in parts of the main lake's riparian edges and in satellite lakes and wetlands.

2.4 SOCIO-ECONOMIC CONTEXT

2.4.1 IMPORTANCE OF ECOSYSTEM SERVICES IN PARTNER STATES

Humans benefit in a multitude of ways from ecosystems. Collectively, these benefits are known as ecosystem services (MA, 2005). While ecosystem services have been shown to be intrinsically linked to human well-being, the key finding of the Millennium Ecosystems Assessment was that 60% of the ecosystem services evaluated are being degraded or used unsustainably. It is argued that such a situation has major implications for development, poverty alleviation, and the strategies needed by societies to cope with, and adapt to, long-term environmental change (Haines-Young & Potschin, 2010). Fundamental changes are needed in the way biodiversity, ecosystems, and their services are viewed and valued by society. A major difficulty is that many ecosystem services are mixed public goods, and use levels are therefore difficult to regulate, even when they are at or near the point of exhaustion (TEEB, 2010).

The MA defines four categories of ecosystem services: provisioning services, cultural services, regulating services, and supporting services (Table 8). Provisioning services cover the renewable resources that are mostly directly consumed and that generally have well-defined property rights. Cultural services capture many of the non-use (or passive use) values of ecological resources, such as spiritual, religious, aesthetic, and inspirational well-being.

Table 8. Provisioning and cultural services as defined by the Millennium Ecosystems Assessment and their relevance to LVB

SERVICE	DESCRIPTION AND RELEVANCE TO LVB
Provisioning services defined in the MA	
Food and fiber	• People within the LVB make use of wide variety of food products (fish, wild harvested vegetables and fruits) as well as fiber for building and other uses.
Fuel	• Wood, dung, and other biological materials serve as sources of energy to a large number of individuals in the LVB.
Genetic Resources	• This includes the genes and genetic information used for animal and plant breeding and biotechnology. A prominent example would be the hardy cattle used by the Maasai people.
Biochemicals, natural medicines, and pharmaceuticals	• Many medicines, biocides, food additives (such as alginates), and biological materials are derived from ecosystems. Much of the population would use these products across the LVB.
Fresh water	Fresh water is considered to be among the most important services provided by ecosystems.
Cultural services defined in the Millennium Ecosystems Assessment (MA)	
Cultural diversity	• The diversity of ecosystems is one factor influencing the diversity of cultures. The culture of the Maasai people is closely linked to the greater Maasai Mara/ Serengeti ecosystem.
Spiritual and religious values	• Many religions attach spiritual and religious values to ecosystems or their components.
Knowledge systems	• Ecosystems influence the knowledge systems developed by different cultures.
Educational values	• Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
Aesthetic values	• Many people find aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations.
Sense of place	• Many value the sense of place that is associated with recognized features in their environment, including aspects of the ecosystem.
Recreation and ecotourism	• People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area. Tourism is an important economic benefit from the several Nation Parks and PAs within the LVB.

Regulating services are indirect services that determine the capacity of ecosystems both to regulate the impact of external shocks and to respond to changes in environmental conditions without losing functionality. The regulating services affect the distribution of outcomes, and in particular, they affect both variation about the mean response and the likelihood of extreme responses. See Table 9 for a detailed definition of regulating services.

Supporting services, e.g., nutrient cycling, capture the main ecosystem processes that support all other services. Much of the value of biodiversity is embedded within the regulating services. Refer below for a brief discussion on the importance of ecosystem services for each of the countries found in the LVB.

Table 9. Regulating services defined by the Millennium Ecosystems Assessment framework of ecosystem services and relevance to LVB

REGULATING SERVICES DEFINED IN THE MA	DESCRIPTION AND RELEVANCE TO THE LVB
Local climate regulation	Ecosystems may influence climate both locally and globally (e.g., locally, land cover changes can affect temperature and precipitation; globally, ecosystems play an important role in the carbon cycle). Lake Victoria provides an environment conducive to complex interactions and integrations among regionally induced and large-scale circulation systems.
Water regulation	The timing and magnitude of runoff and flooding can be strongly influenced by changes in land cover—including changes in the water storage potential of the system, such as with the conversion of wetlands or the replacement of forests with croplands or of croplands with urban areas. Several ecosystems within the LVB play an important role in water regulation. These include wetland systems such as the Mara wetland system and the Yala wetlands.
Erosion regulation	Vegetative cover plays an important role in soil retention and in the prevention of landslides. Degraded aquatic and terrestrial systems contribute to increased erosion and a resultant increase in sedimentation.
Water purification and waste treatment/ water pollution sink	Ecosystems can help filter out and decompose wastes introduced into inland waters and coastal and marine ecosystems. In many cases, the waste removal capacity of the ecosystem may be exceeded. In such cases, the ecosystem serves as a water pollution sink. Wetlands within the LVB provide a water purification function for water entering Lake Victoria.
Disease regulation	Changes in ecosystems can directly change the abundance of human pathogens such as cholera and can alter the abundance of disease vectors such as mosquitoes.
Natural hazard regulation	Ecosystems play an important role in protecting human well-being from the impacts of natural hazards or natural disasters, e.g., flood control, storm protection.

Rwanda

Ecosystem services play an important role in the economy of Rwanda. The livelihoods of approximately 90% of the population link directly to the land. The agricultural sector is the dominant contributor to gross domestic product (GDP), accounting for 47% of the total and 80% of all exports. Tourism, another sector based primarily on the environment, has been estimated to be the third-largest contributor to national GDP. Out of recognition that natural resources are important in the development of Rwanda, the Government of Rwanda is evaluating and measuring natural assests' contribution to GDP. Of particular importance to this study was the contribution of regulating services delivered by Nyungwe National Park.

Burundi

The economy of Burundi is mainly based on subsistence agriculture. Agriculture and natural resources (including forestry, fisheries, and livestock) account for more than 50% of the GDP, roughly 90% of the export of goods, and employ about 90% of the labor force. Many communities will depend on the provisioning of fresh water as well as the collection of wild produce to supplement their dietary requirements. As most of Burundi's energy requirements are produced through hydro schemes, energy production is linked to the sustainable management of upstream catchment areas, similar to many East African countries. Tourism revenue through the Kibira and Ruvubu National Parks would provide an important source of foreign currency.

Kenya

The entire Kenyan population depends to some extent on biological resources for livelihood, income, shelter, and health-many of which are dependent on wildlife-based tourism. Apart from tourism, Kenya's economy is highly reliant on water resources found in five major water towers (out of 18), comprising more than a million hectares of montane forests. The total water yield from the water towers could be more than 15.8 billion m^3/year, which is more than 75% of the renewable surface water resources of Kenya.

The regulating services of Kenya's montane forest ecosystems are thus important production factors to the following sectors: agriculture, forest and fishing, electricity and water, hotels and accommodation, and public administration and defense. These sectors, together, contributed 33% to 39% to GDP from 2000 to 2010. In addition, the United Nations Environment Program (UNEP) identifies these sectors as having a very significant multiplier effect on the rest of the economy's GDP (UNEP, 2012). The agriculture sector is by far the most important, accounting for over 25% of the country's GDP, 20% of employment, 75% of the labour force, and over 50% of revenue from exports (Deloitte, 2016).

Tanzania

Tanzania, like many other Partner States in the LVB, is reliant on ecosystem services at either a community or national economic level. With a contribution of about 30% to GDP, agriculture is the largest economic activity in Tanzania employing 66% of Tanzanians and covers 100% of the domestic food needs (Deloitte, 2016). Tanzanians are also dependent on fish stocks from the three major lakes (i.e., Victoria, Tanganyika, and Nyasa also known to some as Lake Malawi) as sources of reliable protein and employment. Of particular importance for water provision and regulation are the ecosystem services provided by two catchment forest reserves in the Uluguru Mountains, the Morogoro and Pwani regions, which are the source of water for Dar es Salaam.

Uganda

Like other countries in EAC, the agricultural sector is important to the Ugandan economy in that it employs approximately 69% of the population and contributes about 26% to the GDP (Deloitte, 2016). Because of their economic value, Uganda has adopted an ecosystem approach in the management of all PAs and encompassing ecosystems by adopting the multiple-use zonation concept, which is similar to the biosphere reserve concept of the United Nations Educational, Scientific and Cultural Organization (UNESCO). For example, in forest PAs, 20% of the entire forest estate is a strict nature reserve; 30% is reserved for low-impact uses; and 50% is reserved for more-intensive production purposes. A similar system applies to wildlife-protected areas.

This zonation approach supports Uganda's Wildlife Use Rights initiative, which is a policy instrument for motivating communities to manage wildlife on communal and private land sustainably. The Wildlife Use Rights initiative is based on the principle that economic benefits derived from ecosystem services promote biodiversity stewardship. There are six classes of wildlife-use rights: hunting, farming, ranching, trading, education and research, and general extraction use. Examples exist in Lake Mburo National Park and the Kabwoya Wildlife Reserve, where wildlife numbers have increased since the sport hunting program was launched.

Communities in these regions have realized that there are greater rewards from the animal fees paid by sport hunters than there were from poaching. In addition to the financial benefits, the meat is made available to the communities. Other tangible benefits include the example of a primary boarding school that was funded by sport hunting.[3]

2.4.2 LIVELIHOODS AND BIODIVERSITY LINKAGES

In most areas of the LVB, agriculture accounts for roughly 75% of the land's productive uses. However, the varying ecologies provide for a range of locally adapted cropping, livestock and fishing activities, and livelihood systems that are strongly influenced by water availability and quality.

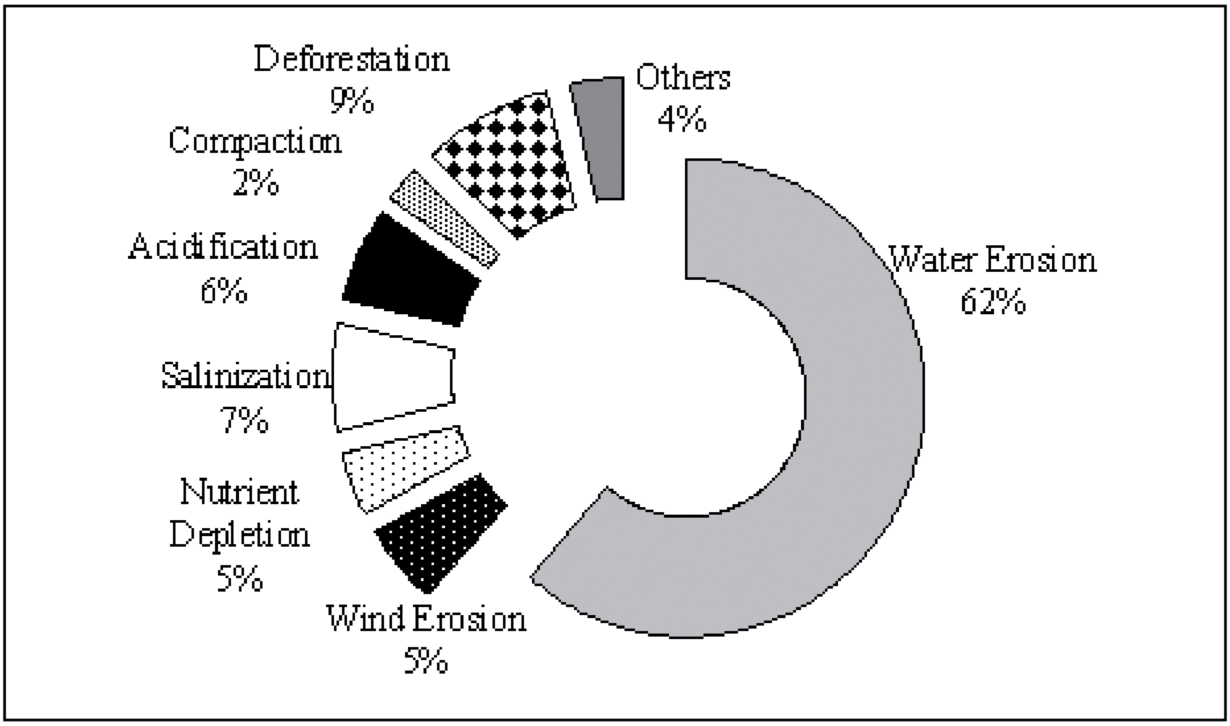
Local communities bear the major responsibility and cost of biodiversity conservation. They also have the greatest potential to affect biodiversity through their day-to-day economic activities. Because local communities typically benefit little from biodiversity and face multiple livelihood constraints, they are often unwilling and economically unable to support conservation (NEMA, 2016). The impacts on biodiversity exerted by key livelihood activities are briefly described in the following sections.

3 http://www.ugandawildlife.org/

Agriculture

The poverty of the majority of Lake Victoria region's inhabitants is linked to continued land degradation. According to Ochola (2006) and numerous other studies, the key land degradation issues include escalating soil erosion, declining soil fertility, agro-chemical pollution, salinization, and loss of land cover (see Figure 19 below). These factors affect biodiversity negatively in the long run. There is also incremental wetland loss and its associated biodiversity loss occasioned by natural hazards and intensification of land use as well as other anthropogenic activities. Present land use and environmental courses of action no longer constitute options for a sustainable future.

Figure 19. Impact of agriculture on land resources



Source: Ochola, 2006

The land degradation problems facing the LVB are multifaceted and include both natural and human-induced driving forces. The effects of these factors have been exacerbated by decisions and policies as well as cultural, social, and economic circumstances. These factors have considerably changed the basin's ecosystems, rendering the natural resources-dependent population vulnerable and insecure (Ochola, 2006). More than 80% of this population relies on agriculture as the main source of income and employment. As a result of the growth in human population, the area under cultivation in the basin is increasing at the expense of forest cover, wetlands, and riverbanks, purposely to meet the increasing demand for food and cash (LVBC, World Bank and SIDA, 2012).

Livestock keeping

There are four types of livestock production systems in the basin. First is the keeping of indigenous cattle on communal land set aside for such purposes, while the second system is a semi-nomadic system whereby larger herds of cattle graze on communal land and move around depending on the availability of pasture and water. The third system comprises smallholder dairy cattle farmers who practice zero grazing. The fourth is the large-scale ranching system, in which beef cattle are reared in such large numbers that serious overgrazing occurs (Yanda et al., 2001).

For example, in Tanzania's Mwanza region, livestock keeping is concentrated in Msalala and Nyanghwale divisions of Geita District, where serious overgrazing occurs. Watering points in these areas are not evenly distributed. As a result, there is severe degradation along cattle routes and around watering points. Livestock keepers in Kwimba District (Mwanza region) use free-range grazing systems on communal land, leading to overgrazing. Observations show an increase in land-use conflicts, especially between cultivators and livestock keepers, not only in this region but also in other Partner States. This situation has been accelerated by the rapid expansion of farming activities into traditional grazing areas due to population pressure (Yanda et al., 2001). As a result, severe land degradation in concentrated livestock production areas occurs as natural vegetation and biodiversity attached to it is lost or replaced by hardy species.

Mining

According to Twongo & Bugenyi (2006), deforestation and wanton land degradation is rampant in the mining areas of the LVB. Small-scale mining of gold requires the use of huge quantities of logs, which are used to strengthen the mines to avoid collapsing. Some of the ditches are as deep as 50 meters or more. In addition to the logs, the large concentrated population in the mining sites increases the domestic demand for wood. Firewood collection and charcoal making are supplementary activities that are conducted in the mining areas in such districts as Geita, Kahama, Tarime, and Biharamulo in Tanzania.

Charcoal making and tree felling for building purposes are very evident along the major routes linking mining sites to major towns nearby. Mining activities are associated not only with deforestation but also with destruction of the soil surface, by leaving open pits in the ground and covering the top soil with gravel and sub-soils. In some areas, the land is abandoned after the mining activities without any attempted rehabilitation. As a result, mining with no rehabilitation interventions leads to biodiversity loss above and below ground.

Fishing

Fishing is by far the most important economic activity for those living in lakeshore areas. Fishing is undertaken for both subsistence and commercial goals. During the last two decades, the lake has encountered numerous problems and extensive resource exploitation, which has constrained its productivity, resulting in the drastic decline of biodiversity in general and fisheries in particular. This has also threatened the nutrition source for LVB inhabitants. Most fish, particularly Nile perch, are sold to fish processing plants or middlemen. As a result, increased prices are out of reach for the most poor-to-average-income households. Fish processing byproducts such as fish frames are now common sources of nutrition to these households. Fish catch is also declining due to increased fishing efforts and illegal fishing methods (Kulindwa, 2006).

Fish diversity has been affected not only by intensive non-selective fishing but also by the destruction of drainage basin vegetation; poor land management in the catchment due to deforestation, cultivation, river bank erosion, pollution due to industrialization and agricultural development; and the introduction and invasion of exotic species (LVBC, World Bank and SIDA, 2012). Haplochromines, for example, were decimated by the introduction of Nile Perch, overfishing, and environmental changes (Acere, 1988). Fish may also consume small proportions of metal ore and mining chemicals from contaminated water flowing from mining sites or riverbanks. This can lead to death or genetic defects in fish, thus affecting fish diversity.

Lake Victoria fisheries' dependency on few export markets puts the fishing community and LVB inhabitants in a delicate position, particularly when fish exports contribute a large proportion of income to the region. Any event, such as the export ban that occurred in 1999 due to water pollution and illegal fishing practices, causes a major shock to the economy in terms of the region's employment, incomes, and foreign exchange earnings (Kulindwa, 2006).

Bush Meat Exploitation

Wildlife resources are widely used for tourism and as a source of livelihood, particularly for game meat, which makes up a significant proportion of nutritional requirements for those living around wildlife areas. This is a common source of livelihood support around Rumanyika Game Reserve and Biharamulo (1,300 km^2) and Burigi Game Reserves (2,200 km^2) in the Kagera region; Rubondo National Park (460 km^2) and Saanane Island

($50\ km^2$) in the Mwanza region; and Serengeti National Park and Maasai Mara National Reserve on the Kenyan side. Other important wildlife areas in this regard include Maswa Game Reserve ($220\ km^2$) in Shinyanga, and Ibanda Game Reserve in Rwanda.

Literature detailing impacts of bush meat trade on wildlife diversity is scarce, but poaching has become a form of livelihood to some groups in the LVB, and this is causing major impacts on wildlife biodiversity.

The Serengeti-Maasai Mara Ecosystem Transboundary Protection and Monitoring Plan (2012) states that there is decline in the population of some wildlife species and the riverine forest in the northern part of Serengeti National Park (LVBC, 2012). These trends, if left unattended, will result in devastative impacts on ecosystem health and integrity, impacting biodiversity conservation and the tourists' attractions within the ecosystem. The reduced appeal of tourist attractions will simultaneously lead to decreased revenue generation and elevated poverty levels in communities. Climate change impacts will only exacerbate biodiversity loss and habitat fragmentation.

2.4.3 BIODIVERSITY AND GENDER

Just as poor communities disproportionately feel the impact of biodiversity loss, there are also disparities along gender lines. Biodiversity loss affects access to education and gender equality by increasing the time spent by women and children in performing certain tasks, such as collecting valuable resources like fuel, food, and water[4].

Gender roles affect economic, political, social, and ecological opportunities and constraints faced by both men and women. Recognizing women's roles as primary land and resource managers is central to the success of any biodiversity policy. Of significance to the agriculture and rural development sector are five main gender issues, namely:[5]

- Gender, agricultural biodiversity, and commercialization;
- Equal access to land and water resources, and to credit and other support services;
- Gender differences in roles and activities;
- Gender and agricultural extension and research; and
- Women's empowerment and equal access to decision making.

These are interlinked and all require social change, which needs to have substantial political support if the limits to growth are to be overcome.

Women have always played an important role in agriculture, undertaking a wide range of activities relating to food production, processing, and marketing. Beyond the farm, women play a key role in land and water management. Women are most often the collectors of water, firewood, and fodder. They have access to a store of local knowledge on the medicinal use of plants; they have been on the forefront of soil conservation programs. In addition, women perform most of the household labor devoted to animals.

A number of socio-economic studies have shown that there are gender differences in utilization of natural resources in the basin (Olago et al., 2006). In wetland reclamation efforts in Kampala, Uganda, Nakijoba (1996) discovered that declining wetland resources are affecting women, because traditionally, division of labor among gender prescribes and charges women with certain social and economic chores for the family. In this case, women are naturally using wetlands more than men for their households' food and medicinal resources. This is also true in other parts of the LVB.

In Nyando District in Kenya, other studies show that the degradation of wetlands affects men and women differently depending on socio-demographic attributes, especially gender and age (Raburu et al., 2012). Community development processes depend on the different roles, responsibilities, and socio-economic status of

4 https://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-gender-en.pdf
5 Gender mainstreaming in Agriculture and Rural development. A reference manual for governments and other stakeholders. Commonwealth Secretariat.

both men and women. In Nyando wetland, women usually undertake food production and home maintenance chores, while men are entrusted with the decision-making process as heads of household. Several reasons explain the observed differences in the gender roles. First, men usually cultivate virgin wetlands for crop farming, while women are involved in home-and market-based activities to obtain household income and households' food security. Secondly, some gender roles are socio-culturally sensitive. For example, grazing, fishing, hunting, and harvesting of construction materials and medicinal herbs are considered a task for men and male youth; and fetching water and fuel wood is carried out mainly by women and female youth. Thirdly, traditional beliefs also influence the utilization of wetland resources. Rural communities believe that evil spirits live in the wetlands, so one must leave the wetlands by a certain time of day, and women must leave earlier than men. Men also believe that their ancestors were buried in what are now wetlands, so it belongs to them by lineage, according to the Nyando Wetlands Community Program (Raburu et al., 2012).

In addition, while men engage in clearing wetland vegetation for agricultural expansion, the women perform such labor-intensive activities as weaving papyrus mats, as well as agriculture and local trade activities. Women are also directly involved in household food provision, and they interact with the wetland on a daily basis. Male and female youth are mainly responsible for fetching firewood and water for domestic use. Male youth do what men do to a lesser extent, as they are doing schoolwork as well.

A gender analysis conducted in the upper Mara region (LTSA, 2012b) showed that in the Olenguruone area, men usually engage in livestock rearing, small-scale businesses, poultry farming and fencing; while the women are engaged in crop farming, livestock rearing, and tea picking. In the Nyangores and Nairotia areas, men engage in small-scale businesses, crop pruning, carpentry, crop and livestock production, casual/informal employment, tea picking, weaving, timber selling, fencing, tailoring, driving, and teaching. Women are engaged in small-scale business, crafts, crop and livestock production, washing, weaving, tailoring, informal/casual employment, poultry farming, pottery teaching, weeding, and transporting luggage.

The impact of resource decline or degradation (e.g., deforestation or drying up of water sources) affects women more than men because women are traditionally expected to collect both water and fuel wood. Forest decline increases the distance necessary for travel to collect firewood, while water pollution means that people have to travel further distance to access clean water sources. The need to boil water results in an increased use of firewood (Twongo & Bugenyi, 2006).

Generally, few studies focus on impacts of biodiversity loss on gender in the LVB, and this can form one of the focus interventions in the BSAs. However, the main threats relate to poverty-related issues and climate change, which are discussed below.

Despite considerable efforts over the past 15 years at national and international forums, such as the Convention on Biological Diversity, very little progress has been made in understanding the fundamental roles that women play in managing and conserving biodiversity. It is essential to recognize that women and men have particular needs, interests and aspirations, and that they make different contributions to the conservation and sustainable management of biodiversity.

2.4.4 POLICY AND INSTITUTIONS

A fundamental challenge in reducing vulnerable populations' dependence on natural resources is how to accelerate equitable income growth and promote access to necessary resources and technologies. What is required is a change from unsustainable practices to appropriate land management practices in the longer term (5–10 years); secure user/property rights for local communities; local governance; incentive measures; adequate institutions; and harmonized sectoral policies, opportunities, and empowerment. For the purpose of sustainability and upscaling, all development projects in the LVB must be coordinated and work effectively within existing national institutional structures, in consideration of current and future policies and laws (LTSA, 2012a).

With respect to the EPA, different government departments and agencies in each of the five basin states deal with various aspects of natural resources management. They do this according to their own individual mandates or needs, and their own legislative provisions, with little integration toward holistic basin-wide planning and management. In addition to this multiplicity of organizations, effective IWRM is further constrained by limitations in the technical, human, and financial capacities of these national organizations. The sections below summarize the different types of regional and national policies and institutions found in the LVB.

Regional Policies and Stakeholders

The EAC has regional policies that can be domesticated within each country. However, the extent to which the regional biodiversity and climate change policies are domesticated in each member state is currently unclear. There may be a need to document the degree of domestication of these policies within the member states.

The protection and conservation of biodiversity resources is anchored in policy and legislation of the regional bodies. For example, there are 11 treaties dealing with the consumptive use of the waters of the River Nile in general and Lake Victoria in particular. Conservation of biodiversity resources also seeks to harness the potential of the Nile for the benefit of the people in the basin, both for current and future generations. This becomes a major challenge as economic growth accelerates, population increases, and water demand grows.

The EAC Protocol on Environment and Natural Resource Management, currently not ratified by all EAC Partner States, has relevant provisions for environmental and socio-development management. Article 5 of the protocol outlines the objectives of the protocol as follows:

- Promote sustainable growth and development of the Partner States through sustainable use and management of the environment and natural resources and through prevention of activities that are detrimental to the environment and natural resources.
- Foster closer cooperation for judicious, sustainable, and coordinated management, conservation, protection, and utilization of the environment and natural resources; and deepen integration and poverty alleviation.
- Promote capacity building and environmental awareness in environment and natural resources management.
- Promote shared responsibility and cooperation in the management of environment and natural resources, including those that are transboundary in nature among Partner States.
- Promote development and harmonization of policies, laws, and strategies for environment and natural resources management to support sustainable development.

Article 9 provides for management of transboundary resources, article 13 for management of water resources, and article 14 for the sustainable management and wise use of wetland resources.

The East African Climate Change Master Plan (2011-2031) attempts to provide an effective and integrated response to regional climate change adaptation. It also seeks to enhance the mitigation potential of Partner States in the energy, infrastructure, agriculture, and forestry sectors; streamline and harmonize existing, ongoing transboundary mitigation and adaptation projects or activities; and foster strong international cooperation to address the issues related to climate change, including enhancing the negotiating ability of the Partner States in the African Union and other forums, including the United Nations Framework Convention on Climate Change (UNFCCC). The master plan acknowledges that mobilization of financial and other resources will be required to implement activities outlined in the plan. Implementation of BSAs interventions will have an effect on climate change adaptation and mitigation efforts. Thus, these Interventions need to take into account the provisions outlined in this plan.

The LVBC, being one of the implementing arms of the EAC, contributes to the EAC's Vision and Strategy Framework for Management and Development of the Lake Victoria Basin (2003) (EAC, 2003), which has five policy areas, namely:

- Ecosystems, natural resources, and environment;
- Production and income generation;
- Living conditions, poverty, and quality of life;
- Population and demography; and
- Governance, institutions, and policies.

Under the ecosystems, natural resources and environment policy area are four priority sector strategies:

- Fish resources management,
- Land use and natural resources management,
- Water resources management, and
- Pollution control and waste management.

Furthermore, LVBC's Lake Victoria Strategic Plan 2011–2016 (LVBC, 2011) guides the implementation and monitoring of specific strategic interventions defined in the 4th EAC Development Strategy (2011–2016). The implementation of this strategy was undertaken within the LVBC Medium Term Expenditure Framework (MTEF). The LVBC MTEF consists of six developmental objectives:

1) Strengthen the coordination and management capacity of the LVBC Secretariat.
2) Enhance cooperation between LVBC and EAC organs, institutions, and partners.
3) Put in place a harmonized approach for sustainable management and development of natural resources of Lake Victoria and its basin.
4) Harmonize HIV and AIDS policy frameworks and practice for mobile populations across the East African region.
5) Improve safety of navigation and security on Lake Victoria.
6) Promote conservation and management of natural resources and biodiversity in and outside PAs.

Only established institutions with the capacity to do so can implement policies and legislative frameworks in biodiversity conservation and climate change. At the regional level, the main stakeholders include the EAC, the LVBC and the Nile Basin Initiative (NBI). Under the EAC, there are various programs addressing biodiversity issues, such as LVEMP Phase II and the Mount Elgon Regional Ecosystem Conservation Program. The NBI is currently addressing the issue of equitable utilization of common water resources. Its Nile Equatorial Lakes Subsidiary Action Program (NELSAP), in particular, addresses biodiversity and climate change issues in the Kagera Basin, which encompasses four Partner States of the LVBC, namely Burundi, Rwanda, Tanzania, and Uganda.

The main national stakeholders are outlined below per Partner State.

2.4.5 PARTNER STATE POLICIES

The above regional picture is reflected at the Partner States level, where national environmental and natural resource policies are summarized briefly below.

Burundi

The sustainable ecological growth of Burundi is defined by the Burundi Vision 2025. The National Environment Strategy of Burundi proposes measures for restoring or safeguarding a balance between the interests of development and those of the environment. It aims to organize a coherent and cooperative set of complementary structures for better management of the national and global environment.

The National Biodiversity Strategy and Action Plan (Republic of Burundi, 2000) states that "all populations are properly informed on values of biological diversity and the risks of its loss, involved and committed in its conservation and its sustainable use for the benefit of present and future generations." It gives orientations on conservation of biodiversity; sustainable use of biological resources; and equitable sharing of responsibilities. It also explains the benefits of managing biodiversity; biotechnology; education and public awareness; training and research; impact studies; reducing harmful effects; cooperation; and exchanging information (Republic of Burundi, 2000).

The Environment Code (2000) sets the fundamental rules intended to enable the environmental management and protection against all forms of degradation to safeguard and promote the rational exploitation of natural resources, fight against pollution, and improve the population's living conditions in respect to the balance of ecosystems.

In Burundi's second Poverty Reduction Strategy Paper (PRSP II) (IMF, 2012), promoting development through sustainable environmental and space management forms a key element in promoting economic growth. Under this sector, emphasis is placed on environmental protection and sustainable resource management by improving legislation on soil conservation and protection; protecting forests, woodlands, and biodiversity; combating pollution; environmental sanitation; and consideration of climate change.

Climate change issues are outlined in the National Adaptation Program for Action, which analyzes climate impacts on socio-economic development and suggests potential adaptation actions for Burundi (Republic of Burundi, 2007). Climate change issues are also well articulated in the National Climate Change Policy (2012) and the National Strategy Action Plan on Climate Change (2012).

Diverse government institutions under the broad coordination of the Ministry of Water, Environment, Spatial Planning, and Urban Development implement the above policies. Principal among these are the General Directorate of Forests and Environment, ***Office Burundais pour la Protection de l'Environnement*** (OBPE), the Geographic Institute of Burundi, and the Soil Protection Department of the Lake Tanganyika Authority.

The main research institutions in Burundi are the University of Burundi and the Institute of Agronomic Sciences in Burundi at the Agronomic and Zoo Technical Research Institute. NGOs include ***Association Burundaise pour la Protection des*** Oiseaux, the Albertine Rift Conservation Society, and ***Action Ceinture Verte pour l'Environnement.***

Rwanda

Rwanda's policy framework for environmental management is grounded in five key documents: the National Environment Policy (2003), Land Policy (2004), Rwanda Organic Law (2005), the Economic Development and Poverty Reduction Strategy (EDPRS, 2013–2018) and Vision 2020. The goal of the EDPRS is "accelerating progress to middle income status and better quality of life for all Rwandans through sustained average GDP growth of 11.5% and accelerated reduction of poverty to less than 30% of the population". The strategy seeks to pursue 'green economy' approach in economic transformation.

The position of environment in Rwanda's overall national governance framework has become more prominent with successive institutional reforms (LTSA, 2012). Rwanda's national biodiversity priorities are articulated in its NBSAP. Its main objectives are improved conservation of PAs and wetlands; sustainable use of the biodiversity of natural ecosystems and agro-ecosystems; rational use of biotechnology; development and strengthening of policy, institutional, legal, and human resource frameworks; and equitable sharing of benefits derived from the use of biological resources.

The National Strategy on Climate Change and Low Carbon Development (2011) and the National Adaptation Plan of Action outlines Rwanda's strategies and proposed actions toward mitigation and adaptation efforts.

The main government institutions involved in biodiversity and climate change are the Ministry of Water, Energy, and Natural Resources and the Ministry of Agriculture. Quasi-government institutions include the Rwanda

Development Board (RDB), the Rwanda Environmental Management Authority (REMA), the Rwanda Water and Forestry Authority, the Rwanda Wildlife Authority and WCS.

NGOs include ***Association pour la Conservation de la Nature au Rwanda, Association Rwandaise des Ecologistes,*** the Great Ape Trust, the Great Land Initiative, the Sabyinyo Community Livelihood Association, and the Rwanda Environmental Conservation Organization.

Kenya

Kenya's Vision 2030 and environment sector policies such as Water Policy (2002), Energy Policy (2006), the National Forest Policy (2016) and the National Wildlife Conservation and Management Policy (2016) regulate the environment sector in Kenya. Legislation most relevant to biodiversity include those dealing with land, environment, wildlife, and forestry: the Land Act (2013), the Environmental Management and Coordination Act (1999) and the Environmental Management and Coordination (Conservation of Biodiversity) Regulations (2006), the Wildlife Conservation and Management Act (2013) and the Forest Conservation and Management Act (2016). Others include the laws governing energy, water, and agriculture as well as gazetted sessional papers for various sectors. Of particular interest is the new Wildlife Conservation and Management Act , which outlined stiffer penalties for individuals involved in wildlife trafficking. The National Museums, with their regional biodiversity collections, cultural archives, and research departments, are governed under the National Museums and Heritage Act, No. 6 of 2006 (Birdlife International, 2012).

Kenya's national biodiversity priorities are articulated in the Kenya National Biodiversity Strategy and Action Plan (2000). Its main priorities are to promote the sustainable utilization of biodiversity products; create an enabling environment for biodiversity conservation by improving national capacity and strengthening regulatory mechanisms; promote awareness in biodiversity conservation; and enhance the conservation of biodiversity through in situ and restorative procedures. It also aims to strengthen research and monitoring activities by improving inventories, databases, and documentation and aims to promote environment-friendly activities like ecotourism and preventive activities like environmental impact assessments.

Kenya's climate change mitigation and adaptation plans are found in the National Climate Change Action Plan (2013), which outlines a low carbon climate resilient pathway for Kenya for the next five years (Republic of Kenya, 2013). A National Adaptation Plan (NAP 2015-2030) that mainstreams adaptation across all sectors has been developed to operationalize the action plan. A new Climate Change Act (2016) and the National Climate Change Framework Policy (2016) have also been developed.

The main government institution in biodiversity and climate change issues is the Ministry of Environment and Natural Resources (MENR). Climate change matters are under the docket of the Climate Change Department in the same ministry. There is also an advisor on food security and climate change matters in the Office of the Deputy President.

Quasi-government institutions include the Kenya Forest Research Institute, the Kenya Agriculture and Livestock Research Organization, the Kenya Forest Service (KFS), KWS, the National Environment Management Authority (NEMA), and the National Museums of Kenya (NMK) – Centre for Biodiversity. The main training institutions in Kenya are the University of Nairobi, Kenyatta University, Egerton University, Jomo Kenyatta University of Agriculture and Technology, and Moi University.

There is a large civil society actor's base that includes non-governmental organizations such as the African Conservation Centre, the World Wildlife Fund (WWF), the East African Wildlife Society, the Green Belt Movement, Nature Kenya, the IUCN, the Africa Wildlife Foundation, and the International Fund for Animal Welfare.

Tanzania

In Tanzania, the key national policies related to the environment and watershed management are contained in the second National Strategy for Growth and Reduction of Poverty (2010), Development Vision 2025, the National Environmental Policy (1997), the National Water Policy (2002) and other sector specific policies. Most of the policies stress the need for community participation and involvement in managing the environment and natural resources. Environmental matters are also governed by the National Environment Management Act (2004) and other sector laws such as the Forest Act (2002) and the Wildlife Conservation Act (2009).

Tanzania's national biodiversity priorities are articulated in its NBSAP, whose main objectives are to ensure sustainability, security, and equitable use of biological diversity for meeting the basic needs of present and future generations. Climate change actions are governed by the National Adaptation Plan of Action (2007) and the National Climate Change Strategy (2012).

In Tanzania, the main government institutions are the Ministry of Natural Resources and Tourism (MNRT), the Division of the Environment in the Vice President's Office, the Ministry of Agriculture, Livestock and Fisheries (MALF), and the Ministry of Water and Irrigation (MOWI).

Research institutions include the National Environment Management Council, the Tanzania Fisheries Research Institute, the Tanzania Wildlife Research Institute, the Tanzania Forest Research Institute, Sokoine University of Agriculture, the University of Dar es Salaam- Institute of Resources Assessment, and the Institute of Marine Sciences, based in Zanzibar.

Civil society includes IUCN, the Jane Goodall Institute, the Tanzania Land Conservation Trust, the Tanzania Alliance for Biodiversity, Participatory Ecological Land Use Management Tanzania (PELUM Tanzania), Sustainable Agriculture Tanzania, the Tanzania Biodiversity Information Facility, and the Tanzania Forest Conservation Group, among others.

Uganda

The National Environment Management Policy for Uganda (1994) laid the foundation for subsequent policies, laws, and strategies for sustainable development. Vision 2025 aims to achieve sustainable social and economic development, which maintains or enhances environmental quality and resource productivity on a long-term basis. Other related policies include the National Water Policy (1999), the Water Statute (1995), the Forest Policy (2001), Wildlife Policy (2014), the National Policy for the Conservation and Management of Wetland Resources (1995) and the Wetlands Sector Strategic Plan (2011). Environment matters are also governed by the National Environmental Act (1995) and other sector laws such as the Forestry and Tree Planting Act (2000) and the Wildlife Act (1996).

Uganda's biodiversity priorities are found in its NBSAP, which has the following objectives: to develop and strengthen coordination, measures, and frameworks for biodiversity management; to facilitate research, information management, and information exchange on biodiversity; to reduce and manage negative impacts on biodiversity; to promote the sustainable use and a fair sharing of biodiversity's costs and benefits; and to enhance awareness on biodiversity issues among the various stakeholders. With respect to climate change, Uganda has a Climate Change Policy (2012). In addition, its adaptation actions are detailed in the National Adaptation Plan of Action (2007).

In Uganda, the main government institutions in involved in biodiversity and climate change include the Ministry of Tourism, Wildlife, and Antiquities, the Ministry of Water and Environment, and the Wetlands Management Department.

Quasi-government institutions include the National Environmental Management Authority, the Uganda Wildlife Authority, the Uganda NFA, and the National Agricultural Research Organization.

Research institutions include the National Forest Resources Research Institute, the Makerere University Institute of Environment and Natural Resources, and the Mbarara University of Science and Technology. Civil society actors include Nature Uganda, IUCN, WWF, Birdlife International, Wetlands International, WCS, and the Environmental Conservation Trust of Uganda.

3.0 ASSESSMENT OF CLIMATE CHANGE IMPACTS

In September 2011, the EAC published the Climate Change Master Plan, which contains a comprehensive, country-by-country account of climate, climate trends, and projections from various climate models. This chapter builds on the Climate Change Master Plan and accounts for the significant progress made in climate modeling and analysis that has taken place in recent years.

3.1 ATMOSPHERIC CIRCULATION

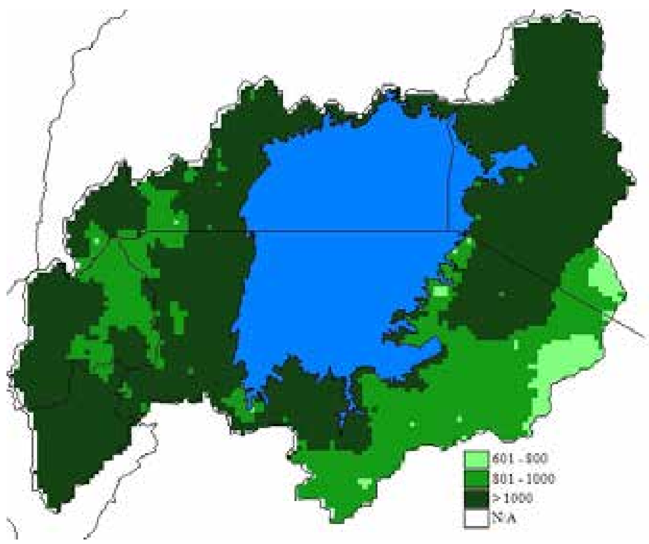
The lake provides an environment conducive to complex interactions among regionally induced and large-scale circulation systems. Lake Victoria is the largest lake in Africa by surface area and due to its size, air currents are generated over its surface. As discussed in Chapter 2, circulation is from east to west, but locally generated winds have an influence onshore and offshore (Sutcliffe & Parks, 1999). Figure 3 depicts the seasonal wind patterns over the lake. Due to the exceptional size and heat storage capacity of the lake, a persistent convection cell develops nocturnally (Seimon et al., 2013).

3.2 AVERAGE ANNUAL RAINFALL PATTERN

The LVB exhibits a biannual rainfall pattern. As discussed in Section 2.1.3, the first peak, or long rains usually occurs from March to May, while the second peak, or the short rains is expected from October to December. The bimodal pattern is a result of the movement of the Intertropical Convergence Zone (ITCZ) that forms over the equator. This band of high rainfall and low pressure progresses northward during the northern hemisphere summer and then returns south.

Rainfall volume varies spatially, with records spanning over 80 years showing average annual rainfall ranging from 847 mm on the eastern shore of Lake Victoria to 2,037 mm on the western shore (Kizza et al., 2009). Others (Tungaraza et al., 2012) have also noted an east-west variation. Kisumu in the Kenyan part of the LVB has a mean annual rainfall of 1,390 mm (UK Met Office, 2011). During the wet seasons, rainfall can be 50–200 mm per month, but may exceed 300 mm (McSweeney et al., 2010a, b and c). The PREPARED Project analyzed average annual rainfall for the period between 1981 and 2014 for the LVB using the GeoCLIM software tool developed by the United States Geological Survey Famine Early Warning System Network. The results are presented in Figure 20. Figure 21 shows the rainfall Coefficient of Variation (%) indicating that rainfall is highly variable on the lower parts of the basin. The distribution of mean annual rainfall across the LVB is also shown in Figure 4.

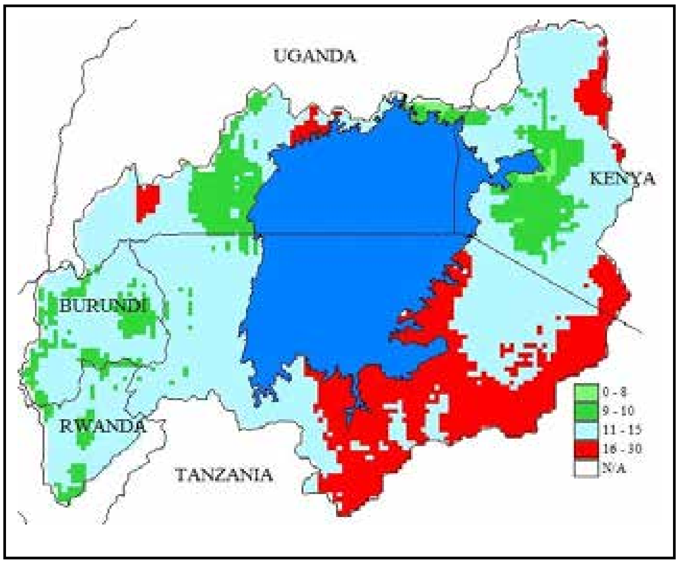
Figure 20. Average annual rainfall (mm) (1981–2014) for the LVB



Interannual Variability

Rainfall variability is determined largely by regional factors. Year-to-year precipitation variability is most strongly influenced by annually varying sea surface temperature patterns in the Indian and Pacific Oceans (Seimon et al., 2013). This variability appears to be strongly influenced by the ENSO. Warm ENSO (El Niño) events are linked with regional rainfall surpluses and cold ENSO (La Niña) events with rainfall deficits. However, it is thought that the Indian Ocean Dipole (IOD) must act together with ENSO in order to yield more significant rainfall anomalies. A positive phase of the IOD combined with El Niño occurred in 1997–1998 and caused the wettest year in decades. The opposite conditions occurred in 2011 and led to an exceptionally dry year.

Figure 21. Coefficient of variation (%) for annual rainfall (1981–2014) for the LVB Interannual Variability-the Influence of ENSO and Sea Surface Temperatures



in

These regional factors do not affect the long rains and the short rains in the LVB in the same way. The long rains appear to be more heavily influenced by the north-south movement of the ITCZ, while the short rains are more affected by the east-west oscillation (Indeje et al., 2000). El Niño years tend to bring excess precipitation during the short rains. Indeje et al. (2000) argue that the long rains arrive later during ENSO years and that rainfall in the following year is usually lower than average.

The degree of ENSO influence compared with the Indian Ocean sea surface temperatures is under debate (Marchant et al., 2006). It has been suggested that these two factors may interact (Williams & Hanan, 2011). There is also evidence that Pacific Ocean sea surface temperatures influence long rains (Lyon & DeWitt, 2012).

3.3 TEMPERATURE

Kisumu, which is located in the far east corner of Lake Victoria in Kenya, has a mean annual temperature of 26°C (UK Met Office, 2011). The temperature from September to March ranges from approximately 17°C to 30°C and 16°C to 28°C in April to August. Data from Makerere in Kampala, Uganda, show slightly cooler temperatures (CSAG, 2013). Figures 22 and 23 show the average minimum and maximum temperature using GeoCLIM and the Lund-Potsdam-Jema (LPJ) software for the period 1981–2014 in the LVB.

Figure 22. Average minimum temperature (C) (1981-2014) for the LVB

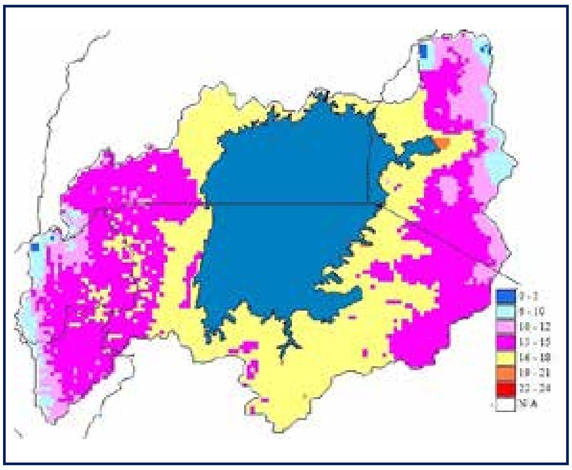
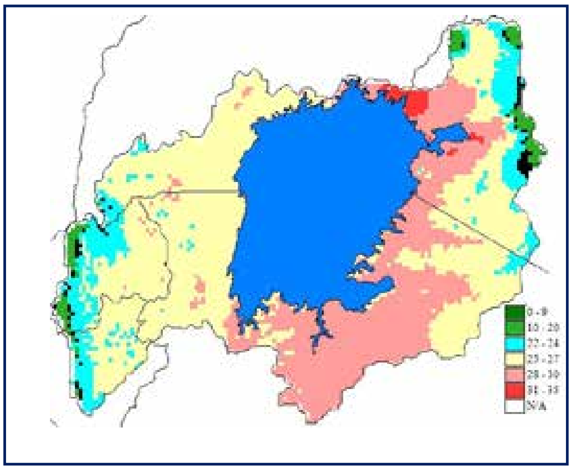


Figure 23. Average maximum temperature (C) (1981-2014) for the LVB



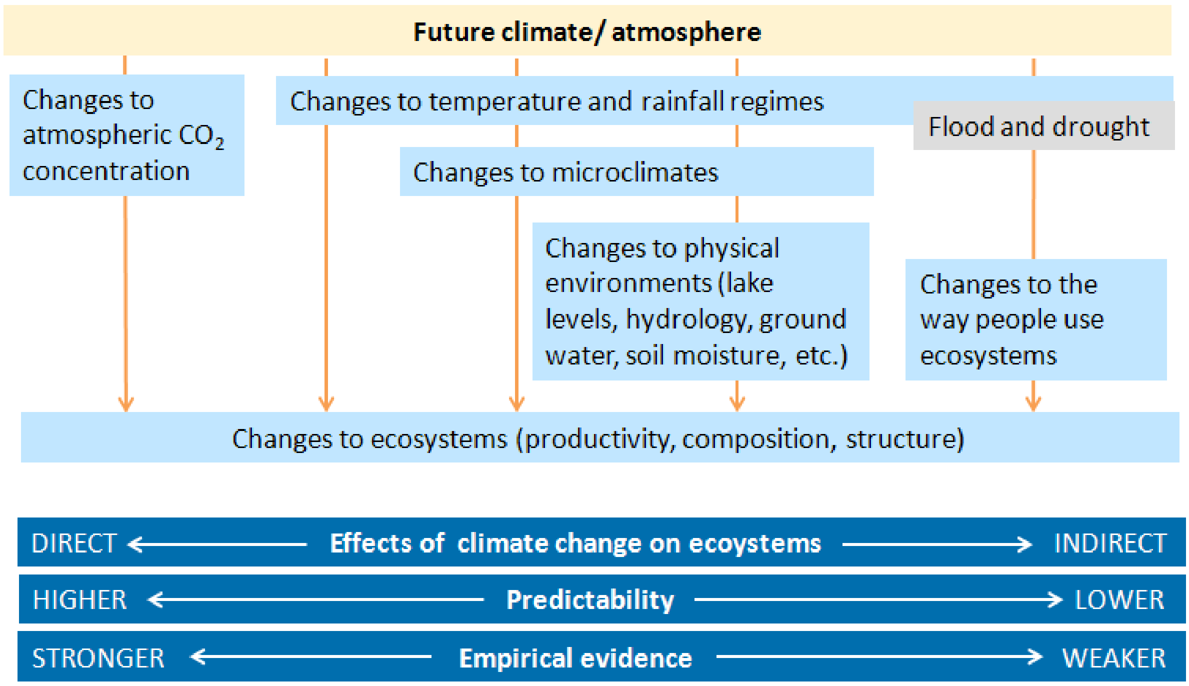
The details of current trends based on measurements since around 2000, and future projections based on outputs of climate models described above are presented in the following sections.

3.4 IMPACTS OF CLIMATE CHANGE ON ECOSYSTEMS IN LAKE VICTORIA BASIN

In this section, interactions between climate and ecosystems are discussed. The evidence of species, habitats, and ecosystems responses to climate change is also reviewed.

Climate change can affect ecosystems by many mechanisms (see Figure 24). Changes in cloud cover, winds, temperature, and humidity may have a direct effect on flora and fauna. Microclimates, such as those found over Lake Victoria itself, may ameliorate or exacerbate regional-level changes. Changes to any climatic variables affect the physical environment (i.e., soils, water bodies). Changes to climate, and in particular to the frequency of climate extremes such as flood and drought, affect human populations and the way they interact with ecosystems. The more complex the interactions between climate and ecosystems are, the less predictable the climate change impacts become.

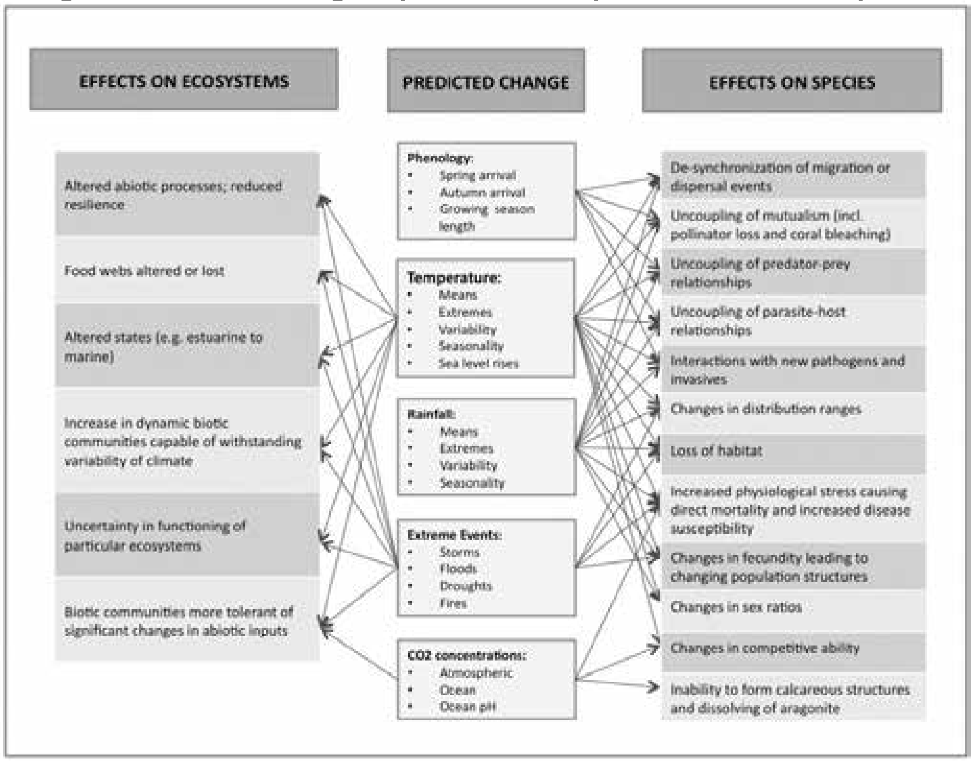
Figure 24. Characterization of the effects of climate change on ecosystems



Kingsford & Watson (2011) highlight the difficulty of disentangling the effects of climate change on ecosystems and their constituent species (Figure 25). These complexities are emphasized because they underline the enormous challenges faced by scientists in understanding how climate change will affect ecosystems. A change in any single climate variable has a multitude of impacts on a species or an ecosystem that can range from fundamental (such as a rainfall threshold for survival) to relatively insignificant in its future growth and survival.

The published and unpublished literature on climate change impacts has a tendency to simplify and generalize, using unsubstantiated assumptions about what kind of climate changes will occur and how species and ecosystems will respond. For example, common misconceptions are that the LVB will become drier, and that recent flood and drought events in the basin are entirely due to anthropogenic climate change. As a result, myths are perpetuated, and the value of these analyses is limited.

Figure 25. Climate change impacts and their predicted effects on species



Source: Kingsford & Watson, 2011

Evidence of Climate Impacts on Ecosystems

Aquatic Ecosystems

There is a growing body of evidence that rising average temperatures will have an adverse effect on aquatic ecosystems. As noted in Chapter 2, several large species of fish are endemic to the main lake, and several that are extinct in the main lake are present and under threat in subsidiary lakes and rivers.

Higher water temperature increases dissolved oxygen demand in an aquatic ecosystem, but it decreases the concentration of dissolved oxygen in water. Fish species may suffer from lack of oxygen with rising temperatures. Ficke et al. (2007) describe the physiological effect of increased temperature on fish oxygen demand under experimental conditions. There is a lack of direct evidence for hypoxia or anoxia with increased temperatures in individual water systems. However, higher temperatures may increase toxicity of the pollutants that fish cannot easily metabolize by increasing storage of the toxic substances in the fish body tissues. The authors suggest that the abundant tilapiine species in Lake Victoria (***Oreochromis esculentis*** and ***O. variabilis***), already subject to intense pressure from fishing and the introduced (***O. niloticus***), are more vulnerable to climatic changes than other species.

Paerl & Huisman (2008) reviewed research on the impacts of temperature rises on phytoplankton (cyanobacteria, algae and diatoms). Higher temperatures favor cyanobacteria growth more than other photosynthetic microorganisms, which reduces ecosystem productivity. In lakes where mixing is limited, higher temperatures also lead to lake stratification, which encourages algal blooms. Blooms increase water turbidity and smother aquatic plants, which degrades the habitats of aquatic invertebrates and fish. Blooms can also deplete oxygen, leading to fish kills.

O'Reilly et al. (2003) analyzed data from Lake Tanganyika on surface and deep water temperature from 1913 and 1938, respectively; wind speed; oxygenated zone depth; and lake phytoplankton productivity inferred from carbon stable isotope records of sediment cores. Sediment records suggest a lake-wide decrease in productivity over the 20th Century, which correlates with the observed climatic changes (i.e., increase in temperature and reduction in wind speed). The authors suggest these two climatic factors would stabilize the water column, reducing mixing and nutrient upwelling. Their hypothesis is supported by empirical evidence of the depth of the oxygenated zone having fallen and implies that climatic changes have caused reduced planktonic productivity in Lake Tanganyika. The authors believe this is the cause of declining fisheries productivity (i.e., lowered fish population). There are significant physical differences between Lake Tanganyika and Lake Victoria, but if circulation is reduced by rising temperature in Lake Victoria, a similar outcome is possible.

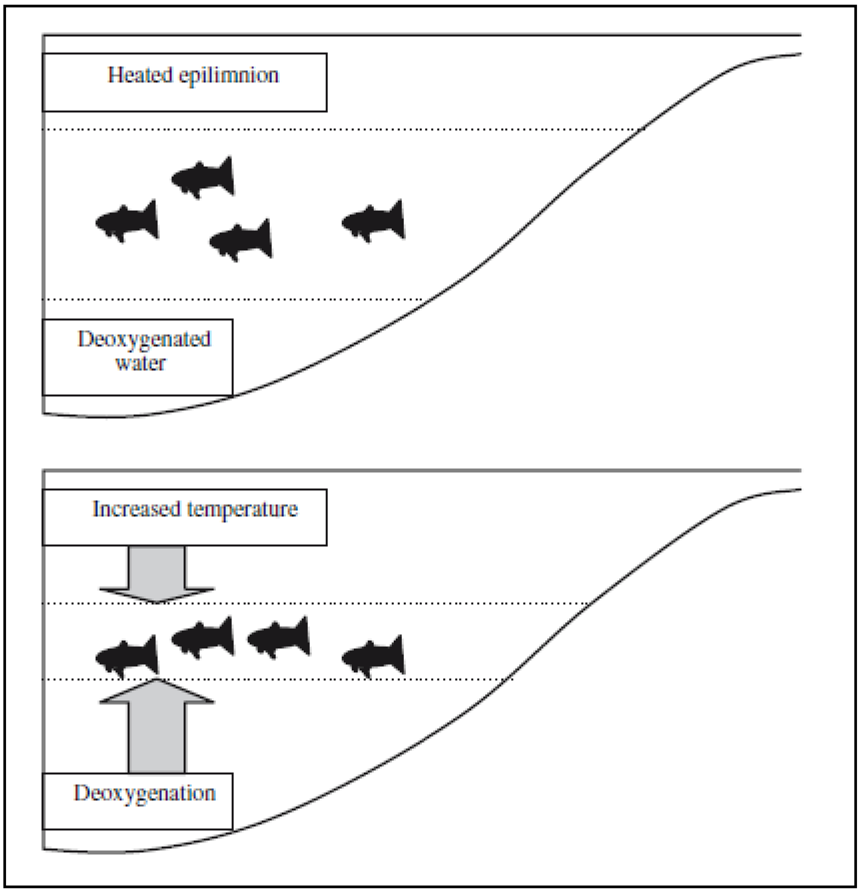
If climate change favors an expansion of water hyacinth, fish may be adversely affected. Research carried out by Honnel et al. (1993) indicates that water hyacinth can reduce lake water oxygen to levels that are harmful to fish. However, the impact of climate change on water hyacinth growth is unclear. A temperature increase to 30°C appears to impede water hyacinth growth, while increasing carbon dioxide seems likely to increase its growth (Burgiel & Moore, 2010). Sato (1988) conducted a lab experiment on water hyacinth to derive a clearly defined, mathematical relationship between temperature, nutrient availability, and biomass. Growth was tested at different temperatures (i.e., 15, 20, 25, and 30 degrees C). The experiment showed that 20° to 25°C is the optimal temperature for common water hyacinth to grow. However, this is affected by different concentration of nutrients, with very high and very low nutrient levels slowing down growth.

The conventional explanation for the death and washing out of water hyacinth in Lake Victoria has been increased wave action further offshore. Williams et al. (2005) attempted to demonstrate the importance of light levels in growth and survival of water hyacinth. The researchers performed a lab experiment that supported the hypothesis that there is a causal link. They also compared data on cloudiness between 1996 and 2001 and found that high cloud levels coincided with a decline in water hyacinth; other causes for decline were addressed and ruled out. Climate change projections are currently unclear whether weather cloudiness over Lake Victoria will increase or decrease, so it is not yet possible to understand future impacts.

Ochumba (1990) considered massive fish kills observed in Lake Victoria in 1984 and reported that weather was a major contributory factor to the deaths. Low precipitation resulted in a drop in lake level. Subsequently, a severe storm caused disturbance of nutrient-rich sediment, which was mixed with inflowing rivers bearing high levels of sediment. This resulted in high levels of suspended sediment and algae that clogged fish gills, lowered oxygen levels, and lowered pH levels. According to the climate models, it appears that an increase in the frequency of this kind of event is unlikely, because annual rainfall in the basin is expected to increase. However, for the smaller satellite lakes around Lake Victoria that may be at risk of greater intra-annual/seasonal variation in lake levels due to a prolonged dry season or drought, this problem could become more prevalent in the future.

In the LVB's satellite lakes and smaller water bodies, changes in flooding regimes may disrupt fish life cycles (e.g., by reducing spawning habitat) or help invasive species as discussed in Section 2.1.12. Higher temperatures could increase evapotranspiration, which may reduce water availability, particularly during dry seasons. This may increase fish availability to predator species or result in increased fish kills (Meisner, 1992). Changes in water levels may affect fish species with narrow bathymetric ranges (see Figure 26), particularly cichlid species, which inhabit shallow, sandy areas. This could decrease the growth rate of species. Climate change may restrict pelagic habitat availability for many species because of species-specific temperature and oxygen requirements (Ficke et al., 2007). Increased solar radiation will thicken the epilimnion, and increased fish metabolism will result in decreased concentrations of dissolved oxygen.

Figure 26. Restrictions expected in pelagic habitat availability for species-specific temperature and oxygen requirements



Source: Ficke et al., 2007

Wetland Ecosystems

Wetlands are also particularly vulnerable to a changing climate. This is not only because of the impacts of changing inputs (rainfall quantity and variability) and outputs (evaporation and evapotranspiration) on water levels, but also because of the effect on them associated with human response to drought. Wetlands are also important resources during years when the climate is not conducive to agriculture on other lands (Chapman et al., 2001; Turyahabwe et al., 2013). In addition to the impacts of climate change, there is a steady conversion of wetlands ecosystem, traditionally regarded as unproductive lands, to agricultural land for growing crops and rearing livestock. These issues are discussed further in other parts of this report. Given their vulnerability, the lack of research on the climate impacts on LVB wetlands is startling.

Terrestrial Ecosystems

Historically, climate change has resulted in dramatic shifts in the geographical distributions of species and ecosystems. In Burundi, pollen sequences over the last 40,000 years from Lake Kashiru indicate a very rapid (circa 100 years) turnover of species composition in response to accelerated climate warming, from grassland to a woodland ecosystem (Bonnefille & Riollet, 1988). Rather than large-scale local extinction, the change appears to have been characterized by a "rapid change in abundance of different taxa" (Willis et al., 2013), with only a few extinctions. The authors conclude from this and other similar sites that plants in this region have exhibited a high tolerance for the type of rapid climatic changes that may occur in the near future.

Current rates of species migration in response to climate change will have to be much higher than rates during post-glacial periods in order for species to adapt (Malcolm et al., 2002). Species that have the capability to keep up with climate shifts may also be confronted by physical obstacles including human barriers, such as agricultural or urban landscapes. Therefore, species ranges are unlikely to shift in cohesive and intact units and are expected to become more fragmented as they shift in response to a changing climate (Channel & Lomolino, 2000). Given these anthropogenic factors, the challenge facing the survival of some of today's ecosystems will be significant.

Climate impact studies focus principally on large mammals in the savannah ecosystems of the LVB, perhaps because of their popularity or their value to the tourist industry. Other ecosystems have received relatively little attention, perhaps because they are rather less interesting from a biodiversity perspective.

Ogutu et al. (2008) carried out monthly vehicle ground counts of ungulate species in the Mara-Serengeti over 15 years. In their analysis, population numbers were related to rainfall data collected using 12 gauges within the study area. Rainfall variability over short periods (months) was found to influence the population size of younger animals, while rainfall over longer periods (years) affected older animals. Accumulated monthly rainfall determined the abundance of newborn calves as follows:

- The three-year moving average of late season rainfall determined the population density of newborn kongoni***, Alcelaphus busephalus*** (Pallas), which increased up to 400 mm rainfall on average and decreased with increasing rainfall.
- For the giraffe, ***Giraffa camelopardalis*** (Linnaeus), newborn population size was strongly related to the five-year moving average for late-dry season rainfall.
- High rainfall during the wet season seems to affect numbers of newborn impala, ***Aepyceros melampus*** (Lichtenstein) negatively.

Accumulated late wet-season rainfall primarily determines the abundance of older animals among the seven ungulate species considered (e.g., population density of older kongoni increased exponentially with increasing three-year moving average late season rainfall). The authors suggest some reasons for this observed relationship between rainfall and population size:

- Direct impact of drought on vegetation-causing starvation in sub-Saharan Africa, several ecosystems, particularly grass and shrub savannahs, are shown to be highly sensitive to short-term availability of water (Vanacker et al., 2005).
- Indirect impact through weakening the animals, increasing their vulnerability to normal trophic/ecological constraints (predation, parasites, and disease).

Ogutu et al. (2009) found that persistent decline in six ungulate species in the Mara-Serengeti occurred at the same time as habitat degradation due to historical drought, warming, and ENSO-related flooding. Kongoni, impala, giraffe, warthog **(*Pharcocoerus africanus*)**, topi **(*Damaliscus korrigum*)**, and waterbuck (***Kobus ellipsyprimnus*)** populations were all observed to decrease (sometimes below average 1984-2003 populations) during droughts in 1993, 1997, the La Niña drought of 1999-2000, and (apart from the waterbuck) during the El Niño floods of 1996-1997. Population numbers rose in 1995-1996, a period of good rainfall. The authors suggest that rainfall has been a determining factor in these species' population size.

Should these extremes become a feature of future climate, these data could be used to understand future mammal populations in the LVB. However, in addition to the rainfall-related fluctuations, there is a long-term decreasing population trend, which Ogutu et al. suggest is due to human population increase, poaching, and livestock grazing.

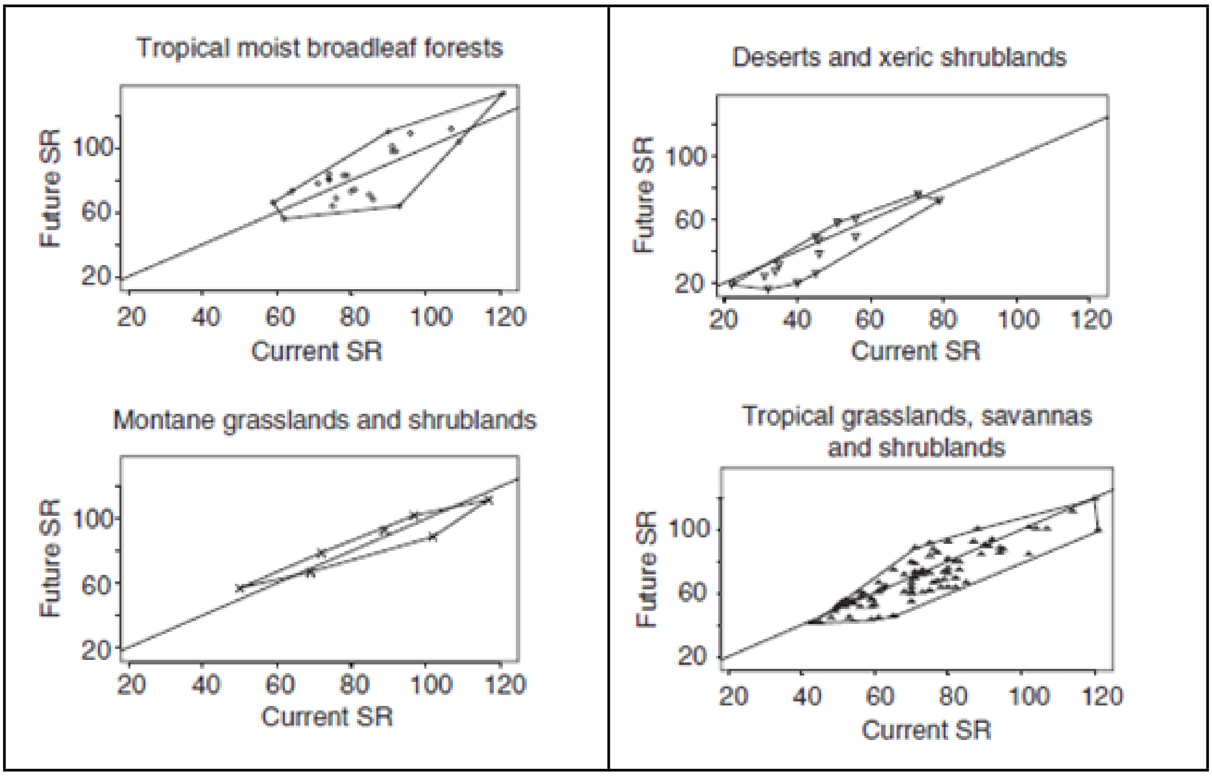
3.5 MODELLING FUTURE CLIMATE IMPACTS ON ECOSYSTEMS

McCLean et al. (2005) attempted to predict the shifts in climatically suitable areas of 5,197 African plant species (10%–15% of the African flora) that occur south of 27°N on the African mainland for 2025, 2055, and 2085. The method incorporated the Hadley Centre 3rd generation coupled ocean-atmosphere General Circulation Model (HadCM3) and three species distribution models (simple genetic algorithm and a Bayes-based genetic algorithm).

The model outputs suggest that 81%-97% of the species' ranges will shrink or change location and that 25%-42% of the species' ranges will be lost by 2085. Higher altitudes are likely to become suitable for species currently inhabiting lower-lying areas. Those species able to do so are, therefore, likely to migrate to higher altitudes. Across the entire study area in sub-Saharan Africa, by 2085, climates in most grid cells had become unsuitable for more than half the species found there at the baseline date. For the Bayesian Genetic Algorithm model, the most important determinants of species range were annual precipitation; mean temperature of the warmest month; and the annual moisture index. The authors admit that the changes may be overestimates, as the model resolution is far too coarse to account for survival of species within refugia. Their study also ignores the role of other physical non-climatic factors in determining species distribution (e.g., soil, fire). Given that annual precipitation is expected to increase rather than decline in the LVB, the impacts of climate change in this region may be rather less dramatic.

Thuiller et al. (2006) recorded current known distribution (but not abundance) of 277 African mammal species from at least 10 taxonomic orders, in order to represent a diverse range of mammal types. These distributions were manipulated using climate projections also, from the HadCM3 model, to predict changes in species distributions by 2050 and 2080. The results for mammals in ecosystems that are relevant to LVB are described in Figure 27; however, note that these diagrams include results from African national parks outside the LVB region.

Figure 27. Current and future mammal species richness (under the A2 scenario for 2050)



Source: Thuiller et al., 2006

The above figures assume full migration inside the African national parks, ranked according to the biome where they occur (Thuiller et al., 2006). Lines indicate the steady state situation, i.e., no species richness gain or loss. A significant alteration in species compositions is predicted. Xeric shrub lands are expected to lose species without a concurrent influx of species; thus, diversity is expected to fall in these areas. There is some evidence that national parks in tropical grasslands, savannahs, and shrub lands will be adversely affected, but change in most tropical broadleaf forests is less clear. National parks in montane and grassland are predicted to maintain their existing species and to gain further species, which the authors suggest is due to the shifting of favorable conditions to higher altitudes. Of course, these changes depend on whether species are able to move to new habitats. Changes in habitat suitability are predicted to reflect precipitation gradients closely. As for the study by McClean et al. (2005), future rainfall increases may limit adverse effects in the LVB region.

The LPJ dynamic global vegetation model was developed by Sitch et al. (2003) to combine process-based, large-scale representations of terrestrial vegetation dynamics and land-atmosphere carbon and water exchanges. It uses 10 Plants Functional Types (PFTs), with those relevant to the LVB being tropical broadleaved evergreen woody; tropical broadleaved rain green woody; and barren. Each PFT is assigned bioclimatic limits, which determine whether it can survive and/or regenerate under the climatic conditions prevailing in a particular grid cell. The major processes of vegetation dynamics-including growth, competition and demographic processes (represented in gap models), and fire regimes-are included.

Phillipps & Seimon (2009) used the LPJ model to incorporate downscaled climate projections from global circulation model ensembles. They focused on the Albertine Rift Valley, but their model outputs cover the western half of the LVB. Results indicate substantial range shifts in ecosystems in this region. Increase in net primary productivity indicates biomass/carbon storage gains on the north and west sides of the lake throughout the 21st century. There are biomass/carbon storage losses on the south side of the lake toward the end of the century. Losses of ecosystems to fire fall significantly, despite the large gains in net primary productivity, due to a moistening climate.

Phillipps & Seimon (2009) used the same climate projections in a crop yield model (based on Thornton et al., 2009) that simulates the responses of maize, phaseolus beans, and forage grass (***Brachiaria decumbens***). The model indicates substantial changes in yield for large parts of the LVB due to future temperature rises, with significant declines in yield of maize and phaseolus beans, but increases in forage grass yield (Picton-Phillipps & Simeon, 2010). On this basis, livestock farming could become dominant around the lake, but this ignores possible human responses to climate change, such as a switch to more temperature-resistant crops or development of resilient varieties.

Doherty et al. (2010) have also used the LPJ model in the EAC. Climate change projections are used to derive outputs, including net primary production, hydrological runoff, evapotranspiration, fire frequency, and various carbon fluxes. The projected long-term warming and moistening trends of the East African climate means that model response is a substantial increase in tropical woody vegetation in grassland regions, large increases in net primary productivity (18%–36%), and total carbon storage.

Doherty et al. (2010) indicate that East Africa is likely to experience some ecosystem service benefits through increased precipitation, river runoff, and freshwater availability. However, their model simulates potential natural vegetation, so it does not actually address the problem of relatively rapid adjustment faced by ecosystems over the 21st century. The authors conclude that increased rainfall, river runoff and freshwater availability, coupled with enhanced net primary productivity in East Africa, may improve conditions for agriculture over the 21st century, if temperature is not a limiting factor.

The SERVIR Africa Biodiversity project (SERVIR, 2012) uses general additive models to determine relationships between 370 plant indicator taxa in the Kenya-Tanzania borderlands and environmental variables. Outputs include habitat suitability for each taxon focusing on the effects of temperature changes in 2020, 2050, and 2090. These are arrived at using the ECHAM5, an atmospheric general circulation model, developed at the Max Planck Institute for Meteorology (using scenarios A1B, 1.7-4.4 C by 2099; and B1, 1.1-2.9 by 2099). Results show that ***Acacia abyssinica*** and ***Prunus africana*** are expected to reduce in range with increased temperature as they track temperature zones uphill, while ***Khaya anthotheca*** may undergo major range shifts as more suitable habitats emerge around Lake Victoria.

SERVIR model outputs for the current climate in the context of the existing PA network show that some of the potentially richest areas of plant biodiversity lie outside of PAs. Important ecosystem diversity is, therefore, unprotected. Using future climate outputs, it appears that the limitations of PAs in conserving biodiversity are amplified. Areas with suitable climate for high-elevation, moisture-dependent taxa are predicted to shrink toward mountain peaks, while areas suitable for low-elevation species are predicted to undergo huge geographic shifts.

These models are often limited in that they are based only on factors associated with exposure to climate change and that they ignore adaptive capacity or sensitivity (Seimon et al., 2013). There is a need to look at the niches of individual species in more detail. None of the models considers the physical barriers to the movement of plant or animal species, or their ability to move long distances over a period of decades. Finally, none of the models takes into account significant ongoing human impacts in the basin and current trends in ecosystem degradation and loss. Human impacts may have a profound effect on LVB ecosystems, changing them to a much greater extent than they will be changed by climate.

Nevertheless, the models are informative and part of a growing body of knowledge that will help us understand how climate change will affect LVB ecosystems. The application of these tools in biodiversity conservation, vulnerability assessment, and adaptation is likely to increase, and as resolution increases, these tools will replace specialized modeling exercises for local studies (Seimon et al., 2013).

3.6 IMPACTS OF CLIMATE CHANGE ON HUMAN INTERACTION WITH ECOSYSTEMS IN LVB

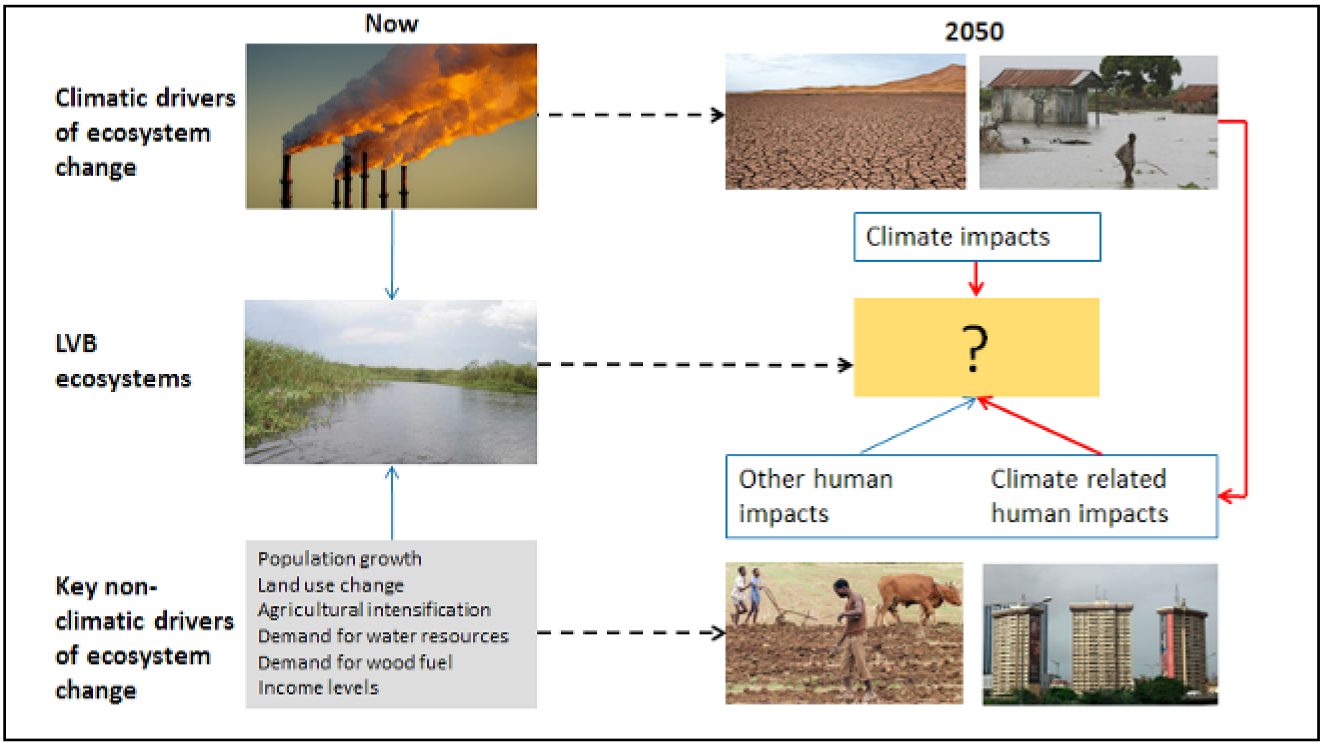
Since the beginning of the 20th century, the land around Lake Victoria has been transformed from forests, savannah, and grasslands to a landscape dominated by cropping and pasture for livestock. As discussed in Chapter 2, rapid population growth through immigration started a pattern of large-scale deforestation and agricultural conversion in the 1930s with the completion of the Uganda railroad (Verschuren et al., 2002). Humans have already had a profound effect on LVB ecosystems. Today, there are strong socio-economic drivers operating in the LVB. If current trends continue, the basin and its ecosystems will be very different by the time more severe climate impacts are felt in the second half of the 21st century.

The impact of climate change on ecosystems by 2050 will be determined in a large part by the impact of human activities on ecosystems. For example, ecosystems that are already heavily degraded are more likely to suffer from climate change than ecosystems that are relatively untouched. Climate change impact studies tend to avoid this additional complexity for understandable reasons. Predicting future climate impacts on ecosystems are already complex enough; predicting future human impacts on ecosystems are even more challenging.

Human impacts on ecosystems are in part driven by climate change, particularly during times of climate stress (e.g., drought and flood) (see Figure 28). Future climate-induced changes in land use and human-driven transitions may have larger impacts on ecosystems than transitions associated only with climate shifts (Doherty et al., 2010).

Therefore, in order to understand how ecosystems will respond to climate change in 2050, it is also necessary to understand how people respond to climate change, and how that response affects their use of ecosystems. Climatic assessments should include how changing climate conditions will drive human response to such changes (Seimon et al., 2013), as shown by the red lines in Figure 28.

Figure 28. What will LVB ecosystems look like in 2050? The impacts of climatic and non-climatic drivers



Source: Doherty et al., 2010

3.7 EVIDENCE OF HUMAN IMPACTS ON ECOSYSTEMS RESULTING FROM CLIMATE DRIVERS

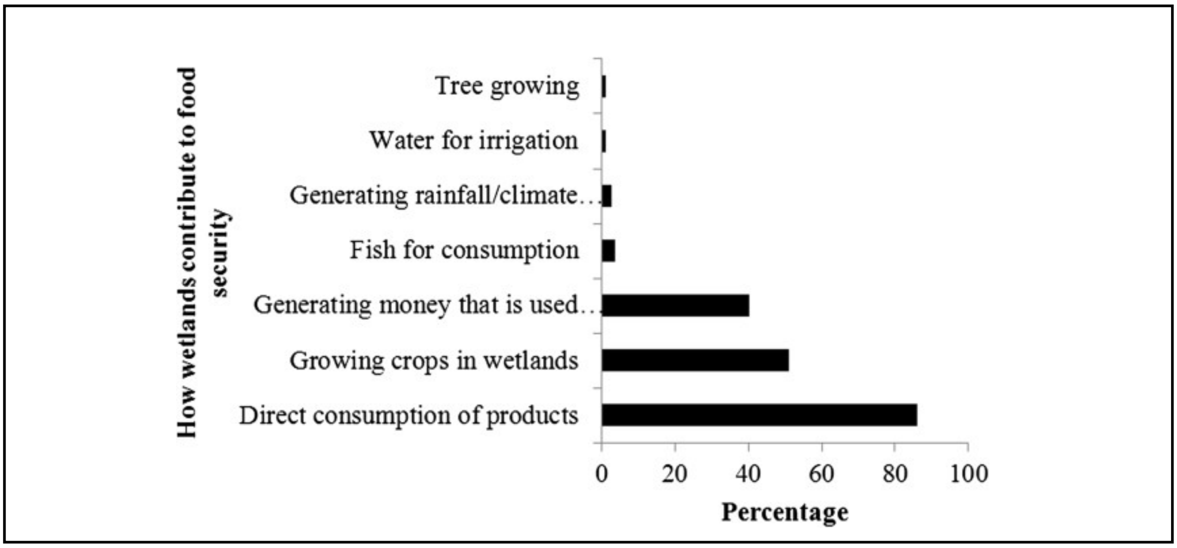
In times of drought, when crops and pastures fail and food supplies dwindle, and in times of flood, when people are displaced from their homes, natural ecosystems provide a valuable safety net. In this section, the published evidence for human impacts resulting in flood and drought on ecosystems is considered.

In the Kenyan part of the LVB, 70% of the population is engaged in agricultural activities, mostly as small-scale farmers. Most of these farmers rely on rain-fed agriculture, which increases their vulnerability to drought (Gichere et al., 2013). The droughts of 1984, 1994, and 2004 in the Nandi Hills and Forest devastated crops and livestock. Annual flooding caused by the conversion of wetlands, deforestation of the catchments, and destruction of the river embankments was also reported in the Nandi region (Tanui & Webb, 2012).

The result of these events was loss of personal assets, food insecurity, the displacement of people, and, in the worst cases, loss of life. These outcomes increase poverty in the basin, affecting livelihoods and resulting in detrimental impacts to ecosystems through mismanagement of the land and resources (Tanui & Webb 2012).

While all ecosystems are affected to some extent, wetlands are particularly susceptible. Wetlands are very important to the livelihoods of surrounding communities (Turyahabwe et al., 2013). During times of unpredictable weather, wetlands in Uganda may be relied upon to meet household food requirements (see Figure 29). Drought causes local communities to use wetlands as "safety nets" due to their retention of water, for crop and livestock farming (e.g. rice, yam, and sugarcane), and for gathering products for direct consumption (e.g., fish, bush meat, fruits, and vegetables). Current unpredictable rainfall means it is likely that wetlands will become increasingly important for meeting households' livelihood needs. It follows that increased human use of wetlands will affect wetland biodiversity, although the extent of this depends upon the intensity of use.

Figure 29. Ways in which wetlands contribute directly to household food security in areas adjacent to wetlands in Uganda



Source: Turyahabwe et al., 2013

Chumo & Agui (2012) identified a number of strategies that are used to cope with drought in the Kenyan part of the LVB. These include the following.

- ***Planting near river banks and lakeshores***: There is relatively high moisture near the river banks, sufficient to supply adequate moisture for hardy crops. This strategy is likely to cause significant damage to riparian ecosystems and wetlands.
- ***Use of alternative pasture***: Depending on the drought severities, cattle are currently moved as far as 20 km away from normal pastures during drought, and owners camp with their cattle. This strategy is likely to put pressure on natural ecosystems that contain pasture, low-level leaf matter and woody material that would be required for fuelwood. ***Use of rivers to provide water for irrigation:*** To enhance productivity and reduce the adverse impact of drought, rivers provide a reliable source of water for irrigation. Abstraction of river water for irrigation to cope with variability in rainfall patterns is likely to damage riparian ecosystems and wetlands further, although the projected increase in rainfall may offset the loss of water to large-scale irrigation projects to some extent.

Despite widespread recognition of the importance of ecosystems for coping with flood and drought, it was not possible to find any studies that attempted to link ecosystem use or degradation with individual flood or drought events for the LVB.

3.8 SCENARIOS OF FUTURE HUMAN IMPACTS ON ECOSYSTEMS IN RELATION TO CLIMATE CHANGE

Projecting future ecosystems is extremely challenging. However, a view on future ecosystem changes is central to sustainable ecosystem management and essential for the meaningful interpretation of climate change projections 20 to 80 years into the future. This section begins with a restatement of scenarios for 2025 developed by Odada et al. (2009). Their study is unique in providing future, evidence-based visions of the LVB, and is therefore extremely relevant to this chapter.

3.8.1 LVB IN 2025 WITHOUT CLIMATE CHANGE

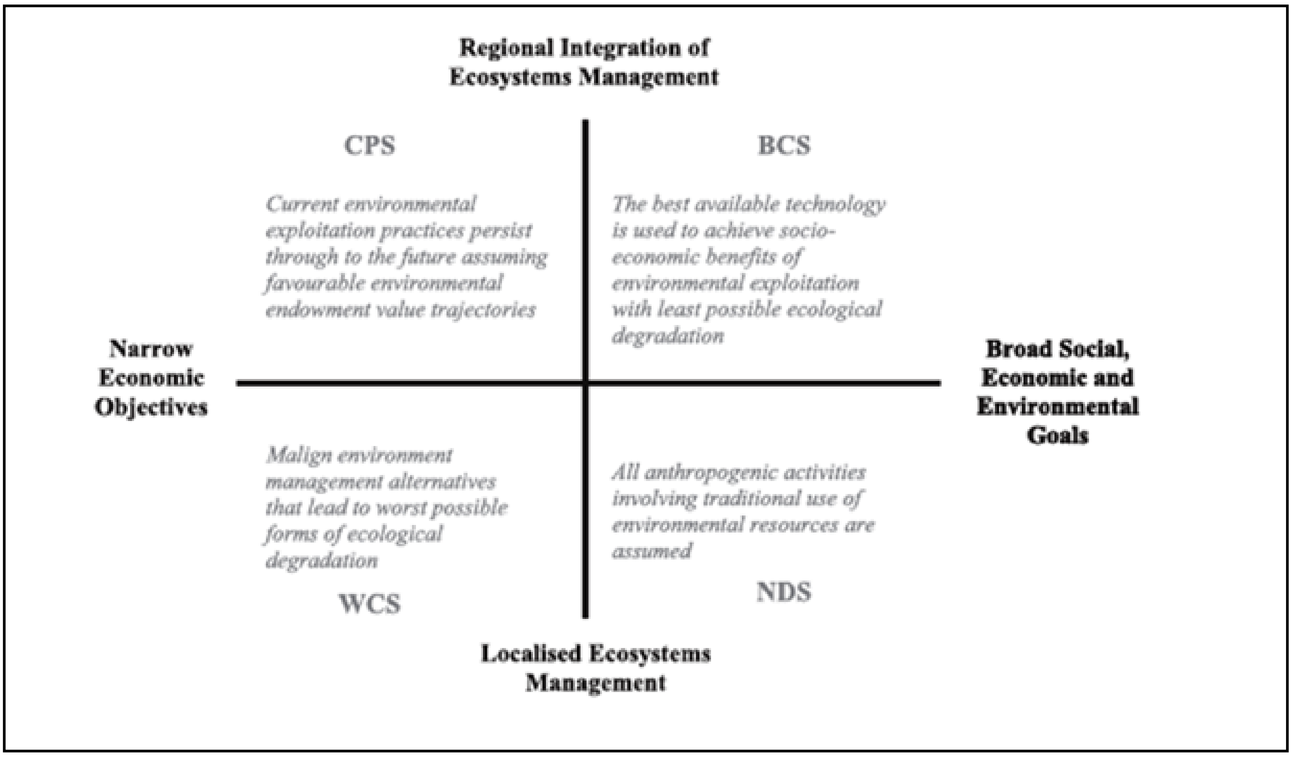
Odada et al. (2009) present a scenario methodology that helps our understanding of how socio-economic drivers can affect LVB ecosystems. It involves a systematic assessment of the future state of ecosystem integrity in the Lake Victoria Basin. Four scenarios have been illustrated as possible future states of the basin in 2025.

These include the no-development scenario (NDS), worst-case scenario (WCSC), the current-practices scenario (CPS) and best-practices scenario (BPS). The latter two assume a relatively high level of regional integration, including specific social, economic, and environmental policies to nurture it.

The WCSC is characterized by pessimism and apathy, neglect, and lack of socio-economic and environment accountability that must be avoided at all costs. The BPS, on the other hand, is characterized by optimism, socio-economic and environmental responsiveness, and an effort to achieve a balance between socio-economic development and environmental sustainability.

All scenarios show increases in agricultural and urban land uses and, except for the BPS, a decline in forest land. The result of the large increase in cropland and decline in forest and grassland areas is that great competition exists among land use types. The pressures toward increasing agricultural areas are counterbalanced by policy mechanisms that seek to limit overcultivation of cropland and conservation of PAs as well as intensification of agriculture for increased productivity. Deforestation would be heaviest in the WCSC and lowest in the BPS, occurring mainly in the frontier highlands of the lake basin. Extensive degradation would occur under the WCSC and CPS and primarily be centered on marginal lands closer to the lake.

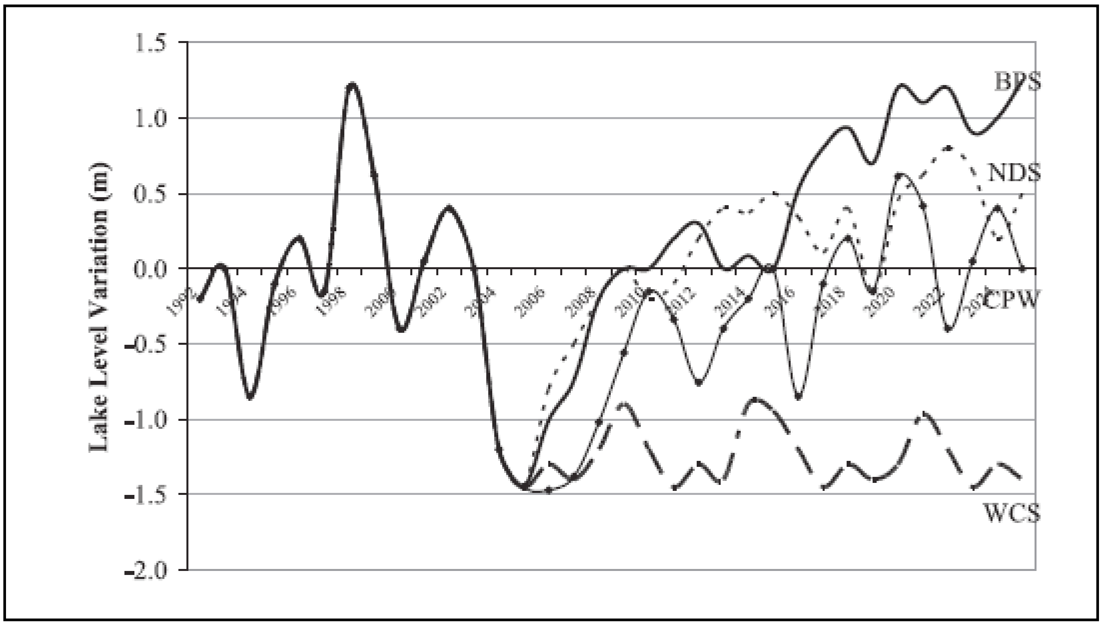
Figure 30. LVB scenario framework depicting the two critical uncertainties and underlying assumptions in each of the four scenarios



Source: Odada et al., 2009b

The current water level in Lake Victoria is below normal and the lowest since 1961. The changes in the water levels for future years are driven by rainfall trends; agricultural land use; industrialization around the lake; (hydroelectric) energy demands; ecosystem management strategies that affect inputs and evaporation; and Nile output and groundwater discharge that affects outputs (see Figure 31).

Figure 31. Projected relative variations in Lake Victoria water levels for the four scenarios



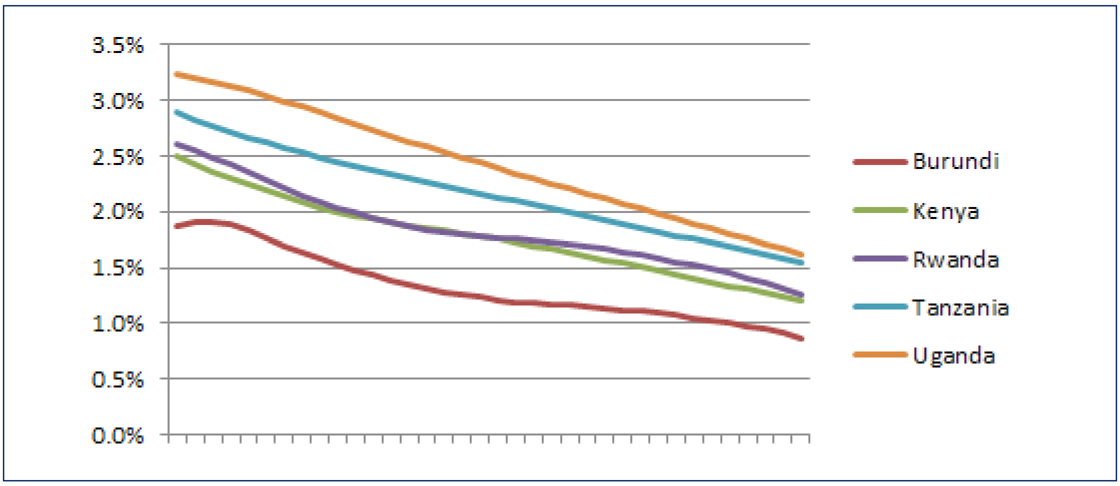
Source: Odada et al., 2009b

3.8.2 LVB IN 2050 WITHOUT CLIMATE CHANGE

The study by Odada et al. incorporates ecosystems into the development of scenarios, but does not set out specific scenarios for ecosystems. Furthermore, it does not look far enough into the future for the purposes of this chapter. Although current trends appear to indicate otherwise, the projections developed by climate modelers do not anticipate anthropogenic climate change to be noticeable above the background "noise" of climatic variation until 2040 to 2060. Therefore, we need to establish ecosystems scenarios for 2050.

Population growth is a characteristic common to all scenarios for 2050, and a considerable increase is anticipated. Growth rates in LVB countries vary considerably, but all are currently 1.5% to 3.5% per year (see Figure 32). These national averages conceal higher rates in parts of the LVB that have growth rates of more than 3% per year. Population growth without migration follows relatively predictable long-term trends. LVB trends may be distorted by immigration or emigration if the local economy performs more or less strongly than surrounding areas or in response to political instability and insecurity. These factors complicate population projections for 2050. However, it is expected that these distortions will alter the fact that 2050 population levels will be much larger than today's. Based on the trends in Figure 32, it is expected that the LVB population in 2050 will be around 70 million to 80 million.

Figure 32. Projected population growth rates from 2015 to 2050 for LVB countries



Source: UN Population Division, 2009

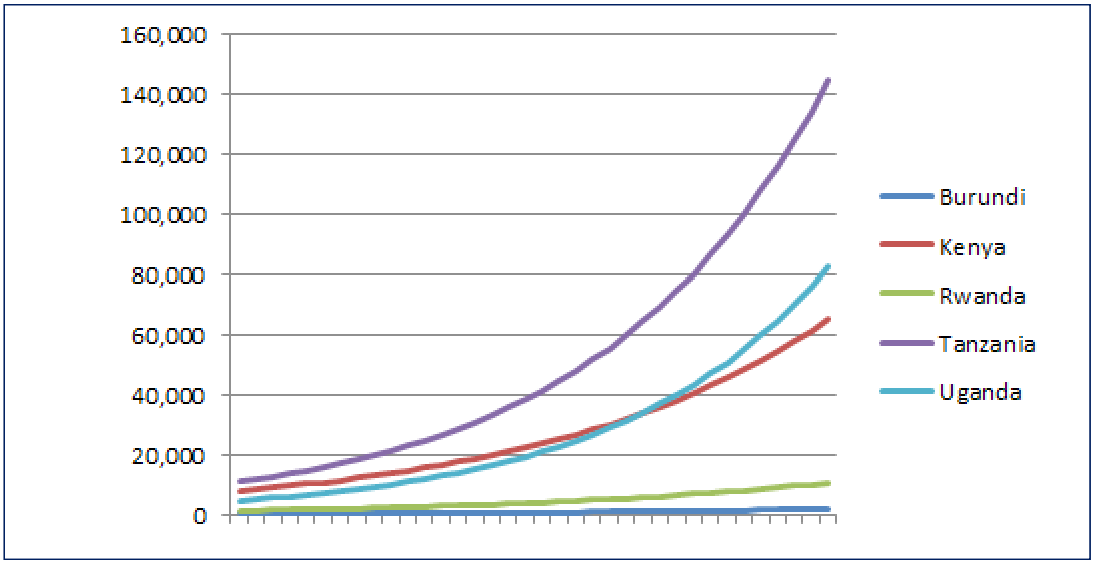
It is possible for rural areas to accommodate some of this population growth, but the carrying capacity of agricultural land is limited. Economic growth and employment opportunities tend to cluster around urban centers. It seems unlikely that the LVB will deviate from this trend. Historically, population increases have occurred principally in large towns. The growth in manufacturing industries (e.g., food processing) and the service sector has caused significant migration from the countryside to towns in the basin.

Farm sizes may be able to shrink further, but the trend cannot continue for much longer unless smallholders can supplement their income by other means. This may be possible around towns but is unlikely in most rural areas. Generating income in rural areas through remote working is feasible, but it requires a skilled workforce and appears unlikely to have a major impact on population distribution over the next 35 years. The small size of average smallholdings now appears to present a real constraint to the expansion of the LVB's rural population.

Therefore, for the reasons described above, the no-development scenario described in Section 3.8.1, characterized by minimal increase in built-up area, appears to be highly unlikely, and the no-development scenario is disregarded.

The path of economic development, on the other hand, is much more difficult to predict. Forecasts are based on extrapolations (Figure 33) that are very sensitive to a wide range of influences, including changes in demand for natural resources, new technologies, regulatory environments, and political stability. Therefore, the use of different scenarios of economic growth, as described in Odada et al., is sensible.

Figure 33. Projected GDP from 2015 to 2050 for LVB countries



Source: Data.worldbank.org, undated

Based on the information described above, the scenarios developed by Odada et al. have been further elaborated and extended to 2050 (see Table 10). Note that these scenarios ignore the impacts of climate change, which are considered in the next section.

Table 10. Scenarios for LVB ecosystems in 2050 (without climate change)

CURRENT-PRACTICES SCENARIO FOR 2050	BEST-CASE SCENARIO FOR 2050
Socio-economic context There is a concentration of wealth in a few large cities around the lake. As a result, there is significant rural-urban migration. Smallholders in rural areas struggle to make a living but are able to fall back on well-managed ecosystem resources during climate extremes. Intensification of agriculture has reduced soil fertility and increased fertilizer application. However, soil conservation and watershed-management schemes have helped limit soil erosion and diffuse pollution of water courses. The management of PAs has been well funded, and exploitation of natural resources for economic growth has been regulated. In general, the demand for resources from the rural poor can be met through well-managed natural resources.	*Socio-economic context* As a result of effective planning and strategic infrastructure development, population has expanded in both cities and provincial towns around the lake. There is significant rural-urban migration, but to multiple destinations. Employment opportunities throughout the basin have taken the pressure off rural areas. Smallholder farm size has increased, and most no longer need to fall back on ecosystem resources during climate extremes. Some consolidation of farms has taken place, increasing productivity. New technology coupled with soil conservation and watershed management schemes have limited loss of soil fertility; soil erosion; and diffuse pollution of water courses. The management of PAs has been well funded, and exploitation of natural resources for economic growth has been regulated. The demand for resources from the rural poor can be met through well-managed natural resources.
Terrestrial ecosystems (forests, savannahs, grasslands) Degradation and loss of natural forests has reduced the number of viable ecosystems around large towns and cities, due to demands of a growing population for fuel wood and agricultural land. Some parts of the savannah ecosystems near urban areas have lost to livestock, and grasslands here have been overgrazed. However, designated PAs away from urban areas have been conserved with limited encroachment.	*Terrestrial ecosystems (forests, savannahs, grasslands)* Natural ecosystems around urban areas are highly valued for their recreational potential and have been expanded, using areas of degraded land. Fuel wood plantations have been established and new electricity generation technologies introduced so that pressure on forests and woodlands has been removed. Timber plantations have been established to meet demand for construction materials. Savannah ecosystems are highly valued for tourism, and revenue-sharing mechanisms have reduced incentives for unsustainable grazing.
Wetlands Many wetlands have been converted into agricultural land, particularly around urban areas. However, the importance of wetland ecosystems is now recognized, and remaining areas are well protected. Effective community management schemes have reduced conversion to agriculture.	*Wetlands* The importance of wetland ecosystems is recognized, and all areas are well protected. Effective community management schemes, coupled with improved incomes, have prevented conversion to agriculture.
Aquatic ecosystems (lakes and rivers) Lake Victoria and its tributaries are more polluted than in 2014, but better land management has restricted growth in diffuse pollution, and regulation of effluent from domestic and manufacturing sources limited the problem. Abstraction is also regulated to a sustainable level, and lake levels have been maintained. Sedimentation around the lake edge has increased somewhat. Incidences of algal blooms and fish kills are occasional, but ecosystem productivity has been maintained.	*Aquatic ecosystems (lakes and rivers)* Pollution of Lake Victoria and its tributaries is falling. New technologies and better land management have restricted growth in diffuse pollution, and regulation of effluent from domestic and manufacturing sources limited the problem. Abstraction is also regulated to a sustainable level, and lake levels have increased. Sedimentation around the lake edge is minimal, and incidences of algal blooms and fish kills are rare.

CURRENT-PRACTICES SCENARIO FOR 2050	BEST-CASE SCENARIO FOR 2050
Socio-economic context There is a concentration of wealth in a few large cities around the lake. As a result, there is significant rural-urban migration. Smallholders in rural areas struggle to make a living, exacerbated by exposure to climate disasters. Intensification of agriculture has reduced soil fertility and increased fertilizer application. This has led to severe soil erosion and diffuse pollution of water courses. The management of PAs has been neglected as policies have focused on exploitation of natural resources for economic growth. The demand for resources from the rural poor means that local support for conservation is low.	*Not considered*
Terrestrial ecosystems (forests, savannahs, grasslands) Degradation and loss of natural forests has significantly reduced the number of viable ecosystems in all accessible parts of the LVB, due to demands of a growing population for fuel wood and agricultural land. Large parts of the savannah ecosystems lost to livestock and grasslands have been overgrazed. Protection is effective only in the most remote areas.	*Not considered*
Wetlands Most wetlands have been converted into agricultural land in order to boost rural incomes. Protection is effective in only small, well-guarded areas.	*Not considered*
Aquatic ecosystems (lakes and rivers) Lake Victoria and its tributaries have become heavily polluted. In addition to diffuse pollution, effluent from domestic and manufacturing sources has become a growing problem. Poorly regulated abstraction means that lake levels are down. Sedimentation around the lake edge has increased significantly. Incidences of algal blooms and fish kills are frequent. Ecosystem productivity is very much reduced.	*Not considered*

3.8.3 LVB IN 2050 WITH CLIMATE CHANGE

In this section, a climate change scenario is added to the above scenarios for human impacts on ecosystems. The analysis covers only the human impacts on ecosystems caused by climate change or indirect impacts, not the direct impacts.

The evidence indicates that the features of a 2050 climate would include higher average temperatures, a slight increase in average rainfall, and more climate variability, which would indicate greater frequency of droughts and floods. This simplified climate scenario is used because the incorporation of more detail will not improve the quality of combined scenarios. The aim is to demonstrate an important constituent of climate impact analysis that has been absent from a vast majority of published climate impact studies.

The elaborated scenarios for LVB ecosystems (based on Odada et al., 2009b) provide the inputs for this analysis. These scenarios are subjected to the climate-change scenario described above, and possible effects have been noted (see Table 11). As with any scenario, these effects are not predictions, but they form part of a possible future situation that has some justification and internal consistency.

The modified scenarios (in Table 11) highlight the importance of the socio-economic context for 2050 in understanding climate impacts of 2050. In the worst-case scenario, the relative poverty of LVB inhabitants and lack of environmental management lead to serious adverse consequences. In the BCS, effective environmental management and the use of new technologies create a climate-resilient population that in turn takes much of the human-induced pressure off all ecosystems. Looking at the effects on ecosystems across all scenarios, wetlands appear to be most at risk to the human response to climate change by virtue of their accessibility and proximity to the large population centers that cluster around the lake. As mentioned above, wetlands in the LVB provide an essential purification function for water entering Lake Victoria and play an important role in water regulation, particularly in the Mara and Yala wetland systems.

Table 11. Outcomes produced by incorporating climate change into scenarios for LVB ecosystems in 2050

	WORST-CASE SCENARIO	CURRENT-PRACTICES SCENARIO	BEST-CASE SCENARIO
Terrestrial ecosystems	Increase in drought and flood frequency increases dependency on ecosystems. The impact on already heavily degraded ecosystems greatly accelerates loss throughout the LVB.	Increase in drought and flood frequency increases dependency on ecosystems around urban areas. The impact on already heavily degraded ecosystems greatly accelerates local loss.	Increase in drought and flood frequency has little (human) impact on ecosystems as income levels are sufficiently high for most households to cope without them.
Wetland ecosystems	Increase in drought frequency increases encroachment on the few remaining areas, leading to the loss of most wetlands.	Increase in drought frequency increases encroachment on remaining wetlands in rural areas, leading to degradation.	Increase in drought frequency has little impact on wetlands as income levels are sufficiently high for most households to cope without them.
Aquatic ecosystems	Increase in intensity of rains and runoff exacerbates (a) soil erosion, leading to increased sedimentation of the lake and (b) diffuse pollution of watercourses, increasing lake nutrient load. Demand for food during drought leads to overfishing of already-dwindling stocks.	Increase in intensity of rains and runoff causes localized soil erosion, leading to increased sedimentation of the lake. Demand for food during drought leads to occasional pressure on fish stocks. Increased abstraction during drought is counter-balanced by increased rainfall.	Increase in intensity of rains and runoff has little effect on soil erosion, due to effective land management practices. Sustainably managed fish stocks are adequate to provide food during drought. Increased abstraction during drought is counter-balanced by increased rainfall.

From recent scenarios, it seems likely that the October to December rains will increase and that variability will increase (see Table 12). There is much less uncertainty over projections of future temperature rises.

Table 12. Summary of rainy season precipitation projections from the models discussed in this paper

TIMEFRAME	SEASON	CMIP5	CMIP3	PRECIS
Early to mid-century	Short rains	Increase (relative to 1980-2000 average)	-	-
Early to mid-century	Long rains	-	-	-
Mid-century	Short rains	Increase (total rainfall and rainfall intensity; relative to 1980-2000 average)	Increase (magnitude and duration; relative to 1981-2000 average)	-
Mid-century	Long rains	-	Decrease (relative to 1981-2000 average)	-
Late-century	Short rains	-	-	Decrease (relative to 1961-1990 average)
Late-century	Long rains	-	-	Increase (relative to 1961-1990 average)

There is plenty of scope for speculation but little evidence to indicate conclusively how the ecosystems that are found in the LVB will respond to climate changes. Building on the work of Odada et al. (2009), it is possible to highlight just how important socio-economic conditions are in the human response to climate change and its subsequent effect on ecosystems. For example, the damage caused under a future scenario with narrowly focused economic objectives and poor environmental management is far more severe than the damage caused under a future scenario with broad social and economic goals, intelligent use of technology, and integrated environmental management aims.

Based on the evidence described, it is unrealistic to predict how particular ecosystems will respond to climate change. However, it is possible to draw some general conclusions:

- Given population growth rates and agriculture's dominance on the landscape, trying to understand ecosystem response to climate change purely based on species' physiological responses to temperature and rainfall variables makes little sense. It can only lead to a distorted and unrealistic view of the future that, in turn, will lead to inappropriate adaptation strategies for ecosystem management.
- Socio-economic scenarios help us understand the importance (or otherwise) of the human response to climate change on ecosystems. They also help us understand the range of possible adaptation measures required. In terms of ecosystem management, implementing adaptation strategies that cannot deal with a range of plausible scenarios is a gamble. Robust and cost-effective strategies will be able to cope with all plausible scenarios.
- Wetland ecosystems appear to be particularly susceptible to combined climate change impacts. Their accessibility, proximity to human populations, sensitivity to lake levels, and sensitivity to intra-annual variations in rainfall leave them exposed to irreversible degradation.
- In comparison with the many existing drivers of ecosystem change, which are leading to degradation and loss of ecosystems across many parts of the LVB, the impacts of climate change may not be particularly significant during the first half of the 21st century. However, the possibility of substantive changes to ecosystem structure and composition remains, and the probability of this increases toward the end of the 21st Century, when critical temperature or evapotranspiration thresholds may be reached.

4.0 THREATS FRAMEWORK RELATED TO BIODIVERSITY CONSERVATION IN THE LVB

This chapter provides an analysis of threats that directly affect conservation outcomes and the ecosystem's integrity, as well as their root causes and drivers. The chapter also describes the status of species and sites that were prioritized based upon criteria that accorded greater weighting to ecosystem values and a set of globally agreed-upon scientific criteria. The past and present geographic, climatic, and biological features of the hotspots, dominant habitats, and ecological processes present are dealt with elsewhere in the report.

Worldwide, ecosystems and habitats are in rapid decline, and extinction is possible for many species. One-quarter of plant species are estimated to be threatened with extinction. The Millennium Ecosystem Assessment concluded that coral reefs are deteriorating most rapidly, while forest fragmentation and degradation continue at an alarming rate. Amphibians are facing the greatest risk as a group, and vertebrate species whose populations have been assessed declined by nearly one-third between 1970 and 2006, especially in the tropics and fresh waters. Global biodiversity has declined by more than 25% in the last 35 years, according to the WWF. The Living Planet Index shows an overall decline in population trends in nearly 4,000 populations of wildlife between 1970 and 2005. The Third Global Biodiversity Outlook concluded that the benchmarks set in 2002 had not been met by 2010.

Accordingly, the CBD has re-focused its work on five strategic goals, guided by a number of benchmarks as outlined in the Aichi Targets, and adopted during the 10th meeting of the Conference of the Parties in October 2010. Five direct threats are the principal drivers of biodiversity loss. These include:

- Habitat change through conversion to cropland, urban areas, and other human-dominated landscapes;
- Overexploitation or unsustainable harvesting of economically valuable species;
- Pollution of the water, land, and air;
- Alien invasive species, including pests and disease pathogens; and
- Environmental change-shifts in climate, increasing in intensity with human ecological footprints.

All five global biodiversity threats are well reflected in the LVB and are summarized in the following sections. While the best-known threats to species in the region impact fish, a large number of species from other taxa are similarly impacted. As discussed in Section 1.4.2, many of the 419 trigger species that CEPF used to identify the KBAs in the Great Lakes Region of Africa are to be found in the LVB (Birdlife International, 2012). A partial list is presented in Table 13.

Table 13. KBA trigger species found in the LVB

TAXONOMIC GROUP	SCIENTIFIC NAME	COMMON NAME	RED LIST CATEGORY	RED LIST YEAR	AZE SPECIES	STRICT ENDEMIC	VULNERABILITY	IRREPLACEABILITY	BIOLOGICAL PRIORITY[1]
Amphibian	***Leptopelis karis-simbensis***	Karissimbi forest treefrog	EN	2004		Y	2	2	**2**
Amphibian	***Petropedetes dutoiti***	Du Toit's torrent frog	CR	2004	Y	Y	1	1	**1**
Amphibian	***Phrynobatrachus bequaerti***	Vissoke river frog	VU	2004		Y	3	2	**3**
Bird	***Apalis karamojae***	Karamoja apalis	VU	2008		Y	3	3	**4**
Bird	***Ardeola idae***	Madagascar pond heron	EN	2008			2	3	**3**
Bird	***Balaeniceps rex***	Shoebill	VU	2008			3	4	**4**
Bird	***Bradypterus graueri***	Grauer's swamp warbler	EN	2008		Y	2	3	**3**
Bird	***Chloropeta gracil-irostris***	Papyrus yellow warbler	VU	2008			3	3	**4**
Bird	***Cisticola aberdare***	Aberdare cisticola	EN	2008		Y	2	3	**3**
Bird	***Cryptospiza shelleyi***	Shelley's crimsonwing	VU	2008		Y	3	3	**4**
Bird	***Eremomela turneri***	Turner's eremomela	EN	2008			2	2	**2**
Bird	***Hirundo atrocaeru-lea***	Blue swallow	VU	2008			3	4	**4**
Bird	***Macronyx sharpei***	Sharpe's longclaw	EN	2008		Y	2	3	**3**
Bird	***Muscicapa lendu***	Chapin's flycatcher	VU	2008		Y	3	3	**4**
Bird	***Phoeniconaias minor***	Lesser flamingo	NT	2008			4	2	**3**
Mammal	***Acinonyx jubatus***	Cheetah	VU	2008			3	4	**4**

TAXONOMIC GROUP	SCIENTIFIC NAME	COMMON NAME	RED LIST CATEGORY	RED LIST YEAR	AZE SPECIES	STRICT ENDEMIC	VULNERABILITY	IRREPLACEABILITY	BIOLOGICAL PRIORITY[1]
Mammal	***Crocidura allex***	East African highland shrew	VU	2008			3	2	**3**
Mammal	***Crocidura fumosa***	Smoky white-toothed shrew	VU	2008			3	2	**3**
Mammal	***Diceros bicornis***	Black rhinoceros	CR	2008			1	4	**3**
Mammal	***Gorilla beringei***	Mountain gorilla	EN	2008			2	2	**2**
Mammal	***Loxodonta africana***	African elephant	VU	2008			3	4	**4**
Mammal	***Lycaon pictus***	African wild dog	EN	2008			2	4	**3**
Mammal	***Otomys barbouri***	Barbour's vlei rat	EN	2008		Y	2	1	**1**
Mammal	***Pan troglodytes***	Common chimpanzee	EN	2008			2	3	**3**
Mammal	***Panthera leo***	Lion	VU	2008			3	4	**4**
Mammal	***Praomys degraaffi***	De Graaff's praomys	VU	2008			3	2	**3**

Note: according to IUCN Red List, EN means endangered; VU, vulnerable; CR, cricially endangered; and NT, near threatened.

4.1 RAPID POPULATION GROWTH AND POVERTY

Over the last few decades, the LVB has undergone substantial changes that can be attributed to several major causes. The human population density within 100 kilometers of the shoreline is estimated to have grown from 60 per km^2 in 1960 to more than 245 per km^2 in the 1990s, higher than national averages. Annual growth rate is about 3% per year (Gitau et al., 2010). This growth rate-far faster than food production-presents an overarching threat to the region's biodiversity, and is the source of all other threats.

Most of the inhabitants of the LVB are farmers (e.g., an average of 73% for Tanzania). Despite the abundant land and fisheries resources, the inhabitants of the lake region are among the poorest in the region. It is estimated that over 50% of the total population in the Basin lives under the poverty line. Countries with the highest levels of poverty include Burundi and Rwanda, which stand at 62% and 60%, respectively (LVBC, 2007). High poverty rates lead to an unsustainable use of resources.

The continuous decline of household land size and cultivated land per person constitutes a threat to food security, especially where rural populations depend on local land resources for their livelihoods. Land resources in the LVB present inhabitants and their development partners with monumental paradoxes. For example:

- Enormous natural resource wealth with potentially high endowment value, yet a majority of the people live in abject poverty.
- The LVB contains incredible land use diversity, yet the ecosystems are fragile and easily degraded by unsustainable land use.

In addition, there has been an increase in land use conflicts, especially by cultivators and livestock grazing. This situation has been accelerated by the rapid expansion of farming activities into the traditional grazing areas mostly due to population pressure.

As human numbers continue to swell, land for cultivation continues to dwindle, wind and water erode fertile soils, and livelihoods become more precarious. Growth in numbers is not the only concern, and threats to sustainability emanate from inequality of access to resources. There is no doubt that persistent pressure on resources associated with increased population amplifies the risk of environmental damage. Even if a massive reduction were to occur in the proportion of people living in poverty, absolute numbers would still continue.

Equally important are the negative implications of under-resourced institutions and a legacy of ineffective policies and legislation or their poor implementation. The situation will continue to put pressure on biodiversity and be the focal point around which most other threats revolve.

4.2 LAND COVER CHANGE, WATER QUANTITY AND QUALITY

Rapid population growth is regarded as the underlying cause of human-induced aquatic impacts in the catchment area (Hecky, 1993). These include the rapid expansion of towns and cities, increasing road construction, discharge of untreated municipal and industrial effluents, and encroachment on wetlands (Hecky, 1993; Cohen et al., 1996; Bugenyi & Balirwa, 1998; Crul, 1998; Kairu, 2001). The intensity of this growth is attributed to the struggle for riparian communities to have greater economic prosperity (World Bank, 1996).

Poor land management practices in the LVB have resulted in large areas experiencing severe soil erosion. As described in Section 2.1.6, soil erosion losses are lowest for perennial horticultural areas and highest for annual crops due to the lack of ground cover maintenance (Majaliwa et al., 2001). In addition, cropping areas often extend down to streams and lake edges, eliminating riparian buffer vegetation (i.e., wetlands). Forested areas surrounding the lake have been cleared for settlement and agricultural activities. Scheren et al. (2001) indicated that land utilization in the basin including increase in cultivation and overgrazing has a high impact on nutrient loading to the lake, thereby contributing to eutrophication.

4.3 HABITAT LOSS, DEGRADATION, AND FRAGMENTATION

Contingent on human population growth, habitat loss, degradation, and fragmentation rank highest among the dominant threats to LVB's biodiversity, seriously imperiling many known and unknown globally threatened species. Habitat loss occurs in a variety of ways, most prominently during vegetation clearing but also with more subtle alterations of ecosystem compositions. Assemblages of species and their interactions are altered when lands are converted, leading to reduced diversity at all levels. In many parts of the LVB, including arable and forested areas like the Mara and Mwanza regions, in the past few decades, have seen a substantial human influx due to subsistence farming opportunities.

Some of the underlying causes include the spread of urban development, road and rail networks, and industrial areas. These come along with associated problems, such as noise and pollution; abandonment of agricultural practices that were favorable to biodiversity; and the spread of invasive species (especially plants) through new road networks and the movement of earth-moving equipment between countries by foreign contractors.

Habitat loss diminishes the ability of the land and water resource base to maintain species density and diversity. The capacity to sustain natural ecological processes is also severely reduced. Fragmentation leads to the loss of migration routes for large mammals and connectivity between habitats. This exposes species to the deleterious impacts of ecological segregation and island biogeographic processes.

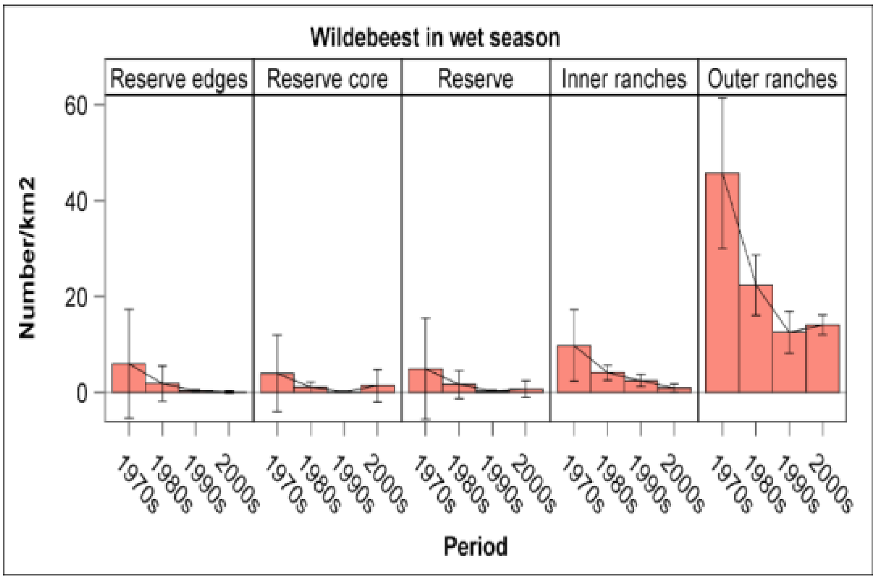
Habitat loss is best exemplified by the Yala swamp (Figure 34) and resident wildebeest population trends in the Mara (Figure 35). Drainage of the Yala has been ongoing since the mid-1960s, with a significant portion of the swamp's original 17,500 hectares converted to crop land.

Figure 34. Satellite images showing the transformation for the Yala Swamp due to drainage and irrigation from 2002 to 2008

Source: UNEP, 2008

Even when there is no apparent physical loss, serious fertility decline and massive soil erosion have occurred, leading to reduced land productivity. Agricultural expansion, poor farming, and animal husbandry methods further exacerbate this problem. Overstocking and overgrazing are responsible for most of the diminished land productivity in the rangelands. As a result, crop yields are on the decline, and rivers, dams, lakes, and the Indian Ocean are experiencing severe sedimentation.

Figure 35. Trends of wildebeest in the Mara indicating continued decline of the resident population from the 1970s to the 2000s



Source: Ogutu et al., 2011

4.4 EXPANSION OF AGRICULTURE

Agriculture and livestock production remain the main sources of livelihood for the majority of people in the LVB, with the exception of people closest to the main lake who rely on fishing. The average landholding per rural household has dropped to less than one-half hectare in some of the population hotspots.

As discussed in Chapter 2, agricultural expansion has led to serious land degradation and massive soil erosion, driven by poor farming methods. Crop yields are on the decline, and rivers, dams, and lakes are experiencing severe sedimentation. Excess use of fertilizer and pesticides, raw sewage, domestic waste, deposition of heavy metals along roads, and effluents from industry are some of the major pollutants. Most of the agrochemicals find their way into water bodies, causing serious pollution and eutrophication.

Irrigation is expanding with little investment in optimal water use. Inappropriate crops impose especially unique demands, such as large-scale land conversion to make up for low harvests. Chemical overload, especially in high agricultural potential areas, is causing an unacceptable loss of pollinators (e.g., bees) and other biodiversity, including soil-enriching microbes. Poor livestock husbandry, overstocking, and overgrazing are exacerbating the land degradation problem.

4.5 OVEREXPLOITATION OF BIOLOGICAL RESOURCES

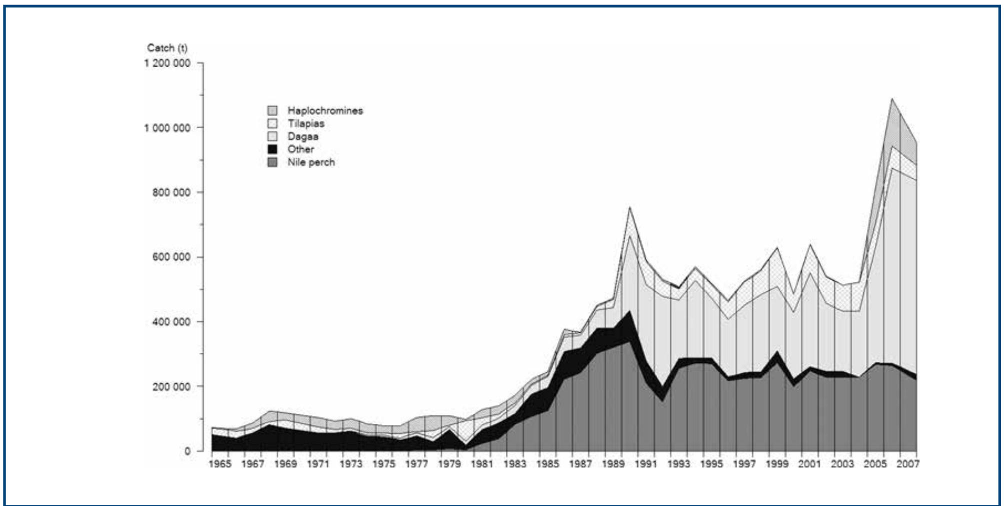
Overharvesting of species is a main cause of biodiversity loss throughout the region. Industrial fishing, use of small mesh sizes, increased demand on target species, and wasted bycatch are some of the main causes of overharvesting in the LVB. Overexploitation can take several forms, ranging from meat and trophy hunting to overgrazing, tree cutting, extraction of wetland plants, and fuel wood and charcoal production. Overgrazing is the single biggest factor causing land degradation, loss of plant production, and ecological change in pastoral lands, whereas tree cutting and charcoaling have a large impact on forests and woodlands. Extensive areas around towns and settlements have been stripped of woodlands and bushlands that are often replaced by invasive plants.

Poaching and uncontrolled harvesting of wildlife are major contributors to the decline of biodiversity. The seriousness of poaching is well known, especially in relation to elephants and rhinoceroses. Poaching for bush meat and trophies has been responsible for precipitous declines in several species over the last 30 to 40 years.

Less well documented is the illegal harvesting of plant species threatened by overharvesting and illegal trade such as the red stinkwood (***Prunus africana***) used to treat prostatic conditions, and the African sandalwood tree (***Osyris lanceolata***), exploited for its scented wood and essential oils used in perfumes.

Overfishing has been identified as one of the multiple stressors that were clearly manifested in Lake Victoria in the early 1980s (Hecky et al., 2010). The number of fishermen and fishing vessels on the lake increased by a factor of 5 and 6, respectively, between the 1970s and 2004 (Hazenoot, 2012; Kolding et al., 2008) (Figure 36)

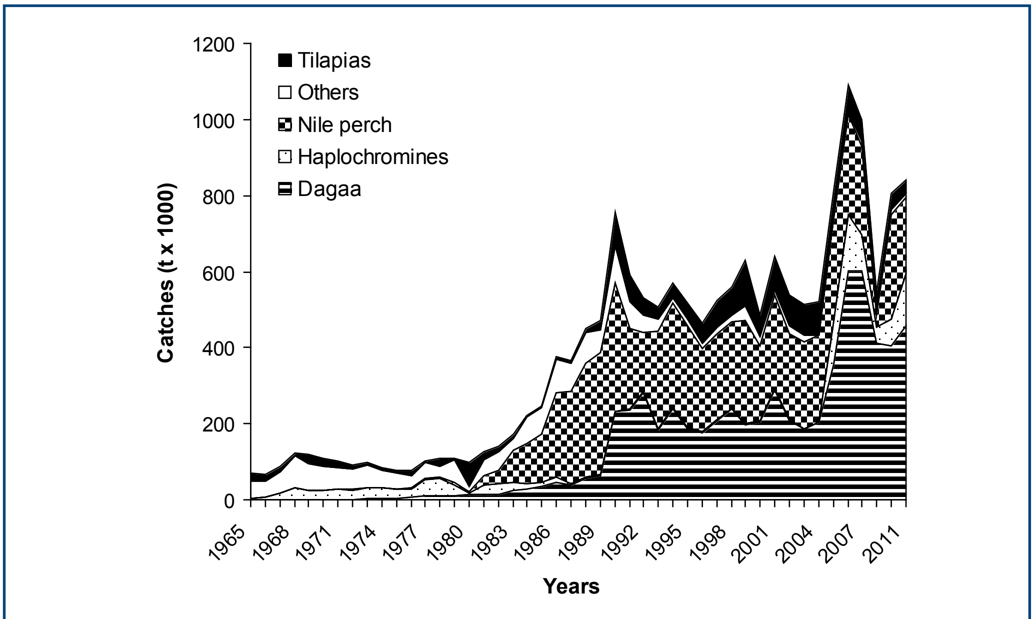
Figure 36. Total fish catch of major species and groups of species in Lake Victoria between1965 and 2007 under the influence of multiple stressors



Adopted from Hecky (2010), using data from Kolding et al. (2008). Source: Freshwater Biology. pages 19-42, 15 Jan 2010 DOI: 10.1111/j.1365-2427.2009.02374.x - http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2427.2009.02374.x/full#f1

The lake is one the world's most productive freshwater fisheries, worth US$ 600 million a year. Over 28 genera and around 350 species of fish had been observed in the lake in the 1950s, of which more than 300 were haplochromine cichlids (Greenwood, 1974). It has since been estimated that 200 species have been driven extinct, largely due to Nile perch predation (see Figure 37).

Figure 37. Fishery trends in Lake Victoria: 1965-2011



Sources: Kenya Marine and Fisheries Research Institute and Lake Victoria Fisheries Organization

Pressure on Lake Victoria fisheries has led to the dominance of the invasive Nile perch. During the period before Nile perch was introduced (1960s to early 80s), the lake had annual fish catches below 100,000 tons. At the Nile perch peak (mid-1980s to early 1990s), fishing increased to more than 600,000 tons annually. During the Nile perch boom (post-2000)-with dagaa dominating in landings-total catch approximated 1 million tons annually.

In some places, the pressure from unplanned tourism is starting to be felt. The decimation of elephants, intensifying human-wildlife conflicts, overexploitation of water resources, and increasingly frequent drought exacerbates the impacts of these threats, a trend that is expected to worsen with climate change.

4.6 WETLAND DEGRADATION

In recent years, enormous pressure has been placed on water and wetland resources driven by rapidly expanding populations; deforestation, agricultural intensification, pollution, and inadequate institutional frameworks are major contributors.

A number of studies on the threats to LVB wetlands are unanimous on the main causes of loss and degradation. Kassenga (1997) reported that policy deficiencies, poor planning, limited information and awareness, and institutional weakness as the main threats in Tanzania. Other studies on wetland use in Kenya and Uganda revealed that the key concerns and obstacles to conservation include:

- Conversion to other uses, thus destroying flood buffers and resulting in siltation, pollution, biodiversity and floods;
- A scarcity of agricultural land;
- Condemnation of wetlands as a breeding ground for mosquitoes;
- Decline in fish catches and preferred fish species in the rivers and lakes;
- Poverty and lack of employment opportunities;
- Ill-defined wetland boundaries;
- Unsustainable resource harvesting;
- Low awareness of wetland economic values and ecological functions;
- Inadequate legislation enforcement and compliance;
- An increase in water hyacinth; and
- Climate change, which may also threaten the hydrological regime of wetlands.

These threats affect both the quantity and the quality of the water resources in the basin, and cause the loss of some or all of the ecosystem services. Some of the most obvious impacts include decreased groundwater recharge, decreased buffering capacity of wetlands against floods, the loss of filter functions to absorb and degrade pollutants, and decreased water quality. Others are the destruction of natural habitats for wetland-related organisms and the disappearance of breeding grounds for fish.

4.7 CHANGING CONSUMPTION PATTERNS

The emergence of toward consumerism is threatening to outstrip the supply of most natural resources. Waste disposal and pollution are growing environmental hazards due to a rapidly expanding material culture. The threats will continue to grow as some countries in the region strive to move toward middle-income status between 2030 and 2050.

In addition, changing lifestyles have been observed in the Mau forest, where communities that were traditionally hunter/gatherers are now changing to agriculture as a means of livelihood. This exacerbates the threats on forests as they seek to cultivate in fertile areas.

Although most of the wastes generated are still organic, and therefore biodegradable, significant and increasing amounts of municipal and industrial disposal create problems for human health, species, and ecosystems.

Examples include disposable plastic bags and bottles (sometimes forming "reefs" of plastic pollution on the edges of the lake and its satellites) and water- and air-borne pollutants released from industrial, domestic, and agricultural sources, including exhaust gases, charcoal and fuel wood emissions, heavy metals, toxins, pesticides, and fertilizers.

4.8 CLIMATE CHANGE

Climate change, as discussed in Chapter 3, is another major challenge to species in particular, and biodiversity in general. The full unraveling of climate change, expected to involve more rainfall over much of eastern Africa, could lead to improved conditions for crop cultivation and could enhance pressure from land use change, thereby exacerbating other threats to biodiversity. In the region, however, it is difficult to separate possible climate change impacts from the effects of natural climatic variability and the consequences of overexploitation of natural resources.

Most climate projections indicate that, on average, annual temperature is likely to rise by 1–4°C by the end of the century. Rainfall is projected to increase, with the LVB likely to become wetter in both rainy seasons. Consequently, floods, erosion, and drought events are likely to increase in both frequency and severity (Stockholm Environment Institute, 2009). Wetland formation and development are influenced by climate. Some wetlands that have formed in wetter and cooler climates may no longer be stable under current or possible future conditions. Climate change would also make wildlife populations prone to new diseases.

In light of the importance of climate change to biodiversity, any new conservation options should acknowledge that there may be a complete shift in livelihood strategies in some communities due to climatic variations. As such, communities need to be assisted in developing appropriate adaptation actions integrating climate risk information, so that environmental and social integrity is not compromised in the end.

4.9 INVASIVE ALIEN SPECIES

Invasive species is another pervasive problem in conserving biodiversity in the LVB. A number of species have recently emerged as particularly serious threats. The main cause of species invasion is international trade and transport including roads, railways, lakes, rivers; exotic trees introduced in forestry; gardening practices; climate change; and exotic pests and pets released into the wild.

The tick berry (***Lantana camara***) has already invaded a number of PAs and forests. It forms dense, bushy undergrowth that inhibits the growth of natural vegetation. The velvet mesquite (***Prosopis juliflora***), while not yet recorded in appreciable quantities in any PAs, is already a serious problem to native plant species in several parts of the region. Aquatic and wetland biodiversity is seriously compromised by alien invasives. Notable among these is the water hyacinth (***Eichhornia crassipes***), which has been described as the world's worst aquatic weed. Water hyacinth infestation in Lake Victoria, as discussed in Section 3.4, is a cause of concern for the local people who depend on the lake for food, water, transportation and recreation, and it is now present in most tributaries of the lake, in many satellite lakes, and in numerous wetlands. The red water fern (***Azolla filiculoides***) has already been described as rampant in many of the LVB wetlands.

A number of alien or naturally occurring pathogens and parasites also threaten many species of plants and animals. They can become a vexing problem as wildlife and people come into closer contact. The pandemic epizootic virus, rinderpest, caused a continent-wide loss of wild ungulates when introduced by cattle in the late 1800s. Canine distemper virus transmitted by dogs killed a third of the lions in the Mara-Serengeti in the 1990s. Tuberculosis and anthrax periodically kill many native animals ranging from elephants to primates. Invasive and infectious diseases have become more pernicious and threatening to indigenous species because of expanded human activity. Another example is Rift Valley Fever, a highly fatal mosquito-borne viral zoonosis that is closely associated with prolonged episodes of rainfall and flooding.

Two relatively new invasive species are spreading across Mara-Serengeti from the west: the ***Parthenium hysterophorus*** and ***Chromolaena odorata***. A number of other incursions were also noted in the Mara including ***Senna didymobotrya***, ***Ipomoea hildebrandti*** (or ***I. kituensis***), and ***Opuntia monacantha***.

Invasive *Parthenium hysterophorus* (left) and *Ipomoea hildebrandti* (right) in Maasai Mara

5.0 INTERVENTIONS FRAMEWORK RELATED TO BIODIVERSITY CONSERVATION IN THE LVB

This chapter provides a framework for selecting interventions in the LVB. The interventions directly relate to the threats to biodiversity conservation in the LVB as a whole and those that are specific to each of the BSAs analyzed during the EPA process. Future interventions will be determined by a combination of factors, including the biophysical and socio-economic objectives and available funding. It is also likely that more than one intervention may be applicable to each BSA, and therefore a range of conservation interventions are provided below.

5.1 PROMOTE REGIONAL AQUATIC ECOSYSTEMS LANDSCAPE CONSERVATION

Within the LVB, the main lake, satellite lakes, swamps, and intervening terrestrial enclaves constitute a well-defined waterscape, a landscape in which an expanse of water is a dominant feature. Uniquely, it is a transboundary landscape sprawled over the five countries of the LVB. As described above, the numerous water bodies within the landscape are interconnected through evaporation, rainfall, and underground seepage, as well as potentially through surface flow in case of a rise in lake levels or human interference.

There is no landscape-level strategy or approach targeting the biodiversity of this entire system. Developing such a strategy and approach would constitute a critical innovation and basis for all other cross-border interventions. Most of the BSAs fit neatly into a regional aquatic ecosystems landscape context involving a matrix of freshwater and wetland patches with intervening terrestrial barriers. The main lake, adjoining swamps, and satellite lakes are interconnected through flows of water, energy, and nutrients. The exchange of water is an especially critical ecological link, notably through underground seepage, evaporation-rainfall, and, potentially, surface runoff. Except for purely aquatic lifeforms, they also experience a significant exchange of species and genes. In designing conservation interventions, it is particularly important to recognize the role played by satellite lakes as faunal refuges for species now rare or extinct in the main lake, a fact widely acknowledged in scientific circles (TAFIRI, 2014; Maithya et al., 2012; Katunzi et al., 2010; Mwanja, 2004). Given the importance of the regional and transboundary dimensions of PREPARED, the regional aquatic ecosystems landscape context should have a strong bearing on all project interventions.

Supporting LVBC in contextualizing and promoting such a regional process would entail the holistic assessment, protection, and sustainable management of biodiversity in the interconnected freshwater systems. It would enable LVB countries to implement interventions that secure and promote the support of native plants, animals and microorganisms; diverse habitats and ecosystem services; clean water; fresh air; sustainable energy; and a range of other important resources and key features. Particular emphasis would be placed on the ecological role of satellite lakes as faunal refuges for species now extinct in the main lake. These act as structural and generally low-oxygen (or "hypoxic") refugia in which a subset of native fauna persists under reduced predation pressure, as well as because of physical and physiological intolerance that help to exclude introduced species (Reid et al., 2013).

Indicative activities could include:

- Developing a common vision based on the compelling issue or set of issues that catalyze people to seek solutions to biodiversity challenges that transcend multiple boundaries and jurisdictions.
- Evaluating and raising awareness on the key ecological role of refugia for native species.
- Building understanding of the use of spatially explicit management approaches to the matrix of wetland habitats, such as the development of secure buffer zones surrounding wetland edges to protect peak species refugia.

5.2 SUPPORT DESIGN AND REVIEW OF MANAGEMENT PLANS

Management plans for natural resources in protected and unprotected areas lay a solid foundation for conserving ecosystems, species, and habitats. They are also critical to strengthening the capacity of regional-, national-, and community-level institutions. Some of the key PAs identified as BSAs have either current or ongoing plans, including those due for revision. At other sites, there are indications of the desire to develop some new plans. Many areas outside PAs have high levels of biodiversity and management plans would assist in capturing those unprotected areas. An important contribution to this effort would be to support the completion of resource inventories for forests and wetlands. Actual biodiversity conservation will only occur when the primary resource users adopt sustainable resource utilization or economic/livelihood alternatives, or when appropriate laws and policies are implemented at the local level.

There are a number of existing or proposed collaborative institutions, management plans, and legal covenants at different stages of development that are aimed at supporting regional, basin-wide, or sub-catchment water resources. Good examples include those in support of the transboundary management of the Mara and Kagera Rivers. Some of these have been undertaken by previous USAID-supported programs and in consultation with regional stakeholders such as the LVBC, NBI, and the Nile Equatorial Lakes Subsidiary Action Program. Support to these processes presents an opportunity for realizing conservation and community objectives, as well as desired collaboration. It would also promote the mainstreaming of sustainable land, water, wildlife, fisheries, and forest resource management approaches in regional and national policies and programs.

Indicative activities could include:

- Completing existing draft management plans and supporting dialogue toward aligning them to the conservation needs of the greater ecosystem and basin contexts. Developing environmental education would be integral to management plans.
- Identifying and elaborating bankable investment packages that can be used to mobilise resources to facilitate implementation of management plans.
- Developing and implementing best practices through integrated land use planning to minimize negative impacts on the wetlands and their biodiversity.
- Harmonizing and coordinating conservation activities currently being undertaken by different stakeholders such as WWF, WCS, and other NGOs, CBOs, and government institutions.
- Generation of detailed information on the biodiversity found in the LVB and on the preparation of monitoring plans to enable prediction of changes that may adversely impact biodiversity.

5.3 IMPLEMENT SITE-LEVEL INTERVENTIONS FOR UNIQUE HABITATS

The unique array of habitats in the LVB, some still fairly pristine even outside of the formally protected areas, are deserving of special attention to save them from destruction. While others that are currently degraded require appropriate measures for restoration. The LVB's hydrological system is particularly valuable to human populations, and in a number of cases is closely associated with the unique habitats themselves, especially the wetlands. In those areas that support wildlife concentrations, buffer zones, scenic landscapes, and suitable tourism-development sites, identifying and implementing the appropriate measures for sustainable species and habitat management would be the primary focus of interventions.

Indicative activities could include:

- For the unique yet threatened species, design and implement activities to protect the lands and waters that living systems depend on to survive, for example:
  - o Rivers, lakes and swamps, which provide drinking water, food, energy, transportation, and aesthetic value;

- o Forests, which provide refuge and shelter, shade, food, water, and recreation; and
- o Forest glades/grasslands, which are often centers of locally rich animal and plant diversity.

- Ecological restoration-implement activities aimed at assisting in the recovery of the structure, composition, and processes necessary to facilitate terrestrial and aquatic sustainability and to maintain the environment's health and its benefits. This would involve addressing a variety of real and potential threats, for example:
  - o Fire,
  - o Climate change,
  - o Pest infestation,
  - o Destruction of watersheds, and
  - o Soil erosion and landslide control.
- Identify and zone existing buffer zones or buffer zones to restore.
- Explore viable alternative benefits to forest-dependent communities.
- Support park management in the program for ameliorating threats from competitive/invasive species, for example:
  - o Clearing out ferns every three months, which has shown positive results within three years;
  - o Implementing measures to reduce the impacts of the proliferation of ***Sericostachys scandens,*** an intrusive creeper in the Nyungwe forest; and
  - o Establishing and improving park infrastructure, including offices and equipment.
- Establishment of protected aquatic areas.

5.4 STRENGTHEN CROSS-BORDER COLLABORATION

Previous interventions in the LVB have identified priority transboundary issues relevant to this EPA. These include (i) unsustainable water resources; (ii) wetland and forest degradation; (iii) wildlife and habitat loss; (iv) governance, policy, and institutional weaknesses; (v) declining fisheries and fish stocks; and (vi) increasing sedimentation, pollution, and eutrophication. Strengthening the existing institutions for governance and sustainable management of transboundary resources will be critical in this regard.

Indicative activities could include:

- Strengthening transboundary water resource users' forums to encompass wider biodiversity concerns;
- Building synergies between water resource users forums and other transboundary resource use and management forums; and
- Monitoring and exchanging hydrological, biodiversity, and other types of data among countries.

5.5 BUILD CAPACITY FOR SUSTAINABLE USE

Sustainable resource use is another important measure to incorporate in future interventions. Such measures attempt to influence production processes, such as agriculture or pastoral activities, or they attempt to cap extraction processes through, for example, cap-and-trade mechanisms. These measures are also applicable to land management. The IUCN recognizes the concept of sustainably using wild living resources as a biodiversity conservation mechanism. This is because the social and economic benefits derived from such use provide incentives for people to conserve them, and therefore, when using wild living resources, people would seek to minimize the loss of biological diversity.

Sustainable use of resources is critical for rural livelihoods and economic growth. Countries that share the LVB have identified the need for stress-reducing interventions in land and water management, invasive species, pollution control, among others. Future interventions should explore initiatives that promote understanding of the intrinsic value and utilization of biological resources (especially "wise use")-as well as their links to ecosystem integrity and ecosystem goods and services. These include activities aimed at balancing the needs of competing resource users and activities that reduce excessive abstraction and pollution. One way to achieve this is to build upon transboundary resource management programs already established, to support capacity building of key transboundary institutions by the regional bodies.

Indicative activities could include:

- Building local community and youth group capacity for identifying and monitoring biodiversity;
- Providing institutional and managerial support for local-level youth and resource user groups;
- Contributing technical backstopping and facilitation of group activities;
- Enhancing knowledge on wetlands "wise use" concepts and integrating wetlands issues into local and national development agendas;
- Using accepted methodologies to conduct wetlands inventory, assessment, and monitoring, including biodiversity measuring and monitoring;
- Identification and implementation of wetland-friendly activities/investments;
- Mainstreaming wetlands (environmental/conservation) education into teaching and/or school curriculum; and
- Assessing the condition of, threats to, and management effectiveness of the swamp and use of bio-indicators to assess water quality in the swamp.

5.6 STRENGTHEN LIVELIHOODS DIVERSIFICATION AND ENHANCEMENT

Poverty is a main contributor to the overexploitation of biological resources as people struggle on a day-to-day basis. As described in previous sections, biodiversity loss leads to diminished livelihood strategies, raising poverty levels, and ultimately resulting in more biodiversity loss. Climate shocks exacerbate the negative impacts on livelihoods. As such, for livelihood strategies to be sustainable and resilient, biodiversity resources need to be conserved and managed appropriately. Furthermore, any intervention that seeks to strengthen livelihoods should consider gender roles and responsibilities to ensure vulnerabilities are minimized.

Indicative activities could include:

- Development of non-agricultural income-generating activities. This can only take place in communities that are broadening skills and building assets in other non-traditional livelihood strategies. For example, improving entrepreneurial skills, stimulating savings, and raising education levels would help provide opportunities for communities that are traditionally agriculturalists or pastoralists in the basin.
- Participatory land use planning outside PAs. With such planning, communities participate in making decisions on the types of land use that are appropriate for their area.
- Climate-smart agriculture would increase sustainable productivity, strengthen farmer resilience, reduce greenhouse gas emissions, and increase carbon sequestration (World Bank, undated). This intervention would require farmers' capacity building in designated BSAs. The use of agricultural biodiversity (as opposed to non-diverse production methods) can contribute to food security and livelihood security.
- Adoption of sustainable livestock production approaches that minimize destruction to the environment, such as commercial ranching and improved livestock breeds for better milk and meat production; sustainable approaches enhance incomes with fewer animals, improve pasture, and water management in the rangelands.
- Diversification of income-generating activities through the promotion of nature-based enterprises (e.g., beekeeping, tree nursery, bamboo establishment along riverine areas, eco-tourism, etc.). This strategy has been piloted in major water catchment areas in the region with varying degrees of success.

- Strengthening value chains in order to increase incomes for agricultural and livestock producers and other local-level value chain actors. Inclusion in agricultural value chains means that smallholder farmers can sell more products at higher prices. This results in increased incomes and long-term social benefits in rural areas, which in turn reduce the pressure on biological resources.

5.7 DESIGN AND PILOT MARKET-BASED MECHANISMS

The LVB has potential for three types of PES schemes that can contribute to biodiversity conservation: carbon, biodiversity-based tourism, and watershed-protection. In each case, it is important to establish (1) an ecosystem service beneficiary system, which has the wherewithal as well as the ability to pay for ecosystem services; and (2) practical interventions that can secure the delivery of ecosystem services while achieving biodiversity conservation objectives. The three types of PES schemes are described below.

- **Carbon.** Peatland carbon schemes are of interest as a carbon offset in exchange for conservation of unique peatland systems. Peatlands are unique and scarce wetland systems with very large carbon storage potential. In a bilateral agreement, a developed country with high carbon emissions may offset carbon, while a developing country may gain valuable revenue for land management and biodiversity conservation. This may be an interesting vehicle for participation of the UNFCCC Reduction of Emissions from Deforestation and Forest Degradation Plus (REDD+) mechanism. BSAs with peatland habitats are also at risk to climate change, and this PES system may hold great potential for conserving BSAs.

- **Biodiversity-Based Tourism.** The LVB already has an internationally renowned form of PES system in the Maasai Mara, where tourism concessionaires pay local landholders a resource rent in return for tourism services provided by the unique biodiversity of the Maasai Mara. There is great potential to investigate opportunities to improve and expand similar tourist-based PES schemes. In such cases, tourists pay for the cultural services provided by conserved areas. Tourist operators pay concession fees to land rights holders, who in turn change their land management practices. Such mechanisms may also be great job-creating opportunities. The Mara–Serengeti may serve as an anchor, while other BSAs may be reached through establishment of tourist fly-in camps. Many tourism operators across Africa may be interested in such an initiative.

- **Watershed Protection**: Lake Victoria's fishery industry is a multimillion US dollar industry that is greatly affected by catchment degradation. Empirical evidence exists of the linkage between degradation of wetlands and fish yield in the Yala swamp (Simonit & Perrings, 2011). It would be valuable to investigate potential PES systems where the fishing industry invests in wetland rehabilitation practices, which would support the wetland's ability to purify water and reduce erosion, and in turn support increased fish yields.

In addition to the above mentioned PES systems, two other market-based mechanisms are of interest in the LVB.

- **Product Certification.** Product certification acts as an incentive for good land management practices. This could indirectly support biodiversity conservation in the LVB. In terms of agriculture production, biodiversity-friendly agroforestry products could be sold for a premium, either through export contracts or to tourists (Pagiola & Ruthenberg, 2002). These products would be produced through sustainable land management practices that are certified and branded by a suitable body. An interesting example exists in Brazil, where shade-grown coffee is produced and certified as bird-friendly.

- **Waste Discharge Charges.** Formal economic activities, such as commercial farms, mines, breweries, and other industrial activities, often produce large amounts of water-polluting effluent, both at point and non-point sources. Waste discharge charges may be implemented on such water emissions that exceed acceptable thresholds, and the revenue from the charges may be used to implement water-pollution-reduction measures around the LVB. This is a complex PES requiring a strong legal and regulatory institution to develop the requisite monitoring and enforcement mechanisms; however, it is worthwhile to investigate further.

Each of these PES schemes may be applicable to different BSAs and are described briefly in Table 14. To understand whether the schemes are feasible and if a market exists, the relationship between the ecosystem service and the beneficiary would have to be investigated further.

Table 14. Summary of payment for ecosystem services options for selected BSAs

BSA	APPLICABLE PES SCHEME	DESCRIPTION
Nabugabo Lake Complex	Biodiversity-Based Tourism	The site contains a few tourist operators that could be leveraged to support biodiversity initiatives.
Mara Wetlands (Mara Bay and Masurura Swamp)	Carbon, Watershed Protection	Possible peatland PES potential. The Mara Wetlands could play an important role in purifying water from upstream users.
Mara–Serengeti Ecosystem (Catchments for Talek and Sand Rivers)	Watershed Protection	Protection of the catchments that feed the Maasai Mara could be funded by tourism income from the park.
Mwanza Gulf	Watershed Protection	Establishment of an aquatic protected area through contributions from the Lake Victoria fishing industry.
Sango Bay–Minziro Swamp Forests	Carbon	Possible peatland PES potential.
Nyungwe–Kibira Forest/National Parks	Biodiversity-Based Tourism	The site contains a few tourist operators that could be leveraged to support biodiversity initiatives.
Yala–Nzoia Wetlands	Carbon	Possible peatland PES potential.
Rweru–Mugesera Complex and Northern Aquatic Protected Landscape	Carbon	Possible peatland PES potential.

Indicative activities could include:

- Building a stronger evidence base to better understand the way in which current and emerging legal, policy, institutional, and market frameworks support and enable PES;
- Surveying existing PES-related schemes in the LVB to generate lessons on enabling conditions for PES to thrive and to establish examples of best practice;
- Developing and piloting PES guidelines focused on the development and implementation of PES schemes in the LVB;
- Developing and carrying out training on economic valuation and wetland assessment methods and approaches that could inform a knowledge-based scheme design process;
- Establishing community user rights with the relevant government agency to levy fees for accessing goods and services or to acquire tradable permits or shares for accessing resources or services;
- Utilizing fiscal instruments (licensing fees and taxes charged on the use and trading of biological resources) and financial instruments (loans and subsidies) for sustainable resource use and management; and
- Supporting livelihood alternatives that would help reduce pressure on critical habitats.

5.8 DEVELOP AND PILOT INNOVATIVE CONSERVATION APPROACHES AND TOOLS

The importance of raising awareness about the threats to biodiversity are clear, at least in the minds of government, regional bodies, and specialized community groups. The challenges, however, remain daunting at all levels. Conservation-related data are relatively scarce or scattered; data is available for small parts of the basin, but it rarely covers an entire ecosystem. In addition, the prospects for sustainable biodiversity conservation are seriously imperiled by illegal or unregulated use, and by inadequate law enforcement. Actions are urgently needed to institute measures for protecting the remaining-and sometimes relatively small and isolated, but important-natural habitats.

Indicative activities could include:

- Developing and promoting ICT tools and applications that would support conservation organizations and users in strengthening data collection and reporting on illegal or unsustainable activities, notably though public-private partnerships;
- Enhancing understanding and awareness of the challenges to biodiversity posed by illegal or unregulated resource uses;
- Developing and maintaining a biodiversity conservation-related database covering the site and entire ecosystem; and
- Introducing measures for protection of the remaining-though sometimes small, yet important-natural habitats, as in the case of Lake Kanyaboli and the Yala Nature Reserve.

This initiative will also require the establishment of innovative institutions to support and ensure sustainable governance of the planned biodiversity conservation interventions. These institutions may require the development of certification and branding schemes, and applicable country regulations required for monitoring and enforcement.

The initiative will also require establishment of transfrontier conservation organizations to, for instance, administer PES schemes or product-certification schemes, or to coordinate capacity-development activities.

6.0 DESCRIPTION OF SELECTED BIOLOGICALLY SIGNIFICANT AREAS

This chapter presents the BSAs or "biodiversity hotspots" identified in the EPA. It describes the activities that could be undertaken to help overcome or mitigate the root causes of biodiversity loss in these areas. The chapter identifies the primary actors responsible for the threats, as well as partners and opportunities for collaboration in ameliorating the threats. It takes into consideration the major efforts in place or previously undertaken for biodiversity conservation by national, bilateral, and international actors, including the public and private sector.

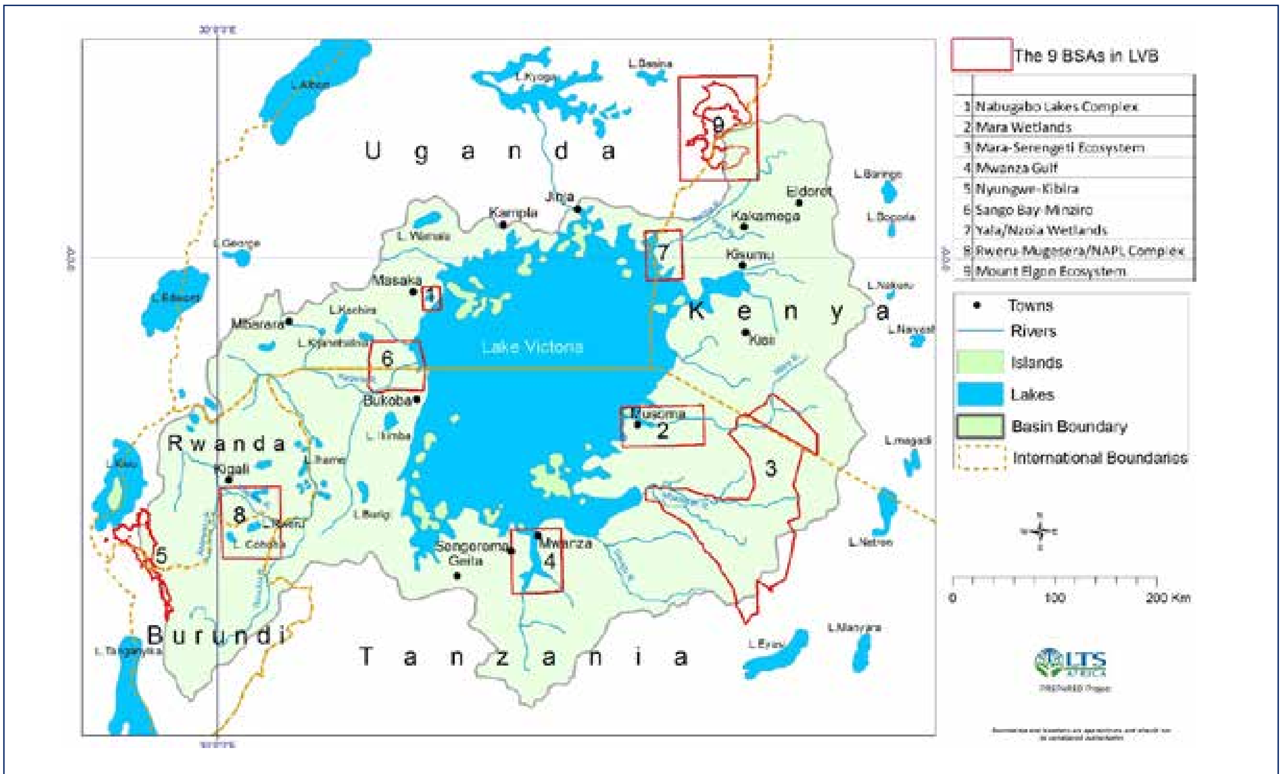
The BSAs represent the areas where future interventions would be the focus of PREPARED, EAC, LVBC, and other partners to have the greatest impact in addressing the challenges facing biodiversity, preventing species and ecosystem declines, ensuring livelihood sustainability, and building resilience.

The sites are presented in Table 15 showing the BSA name, biological priority based on EPA scoring, and size in hectares. Figure 38 displays the general geographical location of each site within the wider LVB context.

Table 15. BSAs selected for further consideration of conservation interventions

BIOLOGICALLY SIGNIFICANT AREA	SCORING	AREA (HECTARES)
Nabugabo Lake Complex, Uganda	11	21,996
Mara Bay and Masurura/Mara Swamp, Tanzania	10	50,000
Mara-Serengeti Ecosystem, Kenya/Tanzania	10	2,500,000[2]
Mwanza Gulf, Tanzania	10	25,000
Nyungwe-Kibira National Park, Rwanda/Burundi	9	117,100
Sango Bay-Minziro Swamp Forests, Uganda/Tanzania	9	86,181
Yala/Nzoia Wetlands, Kenya	9	30,000[3]
Rweru–Mugesera Complex and Northern Aquatic Protected Landscape, Rwanda/Burundi	9	12,000[4]
Mount Elgon Ecosystem, Kenya/Uganda	9	208,821[5]
Total		**3,051,098**

Figure 38. Location and distribution of nine BSA sites



The sections below briefly describe each site, its protection status and threats, an assessment of its ecosystem services, and potential interventions. The potential interventions outlined here are clustered under eight themes as described in Chapter 5, namely:

- Promote a regional aquatic ecosystems landscape conservation process.
- Support design and review of management plans.
- Implement site-level interventions for unique habitats.
- Strengthen cross-border collaboration.
- Build capacity for sustainable use.
- Strengthen livelihoods diversification and enhancement.
- Design and pilot market-based mechanisms.
- Develop and pilot innovative conservation approaches and tools.

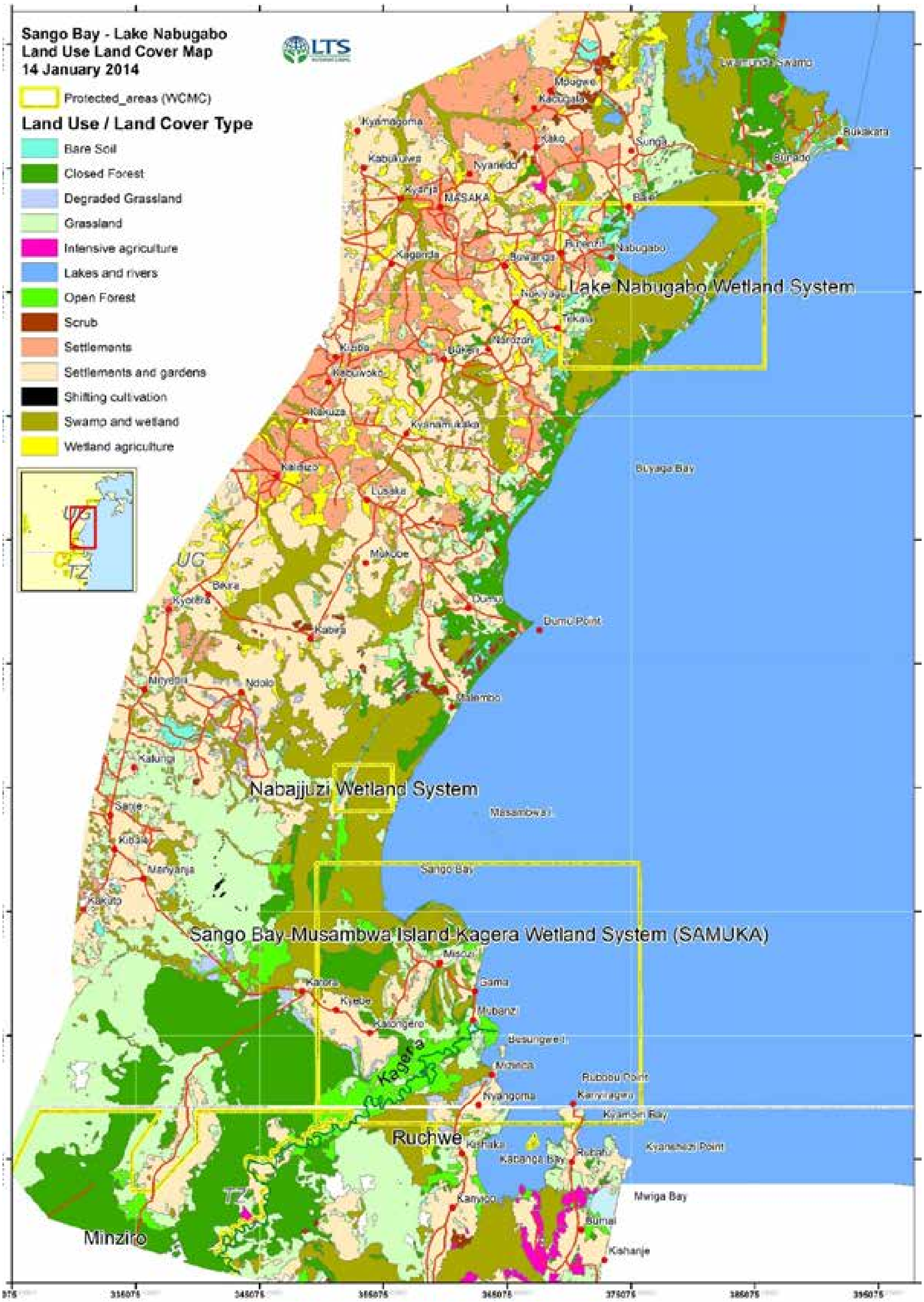
The specific interventions listed under each of the BSAs include one or several of the above themes.

6.1 NABUGABO LAKES COMPLEX, UGANDA

Location: The Lake Nabugabo wetland system is located just south of the equator (0°20´S–0°25´S, 31°50´–31°56´E) at an elevation of 1,200 meters above sea level in south-central Uganda. It represents an inland lagoon that was isolated from Lake Victoria by the accumulation of sand dunes more than 3,700 years ago.

Nabugabo is a shallow freshwater "satellite lake" of Lake Victoria, about 8.2 km long and 5 km wide with a maximum depth of 5 meters, separated from the main lake by a sand bar approximately 1.2 km to 3 km wide. It is located near the rapidly expanding town of Masaka (approximately 15 km from the city center) and about 4 km from the main lake's shoreline. It covers approximately 3,500 ha and is connected to a number of wetlands and three other (but much smaller) satellite lakes, which together make up the Lake Nabugabo Complex. These include Birinzi (formerly Kayanja), Manywa, and Kayuga. The whole complex is a Ramsar site (i.e., designated a wetland of international importance under the 2004 Ramsar Convention) covering an area of approximately 22,000 ha. Nabugabo is also within close proximity of Sango Bay, and the two are part of essentially the same ecological system (see Figure 39).

Figure 39. Lake Nabugabo and relative location of Sango Bay



Marsh, hippo grass, water lilies and stands of papyrus border the lake. The main inflows are springs, the River Juma and the Lwamunda Swamp-an extensive wetland area containing permanent lagoons and small intermittent streams. No surface outflows occur from the lakes, only seepage through the sand bank. The sub-surface water movements may come to the surface in very wet years. An analysis of sediment cores collected near the center of the lake showed that the lake was isolated about 5,000 years ago.

Land use in the area is mainly grazing with areas of mature but degraded tropical forest and woodland. Small areas are under subsistence farming, and local people recognize spiritual attributes of all three satellite lakes, which help serve as temporary protection for the lakes.

Swamp grasslands and characteristic avifauna on the fringes of Lake Nabugabo

Lake Nabugabo (left) with remnant indigenous forest on its fringes (right)

Existing Institutions and Key Players: The key institutions include the Wetlands Management Department in the Directorate of Water Affairs, the Masaka District Local Government, and the Nabugabo Community Development Association. Others are the Forest Sector Support Department (FSSD), the Directorate of Water Affairs, NFA, the Uganda Wildlife Authority (UWA), the Ministry of Tourism Wildlife and Antiquities, and the National Fisheries Resources Research Institute (NaFFIRI). A Site Management Committee was established in line with the requirement of the Ramsar Convention.

Biodiversity: The Nabugabo Complex is important for its unusual water status; very low ionic content and nitrogen status; remnant fish populations that have since become extinct in the main lake; and numerous wetland- and water-related plants and carnivorous plants. Almost 300 plant species have been recorded within the Ramsar site, two of which are endemic, and 14 species are only found at this site within Uganda.

The vegetation of the Lake Nabugabo Complex is uniquely different from all other wetlands of the LVB. There are many types of wetland/riparian vegetation around the main lake, the smaller lakes, and in adjoining wetlands-including ***Typha*** sp., ***Cyperus papyrus***, ***Miscanthidium violaceum***, ***Loudetia*** spp., ***Vossia cuspidata***, and local forest patches that grow to the water's edge. None of these is dominant across the area, and in some places, there are several major reed/grass systems together or in layers from free water to almost dry land. In one of the smaller lakes, Lake Kayugi, the surroundings are almost entirely papyrus-but all this and associated vegetation (including a ***Ficus*** species) are floating and hardly-if at all-attached to the substrate or the lake edge. One of the most striking aspects of Nabugabo is the presence of Droseraceae, which globally represents a very small set of terrestrial and water-based insectivorous plants.

Lake Nabugabo contains nine species of ***Haplochromis***, four of which are endemic. The other five are also found in Lake Victoria. Other fish from this lake include ***Alestes nurse, Bagrus docinac, Clarias mossambicus, C. werneri, Gnathonemus longibarbis, Protopterus aethiopicus, Schilbe nzystus***, and ***Synodontis afrofischeri. Oreochronzis leucostictus, 0. niloticus***, and ***Tilapia zillii*** were introduced to this lake in the 1950s (Stager et al., 2005).

The site is a key migratory stopover-destination for bird species between March and May; the site holds more than 15% of the world's population of the blue swallow. Two hundred and eighty-one bird species have been sighted here, 108 of which are wetland species. Hornbills, fish eagles, pied kingfishers, weaver birds, Ibises, herons, and turacos are common. The site also supports five globally threatened and nearly threatened bird species, including the shoe bill, Hirundo swallow, great snipe and pallid harrier hawk.

On the fringes of the lake are a variety of mammal species, including vervet monkeys and black and white colobus monkeys, which may be found in small forest "islands." The elusive sitatunga is found throughout most of the marshes; ground squirrels and mongooses will often be seen scurrying across open spaces.

The wetlands are rich in amphibians, with 24 species belonging to five families. Snakes are present in the forests and wetlands, but they are wary of humans and very rarely seen.

Protection Status: The unique biodiversity of Lake Nabugabo and the surrounding wetlands have long been recognized as areas of unique global significance. The complex was designated a Ramsar site-officially named the Lake Nabugabo Wetland System (Site No. 1373), covering 22,500 ha, which also includes the three other small satellite lakes (Birinzi/Kayanja, Manywa, and Kayugi). With a slightly larger area of 22,500 ha, it is also an IBA.

Threats: High human population densities and a reliance on subsistence agriculture are reflected in the heavy dependency of the neighboring community around Lake Nabugabo on the lake ecosystem. Poor agricultural practices have impacts on water quality and food production.

Ecosystem Services: A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for Lake Nabugabo is given in Table 16 below.

Table 16. Preliminary ecosystem services assessment for Lake Nabugabo, Uganda

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Unsustainable land use practices	The shores and surrounding areas of Lake Nabugabo are densely populated, and local communities are dependent on subsistence agriculture and fishing. As a result, water quality is an issue in the lake. Poaching and unsustainable fishing methods are a concern.	**Water purification:** Water quality issues reduce the lake's ability to purify water.	**Fresh water provisioning:** Reduction in available fresh water for communities **Food:** Water quality can impact the availability of fish species for human consumption. **Genetic resources:** Potential loss of endemic species, i.e. endemic fish species and sitatunga **Recreation and ecotourism:** Impact on potential ecotourism ventures	Local communities are dependent on the lake for the provisioning of water and food. Income from ecotourism activities is most likely a valuable source in this area.

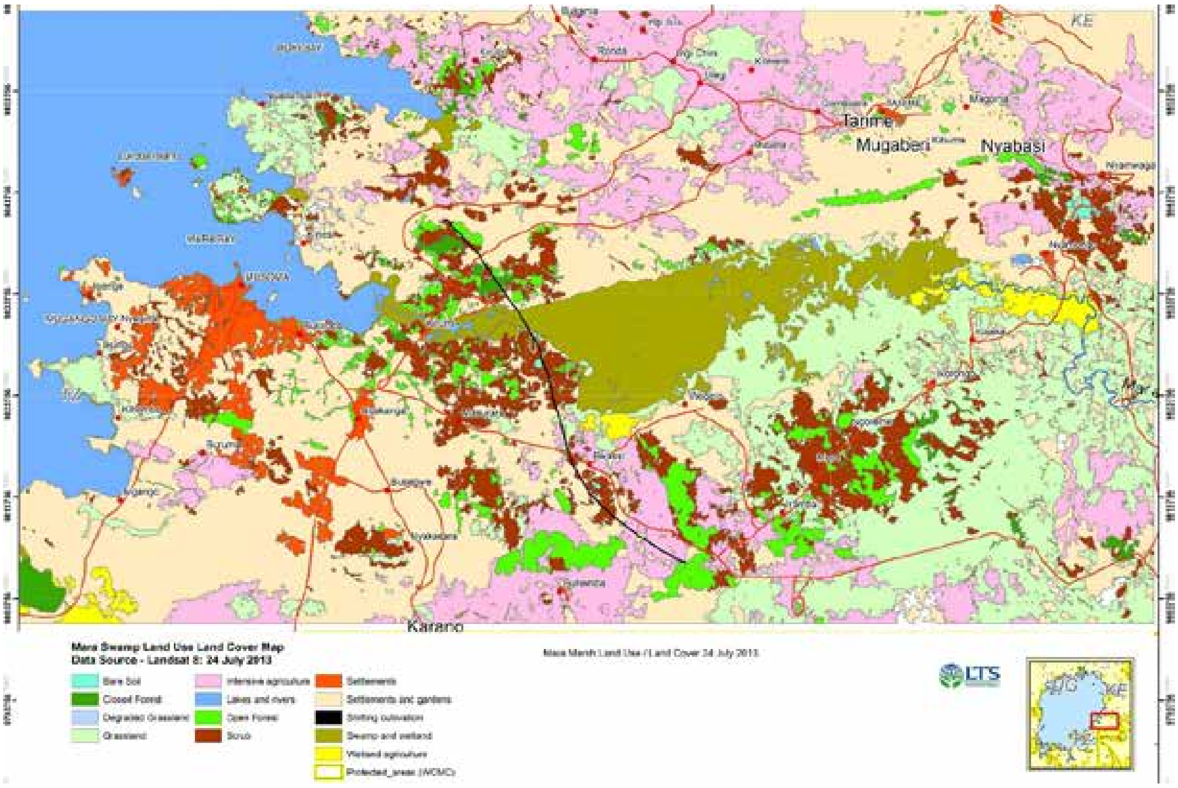
Potential interventions: Potential interventions in the Nabugabo lakes complex could include the following activities:

- *Promote a Regional Aquatic Ecosystems Landscape Conservation Process*-develop a regional strategy to improve sustainable land management practices within the BSA.
- *Support Design and Review of Management Plans*-support the review and implementation of the Ramsar site management plan.
- *Build Capacity for Sustainable Use*-enhance the ability of local communities, youth, and resource user groups to identify and monitor biodiversity and to report damaging activities; strengthen institutional and managerial competencies; provide technical backstopping and facilitation of group activities.
- *Strengthen Livelihood Diversification and Enhancement*-develop plans to include study of the tourism potential of the lake and development of tourism plans.
- *Design and Pilot Market-Based Mechanisms*-establish a market-based scheme in collaboration with stakeholders to take advantage of potential ecotourism ventures.

6.2 MARA WETLANDS, TANZANIA

Location: The area lies downstream of the Mara River between the latitudes of 1°08´S and 1°39´S and at longitudes between 34°00´E and 34°25´E. Just after it flows out of Serengeti National Park (SENAPA), the Mara River meanders sharply northwards and then southwest, after which the main channel breaks up into multiple streams, which feed the wetlands extending about 70 km before emptying into Lake Victoria within Tanzania. This system of streams and wetlands (also known as the Kirumi Wetlands or the Masurura Wetlands) terminates at Musoma Bay, which stretches in an easterly direction for approximately 20 km with an average width of 5 km and a maximum of 12.9 km. The wetland covers a total area of 204.5 km^2, centered on 1°32›00» S and 34°07›00»E at an elevation of 1,208 meters above sea level. Maximum length is 36.8 km, while maximum width is 12.9 km. Including the permanently and seasonally flooded areas, its influence potentially covers some 51,700 ha (517 km^2). However, the actual extent has changed considerably since 1973. The Musoma Bay and wetlands are located in the districts of Butiama, Rorya, and Tarime, as well as Musoma municipality. Annual rainfall around the swamp ranges from 700 to 900 mm.

Figure 40. Mara Wetlands



Existing Institutions and Key Players: Important players include the Tanzanian MNRT; the Ministry of State in the Vice President's Office, Union Affairs and Environment; the National Environment Management Council (NEMC); the Ministry of State in the President's Office – Regional Administration, Local Government, Civil Service and Good Governance; MALF; and the Ministry of Lands, Housing, and Human Settlements (MLHHS). Others include the District Councils of Butiama, Rorya, and Tarime, as well as the Musoma Municipal Council and the Lake Victoria Basin Water Board (LVBWB).

Other important players are the Mara River Transboundary Water Resource Users Forum (TWRUF), NBI, NELSAP, and the WWF –Tanzania Country Office. The Tanzania Fisheries Research Institute and the Wildlife Division also maintain a limited presence.

Biodiversity: Munishi (2007) described the biodiversity of the Mara Wetlands. The dominant vegetation is *Cyperus papyrus*. About 14 types of fish species are known to exist in the swamp, though at different levels of abundance. Three fish species that are also of great socio-economic significance to the local communities include catfish (*Clarias sp*., Kambale), African lung fish (*Protopterus*, Kamongo), and Nile tilapia [*Oreochromis nilotica* (local name, Nimgu)]. Others include *Schlbe mystuo* (Nembe), Nile perch (*Lates nilotica*, Sangara), *Cynodontis afrofishery* (Gogogo), elephant fishes (*Momyridae;* Domodomo, Perege), *Rastrineobola argentea* [a silver cyprinid species known by its local names as dagaa (Tanzania), omena (Kenya), and mukene (Uganda)], *Clarius aluwardi* (Vigugu), Furu, and Kuyu.

Thick papyrus growth in Mara swamp (top) with floating lilies in the more sheltered waters (bottom)

About 30 species of terrestrial and semi-aquatic mammals have been reported in the swamp at different times, including hippo (***Hippopotamus amphibious*)**, sitatunga (***Tragelaphus spekii*)**, olive baboon (***Papio anubis***), and vervet monkey (***Cercopithecus aethiops***). Several others were reported by locals to inhabit the swamp, including bushbuck (***Tragelaphus scriptus***), wild pig (***Potanochoerus lavatus*)**, warthog (***Pharcochaerus aethopicus***), spotted hyena (***Crocuta crocuta***), spotted-neck otter (***Lutra maulicollis***), reedbuck (***Redunca redunca***), waterbuck (***Kobus ellipsiprymus***), and topi (***Damaliscus lunatus***). Nile crocodile (***Crocodilus niloticus***) is also found there. Some of these are present as wetland visitors during different seasons to search for food, water, or shelter, especially during the dry season.

Eighty-one terrestrial bird species belonging to 28 families were identified around the Mara River Swamp, of which seven species are breeding, five are crop pests, and several are endemic and/or endangered. A total of 15 terrestrial bird species were more frequent visitors to the swamp, of which the dark-capped bulbul (***Pycnonotus tricolor***) was the most frequent, followed by the village (black-faced) weaver (***Ploceus cucullatus*).** A total of 33 waterfowl species belonging to 13 families were identified, of which 27% are migrants-with 9% being northern migrants, 6% being African migrants, and 12% being both African and northern migrants. This biodiversity is significant for making the swamp have high regional, national, and global significance.

Protection Status: The Mara swamp does not have any formal protection status. However, its importance for globally significant biodiversity is the subject of frequent discussion on how best to bring it under protection.

Threats: The high level of biodiversity gives the swamp regional, national, and global significance. Major threats to the wetland system include:

- Unsustainable harvesting and degradation of land (siltation and sedimentation);
- Poaching and fluctuating hydrological regimes;
- Threats related to pollution (domestic and agricultural; gold mining);
- Fire burning during illegal hunting or farming practices;
- Unsustainable fishing in the swamp area; and
- Overgrazing.

Ecosystem Services: A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for the Mara Wetland is provided in Table 17.

Table 17. Preliminary ecosystem services assessment for the Mara Wetland in Tanzania

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Fluctuating hydrology	The Mara River is the main source for the Mara Wetlands. Water requirements for upstream economic activities have led to a reduction in available water and water quality, which affects the integrity of the wetland.	**Water regulation:** Decreased hydrological input decreases the wetland's ability to regulate the timing and magnitude of water to affected communities.	**Fresh water provisioning:** Loss of available fresh water for communities **Food:** A decrease in available water would lead to a reduction in fish stocks.	Negative impacts on communities reliant on fishing for livelihood
Agriculture	Unsustainable clearing of land for agricultural and grazing purposes leads to a loss of wetland area and an associated loss of wetland functions.	**Water purification:** Loss of the wetland system's ability to purify water	**Fresh water provisioning:** Loss of available fresh water for communities **Food:** Increased siltation and other contaminants would lead to a reduction in fish stocks. **Genetic Resources:** Potential loss of endemic species (i.e., fish species) **Recreation and Ecotourism:** Impact on potential ecotourism ventures	Negative impacts on communities reliant on fishing for their livelihood within the wetland as well as communities fishing within Lake Victoria Negative impacts on agricultural activities due to low water quality

Potential interventions: Potential interventions in the Mara wetlands could include the following activities:

- ***Support Design of Management Plans-***generate detailed information on swamp biodiversity. This will include wetland inventories; preparation of wetland participatory management plans to enhance value and sustainable utilization, and preparation of a monitoring plan to enable prediction of changes that may adversely impact the swamp biodiversity.
- ***Implement Site-Level Interventions for Unique Habitats-***develop and implement best practices through integrated land use planning to minimize negative impacts on the swamp and its biodiversity. This would include identification and implementation of wetland-friendly activities/investments, biodiversity measuring and monitoring, and spreading awareness on the dangers of agrochemical use.
- ***Strengthen Cross-Border Collaboration-***strengthen the TWRUF to encompass wider biodiversity concerns.
- ***Build Capacity for Sustainable Use-***enhance the knowledge on the wetlands "wise use" concept; integrate wetlands issues into local and national development agendas; mainstream wetlands (environmental/conservation) education into teaching and/or school curriculum.
- ***Design and Pilot Market-Based Mechanisms-***assess the value chains and market chains of wetland products, not only involving adjacent communities but also involving areas outside the swamp, thus providing justification on sustainable use and conservation.
- ***Develop and Pilot Innovative Conservation Approaches and Tools-*****assess** the condition and management effectiveness of (and threats to) the swamp, as well as the use of bio-indicators to assess its water quality.

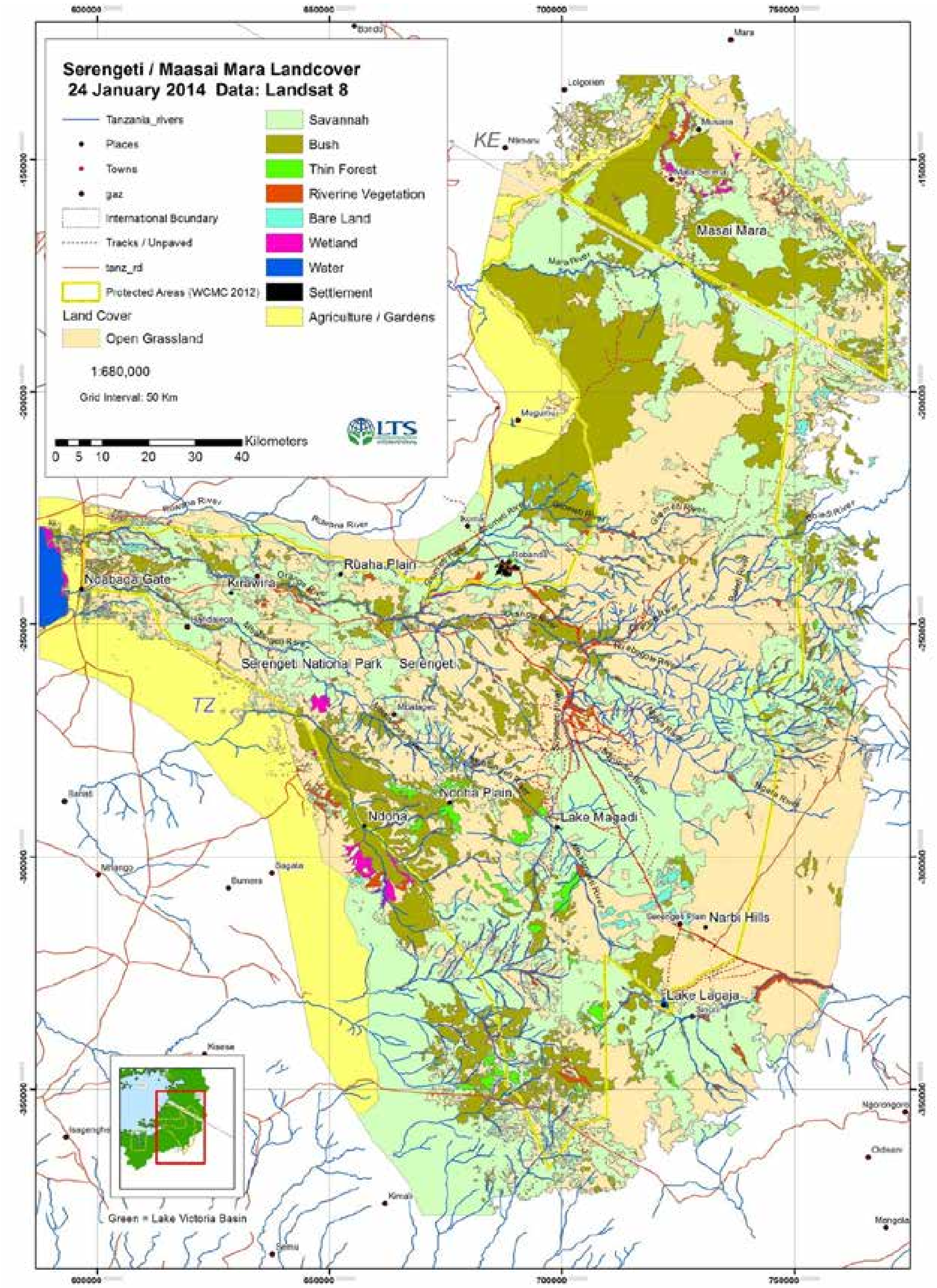
6.3 MARA-SERENGETI ECOSYSTEM, KENYA/TANZANIA

Location: Located in southwestern Kenya and northern Tanzania, the Mara–Serengeti Ecosystem (MSE) is roughly defined by seasonal movements of the migratory wildebeest, which covers approximately 25,000 km^2, between latitudes 1°15' to 3°30'S and longitudes 34° to 36°E (Sinclair et al., 2007). The Maasai, a tribe who grazed the area before the arrival of the first European explorers in the early 1890s, predominately use the ecosystems.

Covering an area of 14,763 km^2 of grassland plains and savannah as well as riverine forest and woodlands, SENAPA (located approximately 1°30'–3°20'S and 34°00'–35°5'E) broadly represents the larger ecosystem in all respects. It derives its name from ***siringet,*** which loosely translates to "the place where the land runs on forever" in the local Maa language. SENAPA is contiguous with the Maasai Mara National Reserve to the north, the Maswa Game Reserve (2,200 km^2) in the south, the Grumeti and Ikorongo Game Reserves in the west, the Ngorongoro Conservation Area (NCA) and Loliondo Game Controlled Area to the east, and several game management areas (GMAs). Significant among these is the Ikona Wildlife Management Area (WMA), covering approximately 450 km^2 in the villages around Fort Ikoma.

The MSE area extends over approximately 2,000 km^2 with the Maasai Mara National Reserve measuring about 1,523 km^2. It comprises the main reserve and associated group ranches and conservancies that fall largely within the Kenyan part of the Mara River drainage basin. Centered at 1°30'S and 35º0'E in Kenya's Narok County, the reserve's altitude varies from l,450 meters above sea level along the lower reaches of the Mara River, where it crosses into Tanzania, to about 1,950 meters above sea level on top of the Siria Escarpment. The reserve abuts SENAPA to the south and is bordered by the Siria Escarpment to the west and the Loita Plains on the northeast (see Figure 41).

Figure 41. Land use and land cover in and around the Mara–Serengeti Ecosystem



Existing Institutions and Key Players: The Narok County government manages the Maasai Mara National Reserve, while Tanzanian National Parks Authority (TANAPA) manages the Serengeti National Park. Within the immediate vicinity of the Mara River Basin in Tanzania are the Grumeti and Ikorongo Game Reserves, which are under the authority of the Tanzania Wildlife Management Authority (TAWA) within the Ministry of Natural Resources and Tourism]. The NCA is a key player in the areas just east of Serengeti. There is also the well-equipped Serengeti Wildlife Research Centre, which was formerly known as the Serengeti Wildlife Research Institute, established in 1966 at Seronera before the formation of TAWIRI.

There are other major community and NGO players in the areas outside the two formal PAs. Notable stakeholders here include the various District Councils around SENAPA and local village committees, such as those within the Ikona WMA. Large parts of the areas surrounding the Mara on the Kenyan side are under private or community conservancies with the South Rift Association of Landowners (SORALO) and a nascent Maasai Mara Wildlife Conservancies Association (MMWCA) being major players.

Numerous NGOs are active in the MSE. Notable among these are the Frankfurt Zoological Society (FZS), which supports all aspects of park management in the Serengeti. The WWF also has a long history of involvement in the Mara. WWF is currently playing a lead role in the consortium led by the UNESCO Institute for Water Education to implement the Mau Mara Serengeti Sustainable Water Initiative for Kenya. Other notables include associations of tour operators in both Kenya and Tanzania and the transboundary Serengeti Maasai Mara Hoteliers Forum.

Biodiversity: The MSE mainly comprises plains that sit atop an elevated plateau that is 900–1,200 meters above sea level, with the lowest elevations toward the Speke Gulf near Lake Victoria in the west (Retouch Africa, 2012). It is largely treeless, with flat, short grasslands that are dotted with rocky outcrops (kopjes). It is characterized by strong climatic and edaphic gradients that broadly define two main habitat types: the treeless short-grass plains in the southeastern portion of the ecosystem and the tall-grass savannah and woodlands in the north and west (Holdo et al., 2009).

Biodiversity richness is staggering: 28 ungulate species; 530 bird species; more than 100 species of dung beetles; and thousands of lions and spotted hyenas. The area also contains prehistoric rock paintings. Seven major vegetation categories have been described: grassland, woodland grassland, bushland, dry woodland, riverine forests, forests, and kopjes. These areas are very dynamic, having changed from open grassland to thick woodland several times in the last few centuries, a factor that contributes to periodic and quite dramatic changes in animal populations.

The annual migration of, at times, close to 2 million herbivores-including wildebeest, zebra, and Thompson's gazelle-defines the ecology of the area. The wildebeests are by far the dominant herbivores, with a population that has fluctuated between 1 million and 1.4 million over the past quarter-century.

Natural vegetation passes through a sequence of zones, from high enclosed canopy forest (moist montane forest) on the escarpment through dry upland forest (e.g., at Loita) to scattered woodland and then the extensive grasslands of the savannah, with areas of scrub and thorn trees. Wetlands and swamps are found throughout the basin but are heavily concentrated in the river's floodplain. Within the Mau Forest there are three separate forest formations: ***Aningeria-strombosia-Drypetes, Albizia-Neoboutonia-Polyscias*,** and mixed podo **(*Podocarpus falcatus*)**, of which one, ***Aningesia-Strombosia-Drypetes*,** is restricted to forests west of the Kenyan Rift Valley and only occupies a substantial area in Mau. The Mara River Basin also contains important riverine forest along stretches of the main river and its tributaries. Management of all types of forest (from closed canopy upland forests, which tend to receive the focus of attention, to savannah and riverine zones) is critical in terms of conserving biodiversity.

The Mau Forest is also habitat for an impressive amount of large animals such as buffaloes, leopards, hyenas, elephants, bongos, yellow-backed duikers, golden cats, giant forest hogs, colobus monkeys, and impalas. Some of the animals are the focus of international conservation efforts. The forests are also home to a rich variety of birds and are said to represent the richest montane avifauna in Eastern Africa. Endemic bird species in the area include Hartlaub's turaco (***Tauraco hartlaubi***), Hunter's cisticola (***Cisticola hunteri***) and Jackson's francolin (***Francolinius jacksoni***).

The Serengeti-Maasai Mara Plains are internationally famous for having the highest density and most diverse combination of large herbivores on Earth. Estimates in 2003 (Gereta et al., 2003) indicated about 1.3 million wildebeest, 200,000 zebras, and 440,000 gazelles. Among the larger carnivores are 9,000 hyenas, 3,000 lions, and 250 cheetahs. The majority of the herbivores participate in the annual circular migration, which is stimulated by the onset of rains that bring new grass to the plains. Individual surveys of ungulate species (giraffe, hartebeest, impala, warthog, topi, waterbuck, and zebra) have shown declines in their numbers from 1989 to 2003 (Ogutu et al., 2011). The losses have been greatest in areas where human settlement has increased. Competition between wildlife and domesticated livestock is becoming intense as more and more people in the rangelands are allowing their livestock to graze in the Maasai Mara National Reserve. A typical MSE landscape is shown below.

Typical MSE landscape showing the Palearctic migrant European white storks

In both Tanzania and Kenya, the MSE is considered to have "exceptional resource value" (Retouch Africa, 2012) and therefore should be conserved and protected for its habitats, biodiversity, migrations of large mammals and birds, and endemic and threatened species. The most important value is embedded in the large-scale mammal migration, which provides the principal justification for SENAPA's World Heritage and Biosphere Reserve status. Its value is also found in high flora and fauna biodiversity within pristine wilderness areas; vast open savannah plains with large predator-prey populations that attract tourists and revenue to Tanzania and Kenya; and a large water catchment area, which is vital to the people living outside the PAs as well as to MSE biodiversity. These values make the Serengeti and Maasai Mara the most-visited protected area in both countries and a vital source of tourism income.

Protection Status: The majority of the ecosystem is under protection in both Kenya and Tanzania. In Kenya, it is protected as a game reserve and as a large group of community conservancies spreading to the north and east. In Tanzania, large parts are protected as a national park with several game reserves, the NCA and several GMAs lying adjacent.

Threats: The exceptional resource values found in the MSE and population growth in the region have led to an increase in the number of threats to biodiversity. A significant proportion of the northwestern boundary and parts of the western corridor directly border rapidly growing farming and herding communities.

Two relatively new invasive species are spreading across the Serengeti from the west. One of these is ***Parthenium hysterophorus***, recorded in significant numbers at the Mara Bridge, close to the Tanzania border with the Maasai Mara National Reserve. The other is ***Chromolaena odorata***, which proliferates on the roadsides at the turnoff to Musoma and all along roads leading to Utegi and Tarime District headquarters. Incursions of invasive plant species-especially ***Parthenium hysterophorus***, ***Senna didymobotrya***, ***Ipomoea hildebrandti*** (or ***I. kituensis***), and ***Opuntia monacantha*** are spreading.

Other major threats to the MSE include:

- Poaching of all wildlife inside and outside PAs, especially a recent rise in elephant poaching;
- Human-wildlife conflict;
- Reduced and degraded water resources;
- Uncontrolled fires, especially in riverine forests and hilltop thickets;
- Scarcity of surface water during dry years;
- Population pressure;
- Spread of invasive species;
- Degradation of Talek and Sand Rivers' catchment management, including water offtakes;
- Unmanaged tourism and increases in visitor numbers and infrastructure; off-roads driving by tourists and operators;
- Livestock pressure on pastures inside as well as outside the reserve;
- Illegal mining and mineral prospecting;
- Pests and diseases; and
- Unplanned land and infrastructure development.

Ecosystem Services: A preliminary ecosystem services assessment for the MSE's regulating, provisioning, and cultural services is provided in Table 18.

Table 18. Preliminary ecosystem services assessment for the MSE in Kenya and Tanzania

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Unsustainable land use practices	The Talek and Sand River catchments around the Maasai Mara National Reserve are densely populated; thus, pressures on the reserve are severe. Degradation of these catchments would be detrimental to a large number of beneficiaries. The areas around the SENAPA are densely populated; thus, pressures on the national park are severe. Some of the threats include unsustainable, poaching, and clearing land for agriculture.	**Water regulation:** The Talek and Sand River catchments provide a valuable and reliable source of clean water.	**Genetic resources:** Potential loss of fundamental species such as the critically endangered black rhino, the elephant, the cheetah, and many smaller mammals. **Recreation & ecotourism:** Impact on potential ecotourism ventures	The SENAPA and Maasai Mara National Reserve are major sources of income for the Kenyan and Tanzanian governments as well as for local communities that work within the PAs or that have business associated with tourism activities.

Potential Interventions: Potential interventions in the MSE could include the following activities:

- ***Support Design and Review of Management Plans*-**support dialogue toward completion of the Mara Reserve Management Plan and align it to the conservation needs of the greater MSE. This includes ensuring the plan is consistent with the existing Serengeti Management Plan. It also entails participatory review of the draft plan to ensure it acknowledges this natural spectacle's international significance and its economic importance to both countries, as well as rapidly mounting threats to the area.

- ***Strengthen Cross-Border Collaboration*-**strengthen the TWRUF to encompass wider biodiversity concerns; supporting the creation of a transboundary wildlife technical working group (based on the existing but relatively inactive group at the EAC Secretariat) that can provide leadership and guidance in the management of environmental concerns regarding economic and social development within the ecosystem.

- ***Build Capacity for Sustainable Use*-**build synergies between TWRUF and the Transboundary Hoteliers Forum, particularly in regard to ensuring sustainable resource use and management.

- ***Design and Pilot Market-Based Mechanisms*-**develop and analyze PES potential, options, and approaches; assess market-based incentives that will encourage people to conserve and sustainably manage the conservancies and resources outside the Maasai Mara National Reserve; use fiscal instruments (e.g., licensing fees and taxes charged for the use and trading of biological resources) and financial instruments (e.g., loans and subsidies) for sustainable resource use and management.

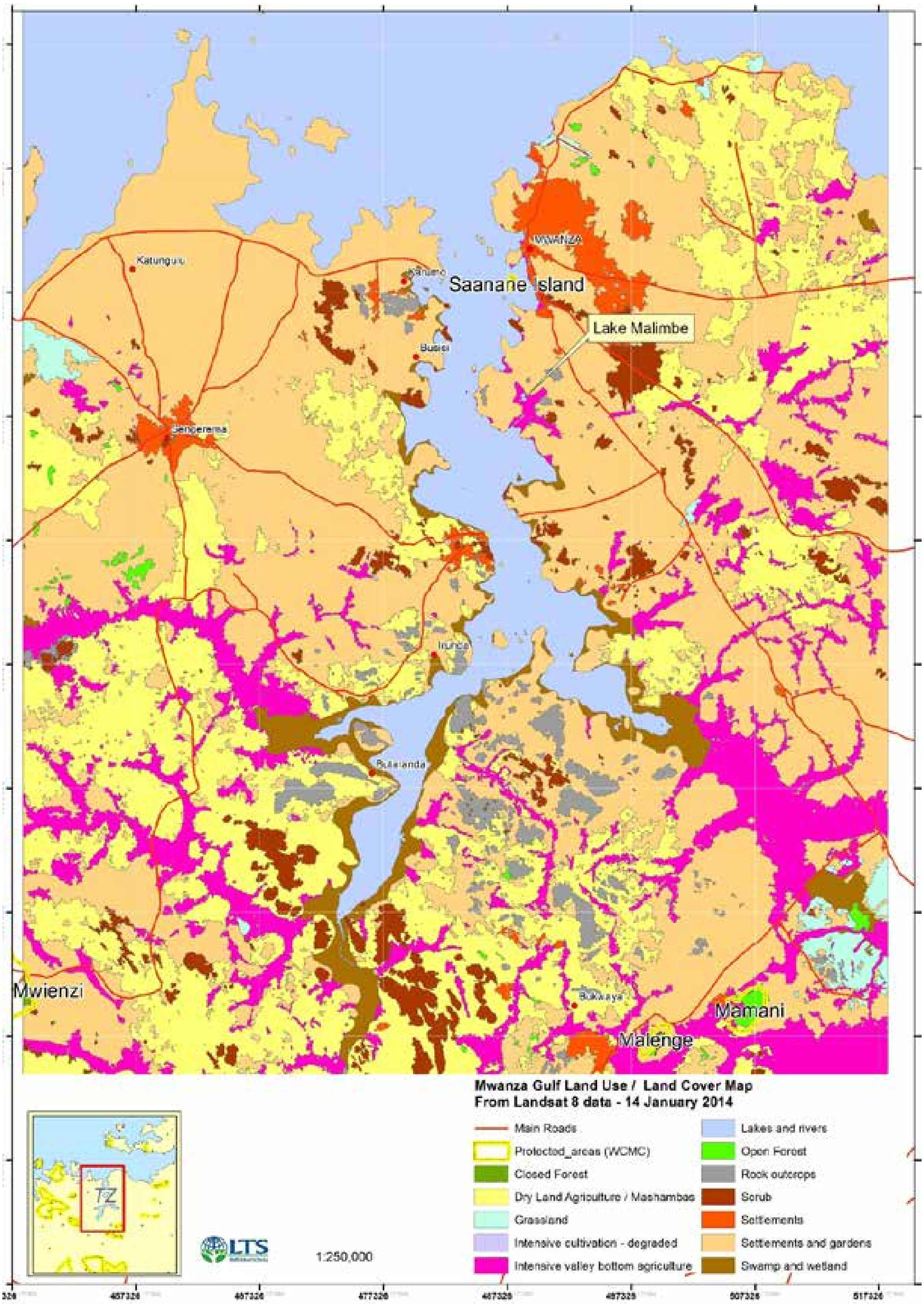
- ***Develop and Pilot Innovative Conservation Approaches and Tools*-**develop and carry out training on economic valuation methods and approaches; establish community user rights, with the authority to levy fees for goods, services, or for acquiring tradable permits/shares to access resources or services; enhance understanding and awareness of the challenges to biodiversity posed by illegal or unregulated resource use; develop and maintain a biodiversity conservation-related database covering the site and ecosystem.

6.4 MWANZA GULF, TANZANIA

Location: Located in the southeastern end of Lake Victoria, centered at 02°30'S and 32°50'E on the southern shore, Mwanza Gulf is about 60 km long and 2.5–11 km wide, with a surface area of approximately 500 km^2 (Cornelissen et al., 2014). The gulf is a prolongation of the lake southwards for nearly 40 miles, cutting through low granite hill countryside that rises around it on all sides. To the west of the Mwanza Gulf and east of the Emin Pasha Gulf, the vegetation is made up of Miombo.

Most of the water flowing into the gulf comes from surface runoff, forming seasonal streams that flow during the rainy season. There are also some permanent rivers, notably the Isanga, Magogo, and Nyashishi (see Figure 42).

Figure 42. Land use around the Mwanza Gulf



Existing Institutions and Key Players: These mainly include the MNRT, MOWI, MALF, the MLHHS, NEMC, Ministry of State in the Vice President's Office, Union Affairs and Environment and Ministry of State in the President's Office, Regional Administration, Local Government, Civil Service and Good Governance. Others are the LVBWB, the Mwanza City Council, and the District Councils of Ilemela, Nyamagana, Misungwi, and Sengerema.

TAFIRI is the lead research organization in the area because the center of the Mwanza Gulf is located at Nyegezi. TANAPA is responsible for Nane Island National Park. Other notable players are a host of NGOs and donor-funded projects active in one or more aspects of environmental management or biodiversity conservation. There are also active beach management units (BMUs).

Biodiversity: The gulf has been recognized for fish species endemism and declared an IBA. The gulf has an irregular shoreline characterized by rock formations and a natural vegetation belt dominated by various reeds such as papyrus **(*Cyperus papyrus*)** and ***Phragmites australis*.**

The significance of the gulf is underscored by the recent history of aquatic biodiversity in Lake Victoria. Several tilapia species (***Oreochromis niloticus*, *Tilapia zillii*,** and ***Tilapia melanopleura*)** and the large predator Nile perch **(*Lates niloticus*)** were introduced in the 1950s to boost catches. Within 20 years of their introduction, these displaced the native species, particularly the haplochromine cichlids from the lake along with the two native tilapias, ***O. esculentus*** and ***O. variabilis*** (Ogutu-Ohwayo, 1990 and; Kaufman, 1992).

Malimbe is one of the satellite lakes that harbors ***Oreochromis esculentus*** (Msuku, 2004), once the mainstay of the people around Lakes Victoria and Kyoga but thought to have been driven into extinction in the main lake following the introduction of several other tilapias and the Nile perch. In a survey of 10 satellite lakes on the Tanzanian part, ***Oreochromis esculentus*** was also recorded in Lakes Ikimba, Merule, and Rwakajunju (TAFIRI, 2014)**. *O. esculentus*,** however, now plays only a minor role in the fisheries of Lake Malimbe (Figure 43), which is currently dominated by ***Orechromis niloticus*.**

Lake Malimbe, surrounded by a thick belt of papyrus

The many rocky islands and fringing swamps are home to prolific birdlife, noted for the little egrets and white-breasted cormorants. Some of the most common birds of the Mwanza Gulf include the reed cormorant, black-headed heron, African fish-eagle, long-tailed cormorant, marabou, hamerkop, the African yellow-billed stork, the jacana, and the great white egret.

Common or reed cormorants (left) and little egret (right), both common in Mwanza Gulf

Saa Nane Island National Park-a rocky and densely vegetated part of the gulf and the surrounding waters-is home to clawless otters, impalas, rock hyraxes, vervet monkeys, De Brazzas monkeys, tortoises, lizards, snakes, wild cats, and about 40 species of resident and migratory birds.

Protection Status: Most of the land surrounding the gulf is under agriculture and urban development and does not have protection status. The Saa Nane Island National Park, an area of 2.18 km^2, was officially protected in October 2013; it includes Chankende Island and parts of the surrounding lake waters.

Threats: The rivers draining into the gulf collect wastewater from domestic sources, fish processing plants, and a brewery. The Mirongo River, a small but important river, collects wastewater from Mwanza City and industrial plants before flowing into the lake. The main threats to the biodiversity of the Mwanza Gulf and associated wetlands have been identified as follows:

- Unsustainable agriculture, fisheries, and grazing;
- Unsustainable harvesting of other wetland-related products;
- Land degradation from illegal mining (siltation);
- Pollution; and
- Poaching.

Ecosystem services: A preliminary ecosystem services assessment for the gulf's regulating, provisioning, and cultural services is given in Table 19.

Table 19. Preliminary ecosystem services assessment for the Mwanza Gulf in Tanzania

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Agriculture	**Water pollution:** A large portion of the area surrounding the gulf is under intensive agriculture. This leads to an increase in water pollutants such as phosphates, nitrates, and increased siltation.	**Water purification:** Loss of the system's ability to purify water	**Fresh water provisioning:** Loss of available fresh water for communities **Food:** Increased siltation and other contaminants would lead to a reduction in fish stocks. **Genetic Resources:** Potential loss of endemic fish species **Recreation and ecotourism:** Impact on potential ecotourism ventures	Negative impacts on communities reliant on fishing for their livelihood Negative impacts on agricultural activities due to low water quality
Increased urbanization	**Water pollution:** Runoff from Mwanza City increases the contaminant load.	**Water purification:** Loss of the system's ability to purify water	**Fresh water provisioning:** Loss of available fresh water for communities **Food:** Increased siltation and other contaminants would lead to a reduction in fish stocks. **Genetic resources:** Potential loss of endemic fish species **Recreation and ecotourism:** Impact on potential ecotourism ventures	Negative impacts on communities reliant on fishing for their livelihood Negative impacts on agricultural activities due to low water quality

Potential Interventions: Potential interventions in Mwanza Gulf could include the following activities:

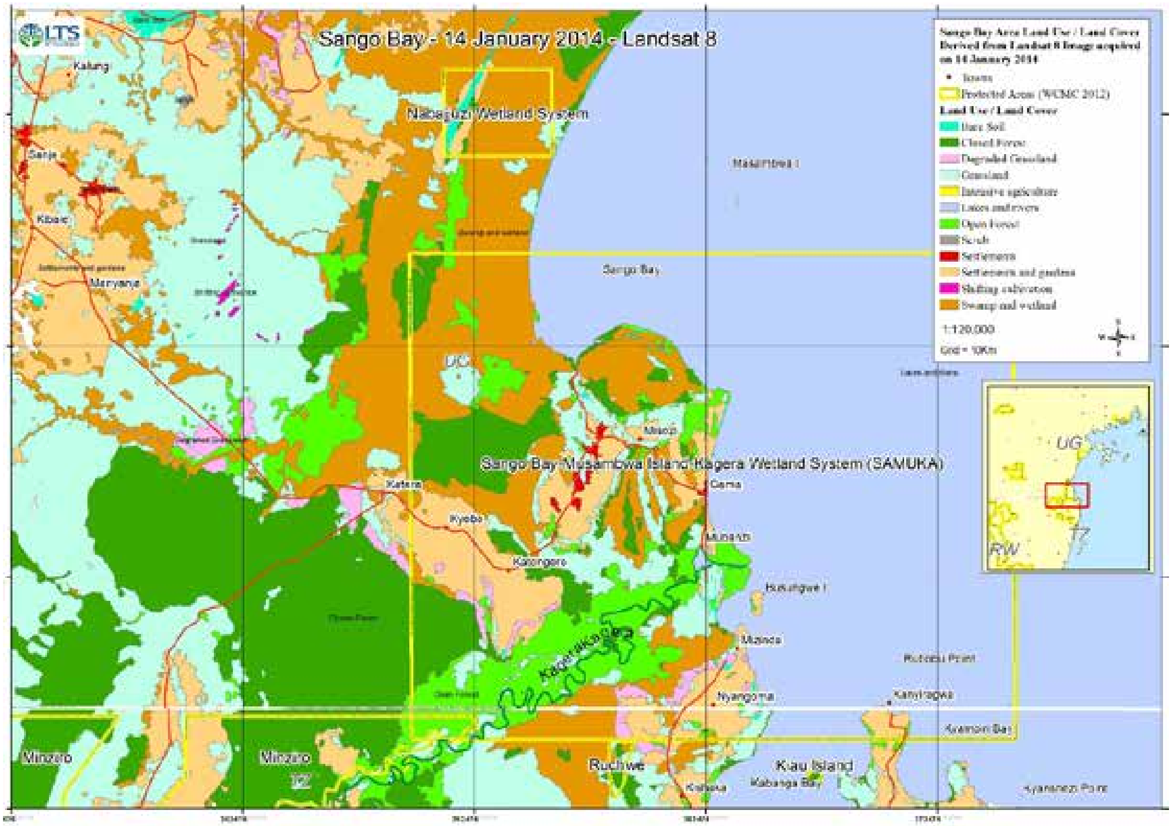
- ***Promote a Regional Aquatic Ecosystems Landscape Conservation Process-***prepare participatory biodiversity and wetland management plans, with detailed wetland conservation and monitoring and evaluation objectives.
- ***Build Capacity for Sustainable Use-***empower communities on the "wise use" of wetland resources.
- ***Design and Pilot Market-Based Mechanisms-***such schemes could entail the following:
  - o Assess market-based incentives that will encourage people to conserve and sustainably manage resources outside the gulf.

- o Fund aquatic protected area(s), including the use of fiscal instruments (licensing fees and taxes charged on the use and trading of fishing and wetlands resources) and financial instruments (loans and subsidies) for sustainable wetland use and management.
- o Create a waste-discharge-charge system. Urban and agricultural runoff from commercial and subsistence users contributes greatly to the pollution load in the lake. This would force large commercial users to discharge clean water or face financial sanction.
- o Establish community user rights with the authority to levy fees for accessing goods and services or acquiring tradable permits/shares to access wetland resources or services.

6.5 SANGO BAY – MINZIRO SWAMP FORESTS, UGANDA/ TANZANIA

Location: The Sango Bay – Minziro Swamp Forests comprise the Sango Bay – Musambwa Island – Kagera Wetland System (SAMUKA) in Uganda and the adjacent newly declared Minziro Nature Forest Reserve in the Misenyi district of neighboring Tanzania. SAMUKA is a Ramsar site as well as an official IBA (UG013) located between 00°49'S to 00°59'S and 31°39'E to 31°52'E. It covers an area of approximately 551 km^2, mainly within the Kakuuto and Kyebe sub-counties of Uganda's Rakai district. The Minziro Nature Forest Reserve is located in the Misenyi district within northwestern Tanzania's Kagera region, and is centered approximately at 01°5'S and 31°30' E (see Figure 43). It occupies approximately 257 km^2, comprises a groundwater forest with extensive areas of grassland, and is located in a generally flat area with small rocky outcrops at an altitude ranging from 1,125 to 1,140 meters above sea level.

Figure 43. Sango Bay – Musambwa Island – Kagera Wetland System (SAMUKA) land use



Within SAMUKA lies the Kagera River floodplain, which is surrounded by extensive swamps, seasonally flooded grassland, and forest communities . Notable features are the Kagera River mouth and the Malabigambo Forest- the latter of which is part of a broader system of forest reserves that lie across the Uganda-Tanzania border. The western limit of Malabigambo Forest is marked by the main road between Masaka and Mutukula and is contiguous with the Minziro Nature Forest Reserve.

Extensive wetlands (left) and riverine grasslands and forests (right) along the lower Kagera in Sango Bay

Photo credit: Willy Kakuru

Existing Institutions and Key Players: According to the 1995 Constitution of Uganda, the government holds wetlands in trust for the people. The Sango Bay wetlands are, therefore, in the hands of the central government, a role functionally played through the Wetlands Management Department. The 1997 Local Government Act further devolved wetland management to local district governments and sub-counties[6].

Large portions of the seasonal swamp forests are included within the forest reserves managed by the local district forest offices, with some oversight from the NFA. The peripheral areas of Sango Bay wetlands are under a ***mailo*** land tenure system, a quasi-freehold tenure system established by the 1900 Buganda Agreement between the Kabaka and the British colonial government. An important feature of this system is that much of the land is used by tenants who are restricted in their security of tenure on the land they farm (Kyomugisha, 2008).

On the Tanzania side, key players include government ministries-notably MNRT, MOWI, MALF, MLHHS, NEMC, Ministry of State in the President's Office, Regional Administration, Local Government, Civil Service and Good Governance, Ministry of State in the Vice President's Office Union Affairs and Environment, Tanzania Forest Service (TFS), and the WWF Tanzania Country Office.

Biodiversity: This area is characterized by a mosaic of wetland types, including the biggest tract of swamp forest in Uganda; papyrus and herbaceous swamps, interspersed with palms and seasonally flooded grasslands; sandy, rocky, and forested shores; and rocky islets offshore. The largest part of Minziro and the contiguous Malabigambo Forest in Uganda consists of ***Baikiaea–Podocarpus*** seasonal swamp forest, while the remainder is flooded acacia woodlands. It is essentially an outlier of the Guinea–Congo lowland forests, with a unique combination of West African and Afro-Montane forest species, including the endemic swamp podo **(*Afrocarpus dawei*).**

Bakamwesiga et al., (2000) proposed the Sango Bay area to be a site for conservation on the grounds of it containing 1,000 species of plants, 78 species of mammals, 431 species of birds, 31 species of amphibians, 44 species of fish, 279 species of butterflies, and 67 species of dragonflies. It is also important because of its rare birds, including the blue swallow **(*Hirundo atrocaerulea*)** and the shoebill **(*Balaeniceps rex*)**, both of which are currently rated as "vulnerable" on the IUCN Red List of Endangered Species (2013). It also hosts an average of 16.5% of the population of grey-headed gulls (***Larus cirrocephalus*).**

Special wild mammals include the African elephant **(*Loxodonta africana,*** rated "vulnerable") and an endemic sub-species of black and white colobus monkey **(*Colobus guereza adolfi-friederici*)** as well as a restricted-range blue monkey **(*Cercopithecus mitis doggetti*).**

6 http://sites.wetlands.org/reports/ris/1UG011_RISen06.pdf

The forests contain many interesting and quite rare species, such as endemics of the tree genera ***Baikiea*** and ***Podocarpus*** as well as many hundreds of species of butterflies as listed by Davenport and Howard (1996). Most significant are the various types of wetland with their dominant and associated plants. Many are dominated by papyrus **(*Cyperus papyrus*)** and tall swamp grass **(*Miscanthidium violaceum*)** with numerous submerged species as well as those that pierce the water surface so that they are partially in air (emergent species). Common reeds **(*Phragmites australis*)** and ambatch, a wetland tree **(*Aeschymonene elpahroxylon*)**, are widespread as well as wetland grasses such as ***Vossia cuspidata*,** the "hippo grass." Sango Bay contains one of the world's stone age or prehistoric sites, locally known as the Sangoan, which dates back to about 200,000 years.

Bukora River on SAMUKA's western edge (left) and a view of Minziro Forest (right)

The wetland system is a source of fish, notably catfish **(*Clarias sp)*** and lungfish (***Protopterus aethiopicus***), a local delicacy. The swamps are a source of water for both domestic use and livestock consumption. The local people also undertake timber harvesting; firewood collection; and harnessing raw materials (such as ***Papyrus reeds***) for handcrafts and building. Forest trees, wetland shrubs, and herbs are used as sources of medicine, while palms **(*Phoenix sp*)** are used as a source of poles for fencing and crushed to form fibrous material used for making luxurious sofa chairs and mattresses. Other activities include sand and clay mining as well as the hunting of sitatunga and other antelopes, hippos, buffaloes, and primates. The plains are also used for grazing and tourism.[7]

Protection Status: The Ramsar site and IBA SAMUKA are not PAs themselves but are the responsibility of the Wetlands Management Department of the Directorate of Environment and the Environment Department- at both the national and local levels. It includes five protected forest reserves covering an area of approximately 15,000 ha (or 27% of the Ramsar site): Kaiso, Tero East, Tera West, Namalala, and Malabigambo. Malabigambo Forest is an unusual swamp forest with a mixture of both swamp-adapted species and dryland species of trees. In addition, it has representatives of both western and eastern African forest flora. Being contiguous with Minziro Nature Forest Reserve in neighboring Tanzania, Malabigambo is, in essence, a transboundary reserve of great regional interest. The proclamation of the Minziro forest as a Forest Nature Reserve, offered the highest level of protection under the Forest Act in Tanzania.

Threats: High human population densities and a reliance on subsistence agriculture are reflected in the neighboring community's heavy dependency on the Sango Bay ecosystems. In particular, wetlands have been drained for sugarcane and food crop production; forests have been encroached upon in search of more agricultural and settlement land; and poor land management in the form of bush burning, overcultivation, and grazing also continue to characterize the Sango Bay area.Various exotic species of floating plants are also present and are mostly recorded as invasive species, such as water hyacinth **(*Eichhornia crassipes*)**, water fern **(*Salvinia molesta*),** and water lettuce (***Pistia stratiotes***). An emergent water plant that is quite widespread in roadside wetlands and that belongs to the genus ***Hydrocotyle*** appears to be similar to ***H. ranunculoides* .**

This species, although a native of "tropical Africa," is invasive and overpowers other small emergent water plants in other parts of East Africa.

7 http://sites.wetlands.org/reports/ris/1UG011_RISen06.pdf

A dense growth of young Hydrocotyle ranunculoides in a Sango Bay wetland

In the Minziro section, illegal harvesting and degradation of land, fire, and encroachment from agriculture and grazing constitute the main threats.

Ecosystem Services: A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for the Sango Bay Minziro area is provided in Table 20.

Table 20. Preliminary ecosystem services assessment for the Sango Bay Minziro area, Uganda/Tanzania

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Unsustainable land use practices	The shores and surrounding areas of the Sango Bay area are densely populated, and local communities are dependent on subsistence agriculture and fishing. As a result, water quality is an issue in the lake. Poaching and unsustainable fishing methods are also a concern.	**Water purification:** Water quality issues reduce the lake's ability to purify water.	**Fresh water provisioning:** Reduction in available fresh water for communities **Food:** Water quality can impact the availability of fish species for human consumption. **Genetic resources:** Potential loss of endemic species (i.e., endemic fish species, sitatunga) **Recreation and ecotourism**: Impact on potential ecotourism ventures	Local communities are dependent on the lake for the provisioning of water and food. Income from ecotourism activities is most likely a valuable source in this area.

Potential Interventions: Potential interventions in the Sango Bay- Minziro Swamp Forests could include the following activities:

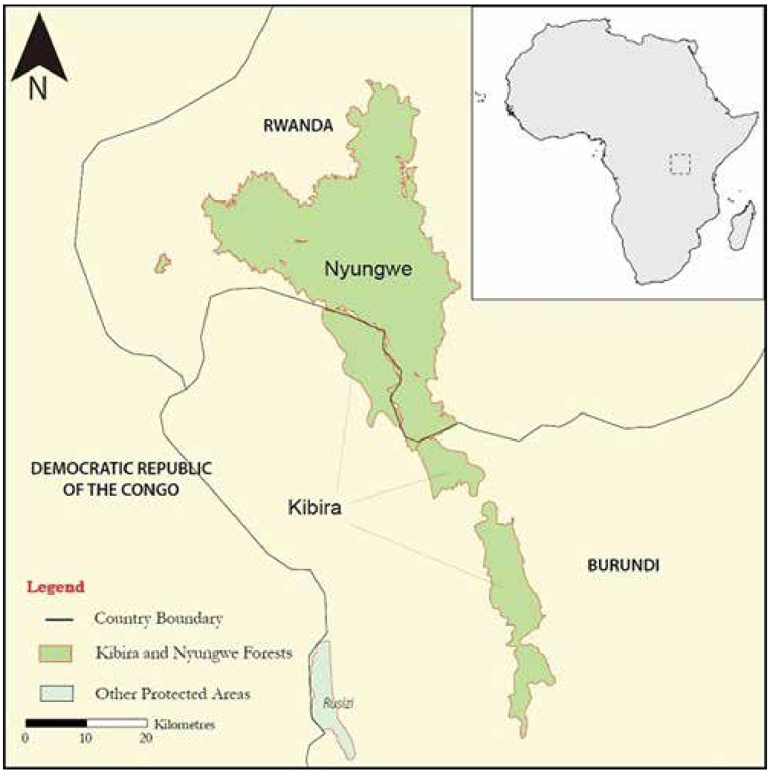
- *Promote a Regional Aquatic Ecosystems Landscape Conservation Process*-aimed at securing overall natural systems, including good quality existing watersheds and water channels (including undisturbed sub-surface flows). A specific example of this is supporting integrated planning and the formulation of a Rakai district conservation and utilization plan.
- *Support Design and Review of Management Plans*-support implementation of management plans for the Ramsar site and adjoining areas; and in liaison with local communities, support the district authorities in the enforcement of existing regulations.
- *Build Capacity for Sustainable Use*-build capacity of communities on the "wise use" of wetland biodiversity to ensure sustainable utilization of resources, which will include ecotourism ventures and other nature-based enterprises; enhance the ability of local communities and youth groups for identifying and monitoring biodiversity and reporting damaging activities; strengthen institutional and managerial competencies of youth and resource user groups; and provide technical backstopping and facilitation of group activities.

6.6 NYUNGWE–KIBIRA COMPLEX, RWANDA/BURUNDI

Location: Nyungwe is located in southwestern Rwanda between latitudes 2°15'S–2°55'S and longitudes 29º00'–29°30'E, within the southern and western provinces and contiguous with the Republic of Burundi. Kibira is located in northwestern Burundi between latitudes 2°36'52"S– 3°17'08"S and longitudes 29°13'31"E–29°39'09"E, straddling the Muramvya, Bubanza, Kayanza, and Cibitoke provinces.

The Nyungwe–Kibira Complex is one of the most ancient and extensive montane forest blocks in eastern Africa, dating back to before the last Ice Age. It forms one of the two most remote sources of the Nile, lying astride the Congo-Nile divide, which runs roughly north-south, placing about two-thirds of Rwanda and its drainage within the Lake Victoria Basin. A significant proportion of the forest lies east of the Nile-Congo divide, and thus falls in the LVB (see Figure 44).

Figure 44. Approximate location of Nyungwe–Kibira

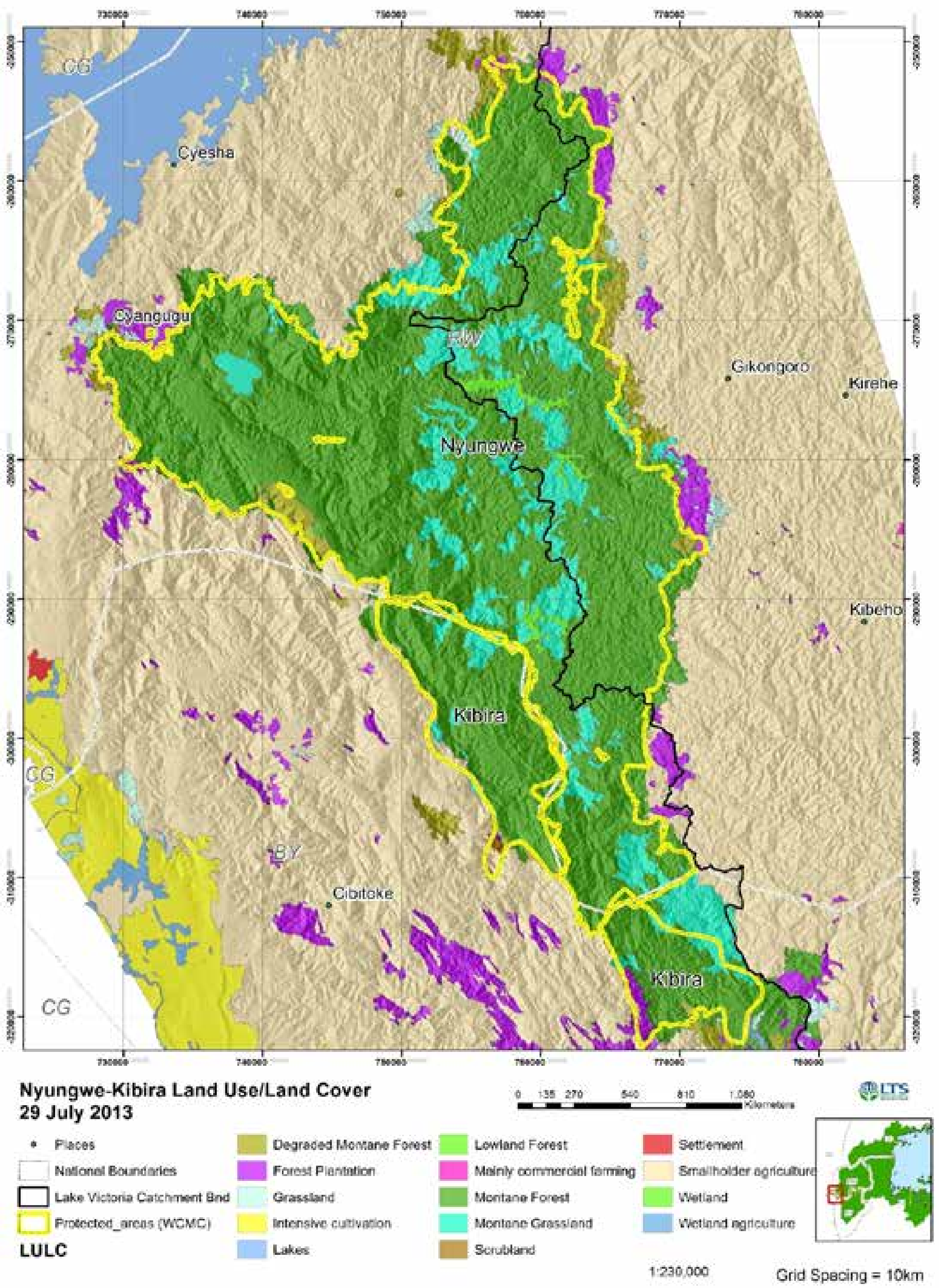


Reproduced from UNEP, 2008. Africa: Atlas of Our Changing Environment.

Nyungwe covers a total area of 1,141 km² (114,100 ha) of mountainous, rugged terrain, spanning an altitudinal range of 1,700–2,950 meters above sea level. First declared a forest reserve by the colonial administration in 1903, it was, however, reduced to 971 km² (97,100 ha) by 1979 and declared a national park in 2005. It is managed as a single unit with the nearby remaining but isolated Cyamudongo Forest.

The Kibira Forest covers 400 km² (40,000 ha) extending about 80 km from north to south. It is the largest protected forest area remaining in Burundi and constitutes a former sacred hunting reserve for the kings of Burundi. Kibira remained a forest reserve until 2000, when it was established as a National Park by Decree-Law No. 100/007. It extends about 8 km wide at the northern end, where it is contiguous with the Nyungwe Forest. Figure 45 shows land use and cover in the Nyungwe Forest and the northernmost section of Kibira.

Figure 45. Nyungwe and northern section of Kibira



Existing Institutions and Key Players: The key institutions are the national park authorities of both countries, namely the Rwanda Development Board (RDB)-which took over from the former ***Office Rwandaise Du Tourisme et des Parcs Nationaux*** (ORTPN)-and the ***Office Burundais pour la Protection de l'Environnement*** (OBPE), established under constitutional decree No. 100/198 of September 15, 2014, to take over the functions formerly performed in Burundi by ***Institut National pour L'Environnement et la Conservation de la Nature*** (INECN). Others are Rwanda's Ministry of Natural Resources and Burundi's Ministry of Water Environment, Land Management, and Urban Development. They also include Rwanda Water and Forestry Authority, REMA, Institut des Siences Agronomique du Burundi (ISABU), and various district authorities. In Kibira, Burundi's premier public utility for water and electricity, ***Régie de Production et de Distribution de l'Eau et de l'Electricité*** (REGIDESO) is a major institutional player.

The WCS has long been active in the Nyungwe-Kibira Landscape. With the facilitation of the WCS, a Memorandum of Understanding was signed in 2008 between the former ORTPN and INECN. This was to ensure mutual collaboration in the protection of the shared landscape[8]. Other NGOs with interest and engagement over the last decade include the Albertine Rift Conservation Society (ARCOS), Dian Fossey Gorilla Fund International (DFGFI), Institute for Tropical Forest Conservation (ITFC), International Gorilla Conservation Programme (IGCP), and WWF.

Biodiversity: Nyungwe is part of the Albertine Rift center of endemism and is part of the Eastern Afromontane Global Biodiversity Hotspot. One thousand, nine hundred and twenty-four species of mammals, birds, reptiles, amphibians, and plants have been recorded in this landscape to date. The area is best recognized for at least 13 species of primates, including the owl-faced monkey **(*Cercopitecus hamlynii,*** classified by IUCN as vulnerable) and the white-bearded L'Hoest's monkey **(*C. lhoesti*)**-which are both restricted-range species. Others include the endangered eastern chimpanzee **(*Pan troglodytes schweinfurthii*),** the golden monkey **(*Cercopithecus mitis kandti*),** and large troops of the Angola colobus **(*Colobus angolensis*).**

The site is also an ornithological spectacle, harboring nearly 300 bird species, of which the great blue turaco **(*Corythaeola cristata*)**, the Ruwenzori turaco **(*Tauraco johnstoni*)**, and numerous vividly colorful sunbirds are among the most outstanding.

About 250 plants are endemic to the Albertine Rift, and at least 47 flowering plants are locally endemic (Fischer & Killmann, 2008). At least 133 species of orchids have been recorded in the Nyungwe Forest alone.

Despite the high altitude that would preclude great reptile and amphibian diversity, up to 40 reptile species are found there, including five chameleons and several snake species. At least 32 amphibian species are present, including some endemics. A new reed frog, ***Hyperolius jackie*,** has been recently found in Nyungwe National Park (Dehlin, 2012). This new frog is characterized by the transparent skin of a glass frog and a call that is distinct from other frogs of the same genus. There are also numerous invertebrates, with more than 120 butterfly species having been identified. The Wildlife Conservation Society has provided more complete lists of birds and mammals (Chao, 2008).

The major plant assemblages in Kibira are characterized by the following tree species and vegetation formations: ***Entandrophragma excelsum* - *Parinari excelsa* var. *holstii*; *Parinari excelsa* var. *holstii* -*Polyscias fulva*; and *Polyscias* fulva-*Macaranga neomildbreadiana-Syzygium parvifolium*.** The secondary forest at varying phases of recolonization comprises ***Hagenia abyssinica*** and ***Faurea saligna*** (the latter of which is endemic in the Congo-Nile crest). There are also pure or mixed stands of bamboo **(*Arundinaria alpina*).** A particularly important vegetation assemblage is locally referred to as ***thalweg*,** comprising high-altitude marshes, bogs, and peat lands.

Approximately 104 mammal species are present in Kibira, divided into eight orders, including the bushbuck, bushpig, the yellow-backed duiker (***Cephalophus silvicultor*),** black-fronted duiker **(*Cephalophus nigrifrons*),** and carnivores such as the serval, the striped jackal, the civet, and a wide variety of primates. The order Insectivora comprises at least 20 species, including endemics like ***Myosorex blarina*, *Crocidura lasona,*** and ***Crocidura niobe*.**

8 Congo Forest Basin Partnership: http://pfbc-cbfp.org/events_en/events/nk-en.html. Accessed November 16, 2014.

Eight species of bats ***(Order Chiroptera)*** have so far been identified in the forest. Primates are the most notable mammalian order, comprising three families and one species-the Cercopithecidae (five genera and six species), the Lorisidae (three genera and three species), and the Pongidae, represented by a single species, the chimpanzee (***Pan troglodytes*** **-** EN). The blue monkey (***Cercopithecus mitis dogetti***) is the most frequent primate in the forest. Other important primates found in the forest are Hoest's monkey [***Cercopithecus l'hoesti*** – lower risk (LR)/nt], the golden monkey **(*C. mitis kandti*** - EN), and Angolan colobus (***Colobus angolensis ruwenzorii*** -VU). The presence of the owl-faced monkey [C***. hamlyni*** - lower risk (LR)/NT] has not yet been confirmed[9].

Kibira's avifauna is quite diverse with at least 200 species, 21 of which are restricted to the Albertine Rift; 13 species are globally threatened. The most remarkable bird species include the long-crested eagle **(*Lophaethus occipitalis*)**, the great blue turaco **(*Corythaecola cristata*)**, and the brown-cheeked hornbill (***Bycanistes sbcylindricus*)**. Others are the hawk eagle, the flufftail, the Ruwenzori turaco, the grey parrot, the turtle dove, the flycatcher, starling, babbler, Kivu ground thrush, francolins, and at least 14 species of nectarines.

The reptilian fauna of Kibira is little known, but snakes are frequently observed, notably two venomous viper species-***Atheris nitchei*** and ***Bitis gabonica***.

Protection Status: Nyungwe was first declared a forest reserve covering 1,300 km^2 by the colonial administration in 1903 (Gapusi, 2007). This has steadily shrunk, and although the extent of decline is not agreed upon, the estimated area was 970 km^2 prior to its declaration as a national park in 2005 (USAID, 2004). Some authors cite an area of 1,019 km^2 when the nearby remnant but isolated forests are included. It is managed together with Cyamudongo forest as a single unit.

Combined with the contiguous Kibira National Park in Burundi, the complex is one of the most ancient and extensive montane forest blocks in eastern Africa, dating back to before the last Ice Age. At 400 km^2 (40,000 ha), Kibira National Park is the largest protected forest area remaining in Burundi. It is also home to Rwegura hydropower dam, the biggest water reservoir in Burundi whose water level has declined precipitously over the last few years.

Threats: The Nyungwe-Kibira Complex is experiencing immense pressure from the expansion of agriculture. In Nyungwe especially, there is strong pressure for wetland reclamation for agriculture due to exceptionally high human population densities. Many of the people live on less than 1 hectare of land and have families of 6–8 people per household. There is also a strong incentive for bush meat. As a result, many of the large terrestrial mammals have been reduced to very low numbers. The buffalo and elephants have been extirpated.

Overexploitation and increasing market demand for timber, bamboo bark products, traditional medicines and other NTFP harvesting. According to some official estimates, about 10,000 ha of the Kibira forest were destroyed during the drawn-out war . Many of the people displaced from other parts of the country who settled around Kibira heavily exploited trees and bamboo for building and firewood, and they hunted the animals for food. Among the most specifically targeted were the rare species of African mahogany (***Entendrophragma excelsum***) and African redwood **(*Hagenia abyssinica*)**, a highly ornamental tree endemic to the Afromontane regions of central and eastern Africa-both of which produce high quality wood and timber.

Mining has increased, fueled by the presence of high prices for minerals such as gold and coltan, especially in Nyungwe but also in the Kibira part of the complex.

Fires often occur as people access the forest for honey hunting/harvesting. These pose the biggest threat, affecting about 30% of the forest, occasioning a major tree loss and secondary colonization by ferns-which shade out the tree seedlings and therefore prevent regeneration.

9 According to IUCN Red List, EN means endangered; VU, vulnerable; CR, cricially endangered; NT, near threatened and LR; Low Risk.

The spread of highly competitive plant species is a key concern. For example, although ***Sericostachys scandens*** is a natural part of the Nyungwe forest, something appears to have changed, causing it to expand. The extermination of herbivores that previously kept it in balance is cited as one of the reasons for the proliferation of this creeper. It smothers forest regeneration, flowers every seventh or eighth year, and then dies back.

Heavily degraded, formerly densely forested hillside in Kibira National Park (left) and a relatively intact stream in the Nyungwe forest

Other specific threats include:

- Poor agriculture practices and siltation of the rivers,
- Eutrophication,
- Inappropriate fishing practices,
- Lack of a clear management plan targeting the entire complex, and
- Unequal protection on both sides of the border for the landscape.

Ecosystem Services: Nyungwe is the watershed for over 70% of Rwanda; its streams feed both the Congo and the Nile basins, with the locals using them mainly for the household and for agriculture. Locals widely use the forest to harvest wood (***Pinus patula*****,** ***Cupressus lusitanica*****,** and ***Acacia melanox*****ylon)** for fuel and building poles as well as to harvest honey and herbal medicine. In addition to this, they have recently started generating income from tourism.

A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for Nyungwe–Kibira National Park is provided in Table 21.

Table 21. Preliminary ecosystem services assessment for the Nyungwe–Kibira National Park, Rwanda/ Burundi

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Unsustainable Land Use Practices	The Albertine Rift contains some of the highest human population densities on the African continent, and all the PAs in this region are under considerable threats. Some of the threats include unsustainable logging, poaching, clearing land for agriculture, deforestation, and charcoal burning.	**Water regulation:** The National Park is a well-known water catchment area and is therefore vitally important to national and regional economies. Increased logging and deforestation result in decreased soil water retention and therefore increased runoff for downstream users. This in turn leads to an increase in siltation load and subsequent decrease in water quality.	**Fresh water provisioning:** Reduction in available fresh water for communities **Genetic Resources:** Potential loss of endemic species, i.e., primate species **Recreation and Ecotourism:** Impact on potential ecotourism ventures	The potential for reduction or loss of the water regulation service has the potential to impact a wide range of downstream beneficiaries, from local communities dependent on water resources to broader downstream communities.

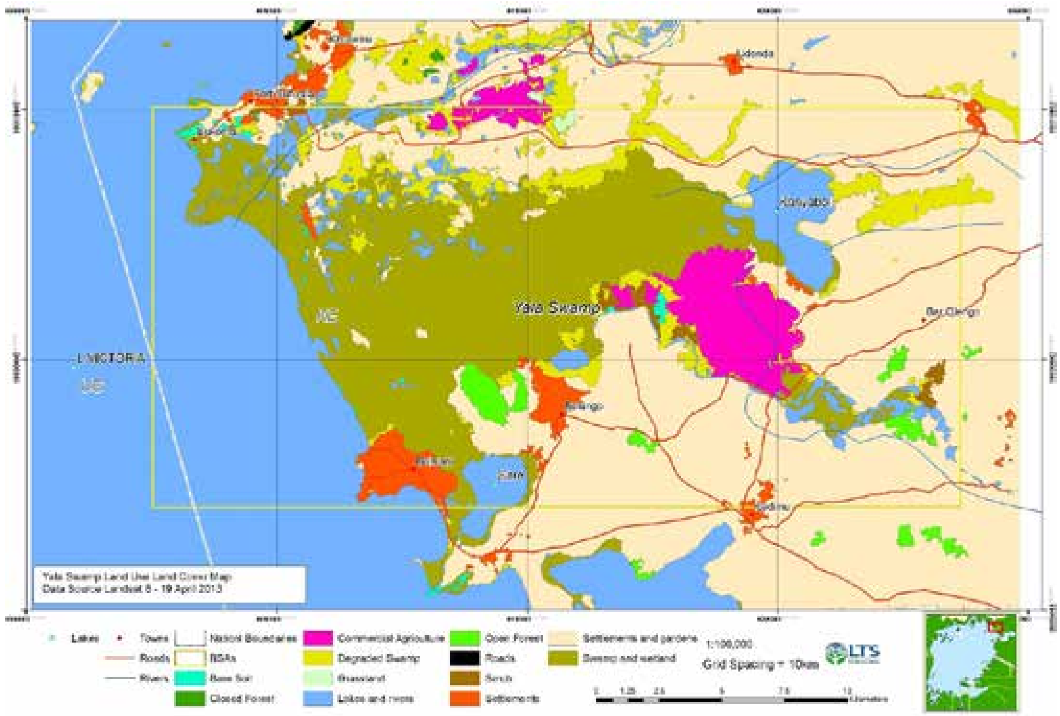
Potential Interventions: Potential interventions in the Nyungwe-Kibira Complex could include the following activities:

- *Implement Site-Level Interventions for Unique Habitats-*ecological restoration, which would entail implementing activities aimed at assisting in the recovery of the structure, composition, and processes necessary to facilitate terrestrial and aquatic sustainability and to maintain the health of the forest and its benefits to the environment; supporting park management in addressing the threats from competitive/invasive species, e.g., measures to reduce the impacts of the proliferation of ***Sericostachys scandens***, an intrusive creeper in the Nyungwe forest. Another could be clearing out the ferns every three months, which already shows admirable results within three years.
- *Build Capacity for Sustainable Use-*legal and regulatory interventions may include:
  - o Clarifying institutional mandates for biodiversity conservation and management in Rwanda and Burundi; and
  - o Developing regulations of access to biological resources in forests and wetlands.
- *Strengthen Livelihoods Diversification and Enhancement-*promote nature-based tourism_utilizing the epicenter of Africa's montane rainforest systems, which is characterized by dense forests and isolated massifs. This is one of the highly competitive tourist destinations in eastern Africa and is particularly known for:
  - o Unique primate viewing. It is the only destination in the world where visitors can see more than five primate species. The destination boasts a unique phenomenon in its huge concentrations of primates, whose numbers reach up to 400–500 individuals in a single group.
  - o Bird safaris. It is richer in bird endemism than any other PAs in the region, enabling visitors to see more range-restricted species.
  - o Nature walks. The area already has well-maintained, rare networks of nature walkways developed so tourists can view unique rainforest features and experiences, including attractions such as waterfalls and spectacular over-the-canopy views.
- *Strengthen Livelihoods Diversification and Enhancement-*find alternatives to declining benefits to forest-dependent communities through nature-based enterprises.

6.7 YALA–NZOIA WETLANDS, KENYA

Location: The Yala–Nzoia wetlands are along the northeastern shores of Lake Victoria lying within latitude 0°07'N–00°1'S and longitude 33°58'E–34°15'E. They fall within the Siaya band Busia counties of Kenya[10]. Stretching from the Yala River to the south, they encompass Lake Kanyaboli, the lower Nzoia floodplain, and all the lakeshore south of Ugowe Bay (Hughes and Hughes, 1992). Broadly speaking, the wetland comprises about 30,000 ha with the distances between the opposite edges extending up to 15–25 km (Hughes and Hughes, 1992; M'mayi et al., 1997). More specifically, the Yala swamp covers an area commonly cited as 17,500 hectares (175 km^2) and is one of Kenya's largest freshwater wetlands. The swamp sits at the Yala and Nzoia Rivers' entry points into Lake Victoria, arising from backflow of the lake as well as the rivers' floodwaters. The wetlands contain three important satellite lakes-Kanyaboli (10.5 km^2), Namboyo, (2.0 km^2) and Sare (5.0 km^2). See Figure 46 below.

Figure 46. The Yala/Nzoia wetlands



Existing Institutions and Key Players: The Siaya and Busia county governments are leading stakeholders for the wetlands and surrounding areas. Kanyaboli National Reserve, established through Legal Notice No. 158 of October 1, 2010, is under KWS jurisdiction. Dominion Farms Ltd. is a major player, having signed a 25-year lease agreement on 17,500 hectares of the Yala swamp in May 2004 to invest heavily in long-grain rice and banana growing and rotation crops, as well as fish farming and a number of related byproducts in the Yala swamp.

The agreement was renewable for another term of 20 years under the Trust land Act Cap 288 of the Laws of Kenya (since repealed).

Others with considerable interest and involvement in the Yala-Nzoia wetlands and upstream include NMK, NEMA, KFS, Lake Basin Development Authority (LBDA), Water Resources Management Authority (WRMA), and the Kenya Marine and Fisheries Research Institute (KEMFRI). There are also a number of notable NGOs and CBOs with keen interests in the area, including Nature Kenya, Friends of the Yala, Wetlands International, and the Royal Society for the Protection of Birds (RSPB).

10 https://www.uni-siegen.de/zew/publikationen/volume0305/abila.pdf

Biodiversity: The Yala-Nzoia wetlands are characterized by the dense growth of macrophytes-the emergent, dense, and sometimes almost monodominant stands dominated by the genus Cyperus (i.e., ***C. papyrus, C. dives, C. exaltatus,*** and ***C. distans***) and ***Phragmites mauritianus***. This provides habitat for several papyrus-endemic birds, such as the papyrus gonolek (***Laniarus mufumbiri***), the papyrus yellow warbler (***Chloropeta gracilirostris***), and the white-winged warbler (***Bradypterus carpilis***).

By far the most important biodiversity feature of the swamp lakes is the diversity of fish species. Kanyaboli is of particular interest given its size, threats, and the presence of fish species that have long been believed to have disappeared from Lake Victoria during the drastic declines over the second half of the last century. It has viable populations of the native tilapias ***Oreochromis esculentus*** and ***Oreochromis variabilis*** (Aloo, 2003). The lake also acts as a refuge for the following haplochromine species: ***Lipochromis maxilaris*** and ***Xystichromis phytophagus*** [both critically endangered, according to IUCN]; ***Astatotilapia nubila***; ***Astatotilapia bigeye*** (Kaufman 1992); ***Pseudocranilabrus multicolor victoriae;*** and ***Astatoreochromis alluaiudi***. Other common fish species include the catfish ***Clarias gariepinus***, the lungfish (***Protopterus aethiopicus***), ***Labeo victorianus***, and ***Barbus spp***.

With respect to avifauna, 172 bird species are listed (Odino, 2009), with the black-headed gonolek (***Laniarius erythrogaster***), ruff (***Philomachus pugnax***), and the African open-billed stork (***Anastomus lamelligerus lamelligerus***) being the most abundant (Ibid). Other interesting species include the papyrus gonolek, the great snapper, and the baillor's crane.

A rich invertebrate fauna is present in the swamp and along the river outlets where mayflies (Ephemeroptera) and dragonflies (Odonata) are common. Other macro-invertebrates include oligochaetes and mollusks.

Protection Status: The only PA in the Yala–Nzoia wetlands is the Lake Kanyaboli National Reserve, gazetted through legal notice No. 158 of 2010[11], with a total area of 41.42 km^2. The remaining areas of associated wetlands and swamps do not have protected status.

Threats: Economic activities upstream from the Yala–Nzoia wetlands are varied and intensive. The major pressure is agriculture, with 6,900 ha already drained for commercial agriculture[12], which has resulted in a large amount of sediment flowing into both the swamps and lakes. Major threats to the biodiversity of the Yala-Nzoia wetlands include:

- Policy challenges surrounding conversion of wetland into farmland, drainage for disease control, overgrazing, and tree removal for local fuel-wood supply;
- Increased sedimentation caused by upstream erosion and increased eutrophication (nutrients);
- Destruction of riverbanks through cultivation or vegetation removal;
- Contaminants (agrochemical pollution, industrial effluent, and wastewater discharge) getting to the lake -poisoning both fish and birds;
- Changes in the wetland's limnological characteristics due to changes in land use patterns and increasing anthropogenic inputs released into the wetland;
- Invasive alien species;
- Development of dams, changes in the drainage patterns, and diversion on both the Yala and Nzoia Rivers;[13]
- Wildlife poaching and habitat loss, especially for the sitatunga; and
- Non-selective fishing.

11 http://www.kenyalaw.org/LegalNotices/pop_ln.php?file=492
12 http://apps.unep.org/publications/pmtdocuments/-Kenya%20wetland%20atlas-2012Kenya_Wetlands.pdf
13 http://apps.unep.org/publications/pmtdocuments/-Kenya%20wetland%20atlas-2012Kenya_Wetlands.pdf

Ecosystem Services: Yala swamp is the main source of livelihood for neighboring communities that are traditionally dependent on it for vegetable collection, grazing, seasonal farming, and income-generating activities, including fishing, hunting, construction materials, and agricultural production. Additionally, local communities rely heavily on the macrophytes found in the wetland for building, fishing gears, and beehives. The wetland also provides services to local communities, such as a water supply for humans and livestock, and as a mode of mass transportation.[14]

A preliminary ecosystem services assessment for the regulating, provisioning, and cultural services for the Yala Swamp and Lake Kanyaboli is provided in Table 22 below.

Table 22. Preliminary ecosystem services assessment for the Yala Swamp and Lake Kanyaboli, Kenya

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Agriculture/unsustainable land use practices	Large amounts of agricultural activities upstream from the sites in question have led to an increased amount of sediment entering both systems. An increase in other associated contaminants has led to the eutrophication of the systems. Other issues include unsustainable land use practices such as burning and clearing, which reduce the functionality of the systems.	**Water purification:** Loss of the wetland system's ability to purify water, and siltation of Lake Kanyaboli	**Fresh water provisioning:** Loss of available fresh water for communities **Food:** Increased siltation and other contaminants would lead to a reduction in fish stocks. **Genetic Resources:** Potential loss of endemic species (i.e., fish species) **Recreation and Ecotourism:** Impact on potential ecotourism ventures	Negative impacts on communities reliant on fishing as their livelihood within the wetland; negative impacts on communities fishing within Lake Victoria Negative impacts on agricultural activities due to low water quality

Potential Interventions: Potential interventions in the Yala-Nzoia wetlands could include the following activities:

- *Promote a Regional Aquatic Ecosystems Landscape Conservation Process*-introduce measures for protection of the remaining small, yet important, natural habitats.
- *Support Design and Review of Management Plans*-formulate a Biodiversity Conservation Plan, which includes a community outreach program. The plan would include a zonation plan, detailed conservation objectives,community outreach objectives, and a monitoring and evaluation plan.
- *Implement Site-Level Interventions for Unique Habitats*-implement ecological restoration measures aimed at assisting in ameliorating agricultural pressure on the wetlands through riverbank protection and soil and water conservation measures.

14 http://apps.unep.org/publications/pmtdocuments/-Kenya%20wetland%20atlas-2012Kenya_Wetlands.pdf

- ***Build Capacity for Sustainable Use-***develop community outreach measures that would include capacity building and citizen science initiatives, which will seek to positively impact biodiversity, primarily through:
  - o Building capacity of local communities and youth groups for identifying and monitoring biodiversity;
  - o Providing institutional and managerial support for local-level youth and resource user groups;
  - o Supporting technical backstopping and facilitation of group activities; and
  - o Empowering communities to assist management organizations in monitoring and reporting damaging activities.
- ***Strengthen Livelihoods Diversification and Enhancement-***build capacity and facilitate communities to begin different forms of nature-based enterprises, so that they reduce their reliance on agriculture as the sole source of livelihood.

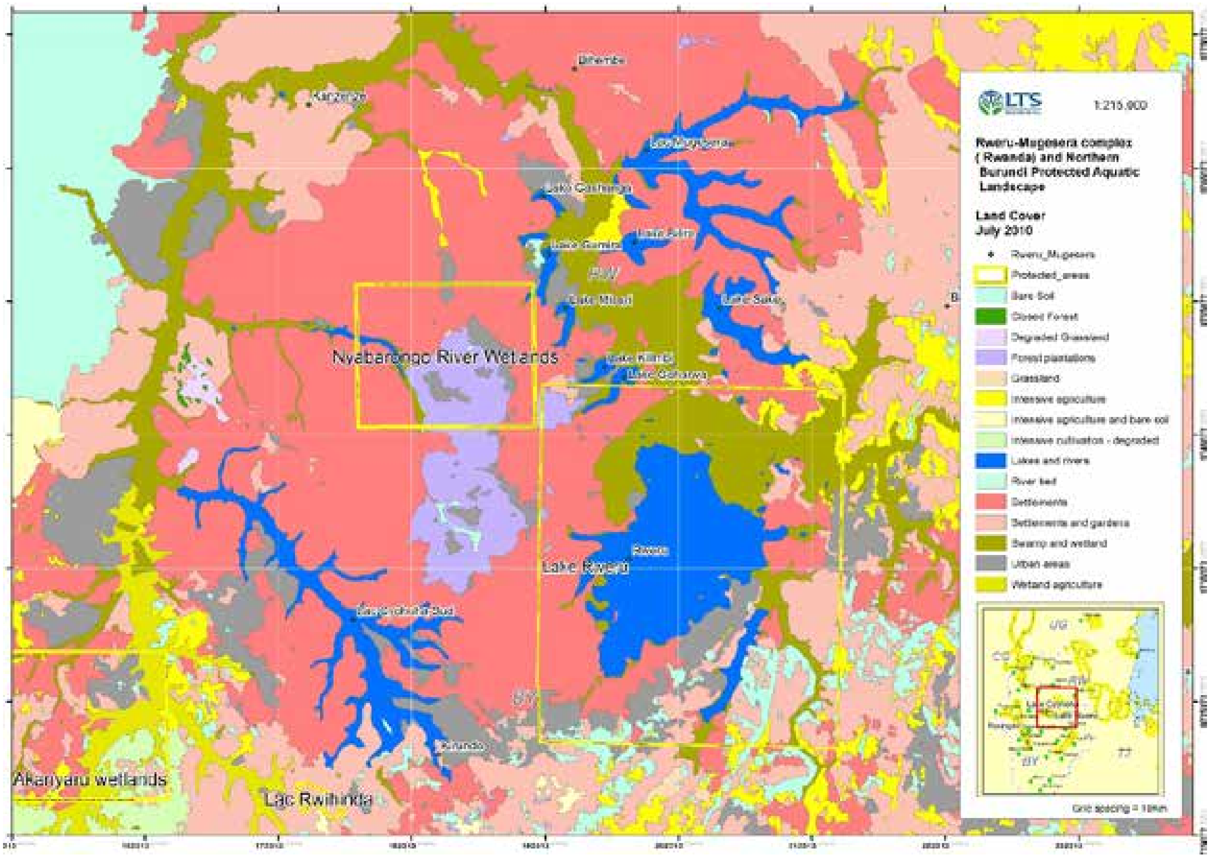
6.8 RWERU–MUGESERA COMPLEX AND NORTHERN BURUNDI PROTECTED AQUATIC LANDSCAPE, RWANDA/BURUNDI

Location: This area comprises a chain of lakes and swamps astride the Rwanda–Burundi border, and the Nyabarongo/Akanyaru river system, roughly between 2°00'–2°36'S and 30°00'–30°31'E. Lake Rweru is about 12,815 ha in extent and some 14.5 km at its widest. The lake is part of a larger system of lakes and marshes with scattered pools of varying size.

Declaration of the Northern Protected Aquatic Landscape by Burundi in 2006 resulted in the placement of more than 30,000 ha under nominal conservation, expanding on Lake Rwihinda which was already a national reserve. It includes seven other lakes, namely Cyohoha, Rweru, Gacamirindi, Kanzigiri, Nagitamo, Mwungere, and Narungazi, along with the adjacent expansive wetlands (see Figure 47).

Lake Rwihinda, including a small island that provides a unique habitat for birds

Figure 47. Rweru-Mugesera Complex and Northern Burundi Protected Aquatic Landscape



The drainage basin of Lake Rweru stretches across part of Rwanda's Bugesera district and two communities in Burundi. The nearby Lake Cyohoha (referred to as Cohoha in Burundi) is 5,642 ha in extent; 24 km long and 500 meters wide. The two lakes are closely associated with the wetlands along the Akanyaru (referred to as Kanyaru in Burundi) and Nyabarongo Rivers, both of which rise in the western highlands of Rwanda and Burundi. They flow through the Ngozi and Karundo provinces in Burundi and the Bugesera, Gisagara, and Nyanza districts in Rwanda. This BSA also includes the Murehe savannah-forest in northern Burundi.

One of Lake Cyohoha's many extensions is pictured with extensive swamps around it

Existing Institutions and Key Players: The Rwandan side of this landscape is under the general purview of the REMA. In Burundi, the key agency is OBPE, which has an operational base in the provincial town of Kirundo. Key stakeholders include the ministries responsible for natural resources, water, and agriculture on both sides of the border, RDB, LVEMP II, the Kagera River Basin Transboundary Agro-Ecosystem Management Programme (Kagera TAMP), and NELSAP. Several local and international NGOs, research bodies, and institutions of higher education also have major interests.

Biodiversity: The dominant aquatic plant species are ***Cyperus papyrus, Typha domingensis, Nyphea alba***, and ***Vosia cuspidata***. Several plant survey reports have recorded 222 species, of which 34 are aquatic or semi-aquatic. Other species include ***Polgonum pulchrum*** and ***Alternanthera sessilis***.

With respect to the bird fauna, various reports indicate that up to 168 bird species are to be found in the Rweru–Mugesera complex, including ***Laniarius mufumbiri***, ***Egretta garzetta, Ardea goliath, Bubulcus ibis, Bostrychia hagedash, Ploceus cucullatus***, ***Dendrocygna viduata***, reed or long-tailed cormorant, spur-wing goose, great white pelican, little egret, ***Haliaeetus vocifer***, ***Stephanoaetus coronatus***, and ***Euplectes afer***. Bush birds such as babblers, drongos, and robin-chats are common in the buffer zone. Both lakes are important for a resting and hibernation spot for intra-African and Palearctic migratory birds.

Lake Rwihinda, located immediately north of the town of Kirundo, has the distinction of being a haunt for many sedentary bird species and of being a stopover for migratory species-which earned it the former name "*Lac aux Oiseaux*" ("Lake of Birds"). The most common of these are the grey pelican (***Pelecanus rufescens***), the African cormorant (***Phalacrocorax africanus***), and widowed ducks (***Dendrocygna viduata***).

Small mammals found in the complex include the sitatunga (***Tregelaphus spekii***), warthog (***Phacochoerus aethiopicus***), serval cat (***Leptailurus serval***), vervet monkey (***Circopethicus aethiops***), blue monkey (***Cercopithecus mitis***), mongoose (***Atilax paludinosus***) and two otter species (***Aonyx capensis*** and ***Lutra maculicilis***). Only a few hippopotamuses (***Hippopotamus amphibious***) remain. Others mentioned include bushbuck, Grimm's (grey or savannah) duiker, genet, and civet cat. There are also several vulnerable reptile species, such as the Nile monitor (***Varanus niloticus***) and the African rock python (***Python sebae***).

In the upper Akagera, up to 24 fish species have been recorded that probably also occur in the Nyabarongo and Akanyaru Rivers. At least 18 fish species have been described in the Northern Protected Aquatic Landscape in Burundi. The ***Haplochromis*** probably includes three species that have not yet been formally described. Two species (***Barbus acuticeps, Synodontis ruandae***) are endemic to the upper Akagera sub-basin. Two species that were common in the 1980s are not seen in the lake at present (***Synodontis ruandae*** and ***Barbus kerstenii***), probably as a result of the introduction of other species and the development of the marshlands around the river tributaries and the lake.

Protection Status: Until the declaration of the Northern Protected Aquatic Landscape in 2006, Lake Rweru, Lake Rwihinda, and the Murehe and Gako forest reserves were the only PAs within the complex.

Threats: The major threats to biodiversity in the Rweru-Mugesera Complex and the Northern Burundi Protected Aquatic Landscape include:

- Excessive and inconsistent use of natural resources resulting in a deforested drainage basin composed exclusively of cropped plots and a lakeside population subjected to a shortage of indigenous resources.
- The clearing and deforestation of recent years, which has caused the Lake Rweru drainage basin to become a remnant floral and faunal reservoir.
- Overfishing and the use of inappropriate fishing methods resulting in diminishing fish stocks.
- Poor agricultural practices around the lake resulting in degrading physicochemical properties and pollution of the lakes.

Ecosystem Services: A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for Lakes Rweru and the Cyohoha and Akanyaru Wetlands is provided in Table 23.

Table 23. Preliminary ecosystem services assessment for Lakes Rweru and Cyohoha and the Akanyaru Wetlands, Rwanda/Burundi

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Unsustainable land use practices	The area surrounding the study sites is densely populated. The dominant land use in the region is subsistence agriculture, and there has been significant loss of wetland area because of land clearing. Approximately 90% of the Akanyaru Wetlands have been cleared for agricultural activities. A reduction in wetland functioning has led to a reduction of harvestable food and fiber from the wetlands and water quality impacts in the lakes downstream.	**Water purification:** Unsustainable agricultural practices and a loss of wetland area have resulted in increased sedimentation and other water quality impacts in the lakes downstream.	**Fresh water provisioning:** Reduction in available fresh water for communities **Food:** Water quality can impact the availability of fish species for consumption. **Genetic Resources:** Potential loss of endemic species **Recreation and Ecotourism:** Impact on potential ecotourism ventures	Local communities are dependent on downstream lakes for food and water provisioning.

Potential Interventions: Potential interventions in the Rweru-Mugesera Complex and the Northern Burundi Protected Aquatic Landscape could include the following activities:

- *Promote a Regional Aquatic Ecosystems Landscape Conservation Process*-support the protection of existing PAs. This component is applicable to the drainage basin of Lake Rweru, which includes the two natural reserves of Murehe and Gako, to halt the human pressures and to maintain their ecological functions.
- *Support Design and Review of Management Plans*-identify and zone existing buffer zones, or buffer zones to be restored in marshlands. This component addresses the challenges of recreating and protecting specific areas of the Akanyaru and Nyabarongo Wetlands and of Lakes Cyohoha and Rweru, in order to ensure that they continue to fulfill their functions of biodiversity reservoirs and water regulators.
- *Strengthen Cross-Border Collaboration*-exchange hydrological, biodiversity, and other data between the two countries. This component, which features both technical and institutional components, aims to promote synergy between the two countries in terms of monitoring and supervising the biodiversity and hydrological dynamics of the three water bodies.
- *Build Capacity for Sustainable Use*-develop environmental education activities. The management plan specifically links responsible and consistent management to the challenge of improving riparian communities' capacities for each of the water bodies.

6.9 MOUNT ELGON ECOSYSTEM, KENYA/UGANDA

Location: Near the extinct volcanic mountain range located northeast of Lake Victoria and centered around 1°14'09''N and 34°35'31''E, the general coordinates are 0°48'–1°30'N and 34°22'–35°10'E. The mountain straddles the international boundary between Kenya and Uganda, which is marked by the rivers Suam and Lwakhakha, and the beacon on one of the peaks (Sudek). It has a crater of about 8 km in diameter and considerable swamps on the caldera's uneven floor.

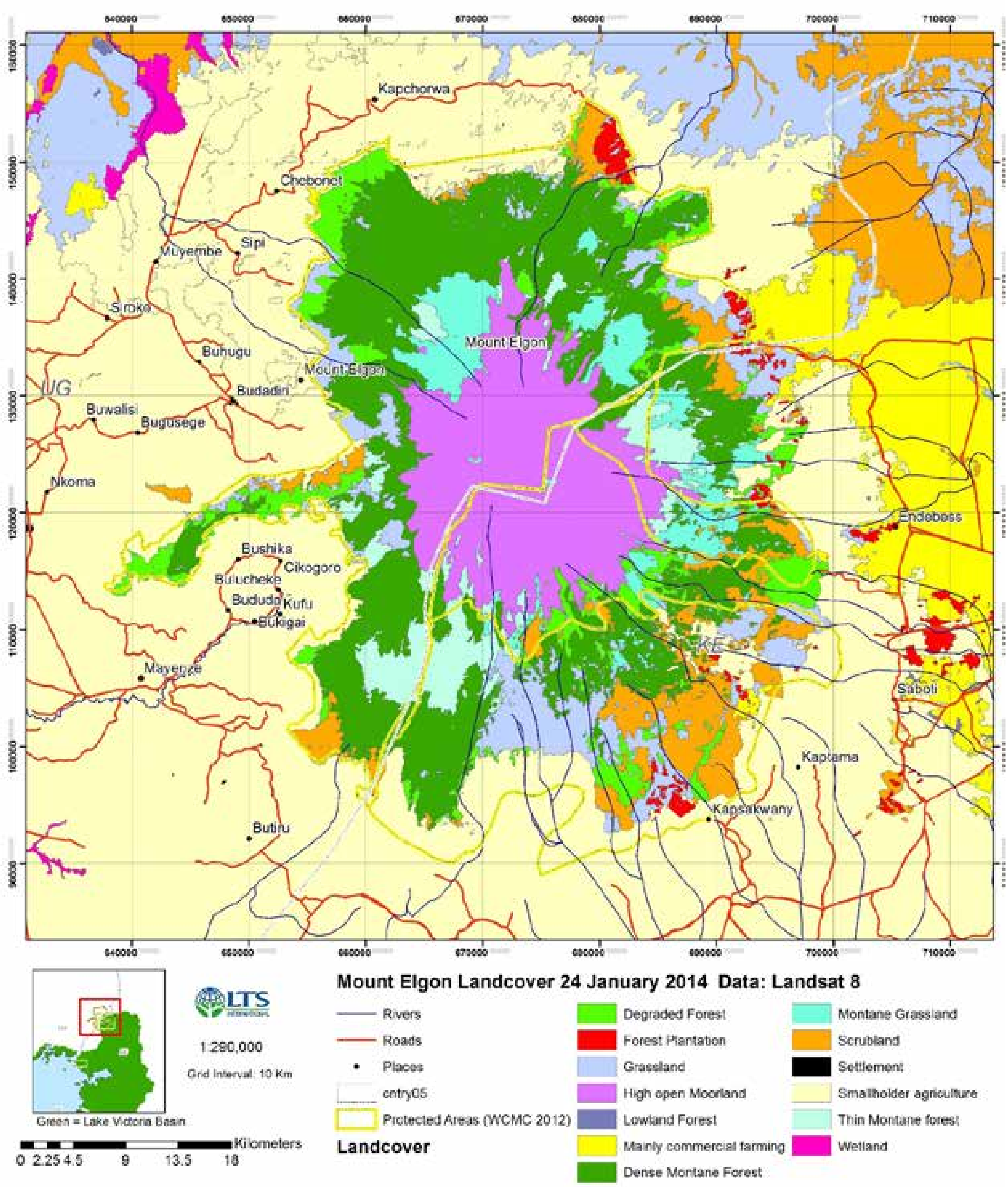
Mount Elgon is an extinct Pliocene shield volcano and the oldest of all East African volcanoes, with an estimated age of 15 million–20 million years old. The range runs roughly NE–SW with several peaks, the highest being Wagagai on the Uganda side, which reaches 4,321 meters above sea level. Three other major peaks include Kiongo (4,303 meters), Mubiyi (4,210 meters), and Jackson's Summit (4,165 meters). On the Kenyan side are Lower Elgon or Sudek (4,301 meters), Koitoboss (4,222 meters), and Endebess (2,563 meters).

Mount Elgon National Park in Kenya covers 169 km^2, while another 1,110 km^2 of the mountain area in Uganda is also a national park. At least three other PAs occur in the ecosystem, including the Namatala Central Forest Reserve in Uganda and the Trans-Nzoia Forest Reserve and Chepkitale National Reserve in Kenya.

Four broad vegetation classes have been described (Muhweezi et al., 2007). More than 3,500 meters above sea level is predominantly moorland and Afro-Alpine zone, dominated by unique vegetation comprising giant groundsels **(*Scenecio barbatipes*)**, lobelias **(*Lobelia elgonensis*),** and ***Helicrysum spp*.** High montane heath occurs between 3,000 and 3,500 meters. A bamboo and low canopy forest belt lies between 2,500 and 3,000 meters above sea level. Mixed montane forest occurs on the lower reaches of up to about 2,500 meters.

The mountain system is an important watershed, feeding into Lake Victoria, a major catchment for many tributaries draining into the major rivers that lead to large bodies of water—i.e., Lakes Victoria, Kyoga, and Turkana and that join the Nile River system. Its waters feed into Lake Kyoga in Uganda via River Mpologoma and into Lake Turkana in Kenya via the Rivers Suam and Bukwa, which ultimately extend into the Turkwel. It is also an important water catchment for many tributaries of the Nzoia River, which flows into Lake Victoria.

Figure 48. Mount Elgon Ecosystem



Existing Institutions and Key Players: Among the key players are the Bungoma and Trans-Nzoia county governments in Kenya, and various local District Councils in Uganda (Mbale, Bududa, Manafwa, Kapchorwa, Bukwo, and Kween Districts). The two national parks are managed by UWA and KWS on the Uganda and Kenyan sides, respectively. The forest reserve in Uganda is managed by NFA, with KFS managing the reserve in Kenya. The LVBC coordinates various activities in the Mount Elgon ecosystem that follow the framework of the Lake Victoria Basin Commission Operational Strategy 2007–2010, notably the implementation of the Mount Elgon Regional Ecosystem Conservation Program (MERECP). The IUCN and the International Centre for Research in Agroforestry – World Agroforestry Centre (ICRAF) are involved in the implementation of MERECP with financial support from the Kingdom of Norway. Across both sides of the border, NEMA (both in Uganda and Kenya) has a broad mandate in the ecosystem. A number of NGOs and CBOs are active in the ecosystem, including World Vision, Action Aid, Greenbelt Movement, Mount Elgon Forest Network, and the Socially Organized Education Team (SOET).

Biodiversity: Mount Elgon has a rich and unique biodiversity. The extensive forests on its middle and lower slopes are home to globally renowned biodiversity resources (Muhweezi et al., 2007). Most of the plant species above 2,000 meters have been shown to be endemic to the Afro-montane region. Renowned dominant tree species include Elgon teak (***Olea capensis***), cedar (***Juniperus procera***), and ***Podocarpus spp***. There are 37 globally threatened faunal species [22 mammals, 2 insect and 13 bird species (9 of which are endemic) (Muhweezi et al., 2007)]. Important wildlife includes elephants and buffaloes, small antelopes, forest monkeys, and more than 300 species of birds. Some of its rare animal species include the blue monkey (***Cercopithecus mitis mitis***), Sykes monkey (***Cercopithecus albogularis***), and the black-and-white casqued hornbill (***Bycaniste subcylindricus***). Notably, Mount Elgon is famed for caves that are regularly visited at night by herds of "salt-mining elephants," bushbuck, duiker and buffalo-all of which are in search of the salts that abound in the mineral-rich earth.

Protection Status: The core ecosystems consist of six PAs: Mount Elgon National Park in Kenya (which was gazetted in 1968); Namatala Central Forest Reserve in Uganda; Mount Elgon National Park in Uganda (which was gazetted in 1993); Trans-Nzoia Forest Reserve in Kenya; Mount Elgon Forest Reserve in Uganda (gazetted in 1934); and Chepkitale National Reserve in Kenya.

UNESCO declared the Kenyan part of the Mount Elgon ecosystem a Biosphere Reserve in 2003, in recognition of its importance as a water catchment for the Turkwel and Nzoia Rivers and its diverse natural habitats[15]. Mount Elgon Forest Reserve in Uganda was first gazetted as protected zones by the colonial government in 1938 under legal notice number 100 of that year. It was regazetted in 1948, 1963, and 1993 when part of it was made a national park.

Threats: The surrounding area is densely populated, with up to 600 people per km^2 in some places. The growth rate of the populations is 2.3–4.3%. Per capita land holdings are small-approximately 0.8 ha on average. The population largely comprises subsistence farmers who value the region's agricultural productivity and who use its natural products and forest resources to help sustain themselves. Members from the local communities get herbs (roots, tree bark, and leaves for medicine); honey; fuel wood; and poles for building, banana stalking, and fencing (from either bamboo or trees) from Mount Elgon. They also gather wild fruits; wild meat; timber; and bamboo shoots for vegetables, ornamentals, and making baskets. They also benefit by grazing animals in the forest. Local populations use the PA to not only gather NTFPs, but also to cut timber, graze livestock, clear land for farming, and poach wildlife (EAC, 2007).

The major threats include:

- Weak governance and conflicting institutional mandates;
- Understaffing and insufficient training and skills among forest authorities;
- Illegal logging;
- High demand for forest products and poor utilization of forest produce leading to wastage and poor value;
- Grazing;
- Forest fires, mostly caused by illegal honey gatherers;
- Invasive species and pests such as forest rodents, especially in forest plantations;
- Claims for forest land by local communities-indigenous forest dwellers, for instance; and
- Forest boundary encroachment resulting from high demand for agricultural land and livestock.

Ecosystem services: A preliminary ecosystem services assessment for regulating, provisioning, and cultural services for the Mount Elgon ecosystem is provided in Table 24 below.

15 http://www.bfn.de/fileadmin/MDB/documents/themen/internationalernaturschutz/2011-AfriBR-14-Mwaura_Kenya.pdf

Table 24. Preliminary ecosystem services assessment for the Mount Elgon Ecosystem

DRIVERS	ECOLOGICAL CONSEQUENCE	ECOSYSTEM SERVICES IMPACTED		IMPACT ON BENEFICIARIES
		REGULATING SERVICES	PROVISIONING & CULTURAL SERVICES	
Agriculture/ unsustainable land use practices	The areas in the ecosystems with high population density are settled, and traditional land inheritance is practiced with land fragmentation reaching unproductive levels of about one-eighth of an acre in some areas. Settlement schemes have had to be carved out of both unalienated and alienated government land, such as gazetted national forests and trust land, to settle the "landless" in Chebyuk (EAC, 2007).	**Water purification:** Unsustainable agricultural practices and loss of forest land have resulted in increased sedimentation and other water quality impacts in the rivers and lakes downstream.	**Fresh water provisioning:** Reduction in available fresh water for communities **Food:** Water quantity and quality can impact the availability for crop production, hence food security. **Genetic Resources:** Potential loss of endemic montane flora and fauna **Recreation and Ecotourism:** Impact on potential ecotourism ventures	Local communities are dependent on the forest services, food, and water provisioning.

Potential Interventions: Only part of the site falls in the LVB, all of which lies in Kenya. This area has a long history of research and conservation measures, and many actors there have undertaken interventions in the following areas (LTS, 2011). Potential interventions in the Mount Elgon Ecosystem would build upon past interventions to include the following activities:

- *Strengthen Cross-Border Collaboration*-enhance and support harmonized cross-border forest governance and institutional arrangements/frameworks.
- *Strengthen Livelihoods Diversification and Enhancement*-promote sustainable agricultural development and livestock production; promote alternative livelihoods activities that do not rely on agriculture (e.g., promotion of forest-based enterprises); launch initiatives piloting voluntary small-scale carbon trade; promote sustainable livestock production that is compatible with forest conservation.
- *Design and Pilot Market-Based Mechanisms*-implement ecosystem-based forest restoration activities, sustainable management of natural forests (avoided deforestation), and community tree growing. Further interventions in this area would entail:
    - Promoting climate-smart agriculture and agroforestry practices, and
    - Developing methodologies for REDD+ and PES.

7.0 INVESTMENT FRAMEWORK FOR THE BIOLOGICALLY SIGNIFICANT AREAS

This chapter describes the approach to the development of a comprehensive biodiversity conservation investment framework for the BSAs. The framework is geared toward leveraging support for implementing the interventions identified in the EPA, and will be prioritized in follow-up work. It presents a way forward for securing natural capital and meeting the national, regional/transboundary, and international biodiversity conservation goals based on prevailing and potential levels of funding. The framework supposes that budgetary sources will remain the first recourse for conservation investment and that alternative sources shall continue to provide the necessary additional funding. It will also be important to explore new ways of meeting funding shortfalls through innovative investment. Finally, the chapter identifies key data and knowledge gaps that hinder the full realization of the economic value of biodiversity and appreciation of degradation-related costs.

Through the EPA, efforts to obtain quantitative data on conservation funding levels in Partner States were met with limited success, mainly because government budgets are rarely aggregated at the appropriate scales for BSAs. In some instances, such information is considered sensitive and requires special authority to be released. The lack of data is especially serious where important biodiversity occurs outside the network of official PAs, as communities become the key players in such areas. Besides, the biodiversity mandate is widely dispersed through numerous ministries and conservation agencies, and the findings would have to be generalized at best.

Identification of the BSAs came late in the EPA process, hence it was not possible to collect the necessary data associated with the formulation of investment packages. It is therefore envisioned that the investment identification and development process will assist in filling this gap.

7.1 KEY COMPONENTS OF THE INVESTMENT FRAMEWORK

Success in biodiversity conservation at the BSAs will depend on strategic investment targeting action and improvement in three important areas. These are all subject to further identification and more precise description by experts, and they will include:

- Priority conservation interventions and activities;
- Synergy with other social and development sectors; and
- Critical enabling factors, such as human capital and financial inputs.

The investment framework takes as its starting point the identification of and consensus building on what is needed at the BSA. This is critical for ensuring that the major players are acting in accordance with agreed-upon principles and plans. The overall objectives of an investment would therefore be agreed upon and form the guiding determinant of all subsequent actions. Consensus is also important in ensuring inclusiveness and fostering participation.

In a similar way, it is essential that the framework recognize that the future of biodiversity depends on the delicate relationship between conservation and rural development in general, and the continued pursuit of sustainable livelihood approaches in particular. This points to the need for implementing biodiversity conservation interventions that have implicit socio-economic objectives, as opposed to the traditional "fines-and-fences" approaches. This represents a radical divergence from "preservationist" approaches to biodiversity and PA management.

Underlying the success of the priority interventions shall be the physical and human resources-the critical enablers-that would enable the stakeholders to implement agreed-upon actions within stated timelines. These are essentially related to funding that would depend on appropriate budgetary support and promotion of innovative conservation financing. Any conservation activities will stall midstream if a steady flow of resources cannot be assured.

7.2 BIODIVERSITY CONSERVATION OBJECTIVES FOR THE BSAS

Biodiversity loss compromises the benefits that humans derive from functioning ecosystems and directly leads to declining livelihoods. The conservation of biodiversity is usually geared toward meeting the broad objective of securing biophysical and socio-economic attributes into the future. These revolve around protecting the composition, structure, and functionality of the ecosystem; the delivery of ecosystem services; and the magnitude of their benefits.

A necessary, though not sufficient, step toward securing the important biodiversity in the BSAs involves the prioritization of conservation interventions. This must be followed by development of an appropriate, strategic, and innovative investment package for each site. At a minimum, it will be critical to ensure there is adequate knowledge of the following attributes for each site:

- The spatial extent and dominant physical attributes of the targeted area;
- Human demographics, economics, biological resources, and ecosystem services of the area;
- Threats to the continuity of biological resources and ecosystem services;
- The interventions necessary to counteract the identified threats;
- Expected reduction in biodiversity degradation or loss to be achieved through interventions when compared with the "business-as-usual" scenario; and
- Economic or environmental benefits of conserving biodiversity at the site, or costs of continued degradation or loss thereof.

Establishing the value of biodiversity (in economic terms), the potential benefits of conservation, and the consequences of biodiversity and ecosystem service loss is critically important for justifying intervention priorities. It also provides a good basis for advocating the mainstreaming of biodiversity priorities in wider policies, plans, and strategies within governments and regional organizations, as well as for promoting rational conservation action. A simplified business case, therefore, represents a minimum requirement for any investment package, with clear descriptions of the real or potential benefits, constraints, and opportunities, including the distribution of these among stakeholders.

Clearly, not all interventions can (or need to) be justified purely in economic terms, however. For example, biodiversity conservation in a world heritage site is a longstanding commitment by government and the international community that does not require the kind of economic justification necessary for some of the BSAs. The application of economic valuation is recommended on an attenuating basis depending on its strategic importance in each BSA. Whether an economic valuation is conducted or not, the proposed investment package should seek to shed light on the following critical issues for each site:

1. The key biodiversity features worth conserving/protecting;
2. Threats to biodiversity and ecosystem services that require action to ameliorate/overcome;
3. Actions needed to address the threats (including those that can make conservation more profitable);
4. The constraints/opportunities (budgetary/institutional) facing biodiversity conservation in a particular site and how the constraints could be overcome or opportunities be realized; and
5. The most viable options for meeting the required funding requirements-providing incentives for supporting the identified actions, countering the constraints, or pursuing the opportunities.

7.3 CAPACITY AND DATA GAPS AFFECTING CONSERVATION DECISION MAKING AT THE BSAS

The EPA generated information that formed the base for beginning to define the broad goals for conservation at the nine BSAs. This supported the broad assessment of biodiversity and enabled analysis of the key issues, threats, and main institutional actors. It also revealed the huge capacity and data gaps that stand in the way of biodiversity-friendly decision making. Going forward, EPA recommended that a PIN or a CIP be prepared for each BSA, setting out strategic conservation objectives, rationale, scope, and investment opportunities among other key attributes. The PINs and CIPs shall also seek to address the capacity and data gaps identified by the EPA. These include human capacity, biophysical attributes, and economic data as outlined below.

7.3.1 HUMAN CAPACITY

Not all the BSAs are either officially protected or overlap with PAs. In some of the BSAs that enjoy a national park or Ramsar site status, the necessary human resource and conservation budgetary support are insufficient for effective conservation. Even when present, the technical capacity of most conservation managers, researchers, and planners is usually highly skewed in favor of protection and extractive utilization. They are also tilted away from the economics of natural resources, a fact particularly true of the EAC region.

At the same time, many of the methods that are commonly used to value biodiversity and ecosystem services are overly complex in terms of their data and analytical requirements (Emerton, 2014). They are also primarily geared toward an academic audience, rather than being targeted at supporting real-world conservation planning processes. Capacity building is necessary for strengthening national and regional technical skills for economic valuation of biodiversity and ecosystem services. Recognizing that most of the BSAs are wetland sites, the EPA also identified the distinct need for training on freshwater biodiversity and wetland ecosystem services. This is required for building the approaches and methods that can be applied in generating practical and policy-relevant information to feed into and strengthen conservation planning-and in situations where time, resources, and expertise are scarce.

An initial training has been provided to a select group of practitioners from the five Partner States and to experts from conservation organizations in two key areas. The first focused on rapid wetland biodiversity and ecosystem services characterization, identification, values and wise use, and rapid ecosystems assessment. The second training was aimed at equipping them with an awareness and understanding of the general principles and applications of biodiversity and ecosystem valuation for conservation planning. These were designed to be training-of-trainers sessions, and the participants are expected to deploy the knowledge and skills gained in their daily work and to impart the same to others in the institutions they represent.

7.3.2 BIOPHYSICAL DATA

For the preparation of highly descriptive and concise PINs to be undertaken effectively, it will be essential that the required biophysical data be gathered for supporting tables, graphics, and the accompanying text. This requires the generation of objective and highly precise data on the aspects of the BSA outlined below.

The spatial extent of the target area (BSA): Conservation and investment cannot occur in an area with arbitrary spatial limits. It will be necessary to establish the exact geographic boundaries and size of each BSA as closely as available data permit. This will be relatively straightforward where such boundaries have already been decided in previous processes, as in the case where the BSA coincides with a national park or existing Ramsar site. At sites where only general descriptions exist, intense discussions will be required with the authorities responsible for natural resources management. Other biophysical data required include the physical features characterizing a site-topography, elevation, soils, hydrology, climate, land use and land cover, etc. This is critical for establishing linkages with the vulnerability impact assessment taking place under the Climate Change Adaptation component of PREPARED. It will also connect the EPA and PIN work to the assessments undertaken by the Water Supply Sanitation and Hygiene component of PREPARED.

Biological resources endowment of the BSA: The EPA made efforts to establish the key species, populations, distribution, temporal dynamics/seasonality, uniqueness, vulnerability, and ecosystem services of different areas. However, these were based on the best available literature, anecdotal evidence, expert narratives in focused group discussions, and interview respondents. The data can be updated with more recent field surveys and published material. It is not expected, however that any new surveys will be undertaken at this stage, as this would be unnecessarily time consuming. Rather, it will be imperative to point out areas where new surveys are needed, as critical data gaps to be filled in subsequent interventions.

The people and socio-economic or environmental benefits: The expected benefits of conserving biodiversity of an area and the beneficiaries are key factors in the success of any conservation efforts. They define another critical body of data that will be needed in the identification of conservation priorities. Most countries conduct decadal censuses, but the results of these are not always published at scales appropriate to a BSA. However, the data exists in different levels of government and for the smaller administrative units in each country. Inter-decadal extrapolations can also be obtained from the various census bureaus and local government development offices. The data of special interest here include the demographic, sociopolitical, cultural, and technological advancement of local human communities.

Threats to the biological resources and ecosystem services: Similarly, threats for each BSA were analyzed at a very general scale. It is necessary for more fine-grained data to be generated on the qualitative and quantitative aspects of these threats. An important dimension of this would be results of field assessments sanctioned by governments and academic and research institutions; photographic records; and statistics of natural resource extraction normally reported in the public reports. Other important data could be obtained from key-informant interviews with resource users and managers. At a local level, the biodiversity measures of interest include rates of land use change, invasive species, exploitation levels, and pollution. Interest in the impacts of climate change make weather records yet another data type of concern to understanding and projecting biodiversity trends.

Current and past biodiversity trends: Whether a resource is increasing, dwindling, or holding its own is a matter of interest to any conservation program. The EPA was able to highlight species of special conservation interest based on their IUCN red list status, but it could not be precise on the actual numbers or most recent trends. Even for species not on the IUCN red list, it is of interest to establish their population sizes and trend over the immediate past, as a way of deducing how they are likely to behave into the future within the conservation planning horizon. These data are the preserve of the conservation and ecological monitoring agencies in the various countries but are usually shared among scientists with few restrictions. Engagement with the various regional and international biodiversity databases active in the region will constitute an important plank of this effort.

Land and resource tenure: There is need for better understanding of resource ownership and access in a number of the BSAs, a vitally important part of the biodiversity conservation investment process. The Food and Agriculture Organization of the United Nations defined tenure in 2012 as the way in which people gain access to land, fisheries, forests, and other natural resources (FAO, 2012). A successful biodiversity conservation investment must seek to establish synergy with existing tenure arrangements and to formalize both the rights and the governance of the tenure system. A deep inquiry into implications of land and resource tenure on biodiversity shall thus constitute an important task in the development of conservation investment.

Ongoing projects, conservation investments, and stakeholders in the BSA under consideration: It will be essential to have a snapshot of Partner States' biodiversity conservation investments, outlining the current portfolio and providing background on past and current conservation-related activities and projects. This is undoubtedly a key consideration in the design of any site-specific interventions. In some of the BSAs, a large number of government programs coexist with NGOs and donor-funded and local community initiatives. Information about this is important, because investment in biodiversity conservation is always essentially incremental. Equally important, there is need to avoid unnecessary competition and ensure that new investment goes where it is needed most.

A synopsis of alternative financing instruments and the respective laws and regulations governing these will be essential. The data for preliminary analyses were drawn chiefly from the NBSAPs, where these existed. Most of these are relatively old, however, and a revision of the socioeconomic figures quoted within is considered a critical necessity.

7.3.3 ECONOMIC DATA

The PREPARED Project envisages that for each BSA, the economic benefits associated with conserving biodiversity and/or the economic costs associated with biodiversity degradation and loss should be clearly understood as a prerequisite for promoting conservation of the biodiversity at the site. This is based on the presumption that providing information about the value of biodiversity and ecosystem services would help to justify and make the case for the conservation interventions and investment packages to be proposed in the PINs or CIPs. It would also assist in better mainstreaming biodiversity priorities into government policies and budgets. That notwithstanding, huge gaps remain in the availability and access to data from the relevant economic sectors.

The barriers to integrating economic valuation into the identification of interventions represent a particularly daunting task. Diverse types of data are required for economic valuation. These include market and non-market prices of biological resources and ecosystem services. Others are the costs associated with biodiversity degradation and loss. Among the main barriers in this regard is the paucity of information on the monetary values of biodiversity and ecosystem services, especially at the geographic scope of the BSAs. This poses the unique problem of undervaluation that characterizes the biodiversity conservation throughout the LVB and EAC region. When such data are available from the national statistics authorities, they are either grossly summarized or otherwise incomplete and unrepresentative of key biodiversity resources.

Lack of data and the subsequent undervaluation downplays the contribution of natural capital and affects the conservation of both biodiversity and ecosystem services. It also hinders the application of important natural resource principles in development planning. Investment decisions on land and biodiversity resources have traditionally been based on a very narrow view of the human link to environmental values. This constitutes primarily the commercial earnings associated with the extractive utilization of natural resources such as wildlife, forestry and fisheries, and conversion of wild habitats to what are more easily identified as productive uses-for example, agriculture and settlement. The associated revenue streams, however, represent only a small proportion of the total value of natural ecosystems, which generate economic benefits far in excess of the physical products or marketed commodities they provide.

Such a narrow worldview reflects not only the limitations in knowledge and the underlying data gaps, but also the significant risk of continued depreciation to the natural resource base as people relentlessly seek to maximize output. As a result of the huge underestimation, the economic worth and opportunities that are associated with the natural environment-as well as the benefit to the diversity of stakeholders that depend on environmental goods and services-are sure to be downplayed in any resource management decision. Keeping within these limiting concepts of economic value also directly influences what are considered the "best" or "most profitable" economic options and development choices, which further imperils biodiversity.

The above observations indicate areas where data gaps are most apparent and define the directions for future effort by PREPARED, LVBC Partner States, and multiple stakeholders. Many development decisions are based on investment appraisals, economic calculations, and cost-benefit analyses that are prepared using widely accepted national economic statistics. In the cases where data are lacking or fundamentally inadequate, decision making and conclusions are based on sometimes-unrealistic extrapolations. This means that relative costs, benefits, and returns from alternative land uses, resources, and investment funds can be grossly misleading. Decisions are thus likely to be based on perceptions that few economic benefits accrue from the conservation of biodiversity and natural ecosystems. Similarly, the economic costs associated with the degradation and loss of these resources is constantly understated.

The ultimate result is that policies are enacted and implemented based on the undervaluation, often serving to hasten processes of environmental degradation and biodiversity loss. The best examples of these are inducements to reclaim wetlands and other natural habitats; intensification of agriculture; and low or non-existent penalties and fines for environmental violations. These concerns are apparent in many of the BSAs identified by the EPA (notably the Nabugabo lakes complex, the Yala–Nzoia wetlands, and the Mwanza gulf), underscoring the urgent need for the generation of relevant and accurate data to support decision making.

There is significant pressure for industry to be given subsidies and tax breaks throughout the region. This represents a potential avenue for apparently benign policies that could pose risks to biodiversity. It highlights an area that should be given serious thought, and more research effort directed toward generating data that brings out the full impacts of such potential policy decisions.

At a more subtle level, data are needed on what are perhaps even more deleterious but less appreciated economic forces on biodiversity. These include market effects such as prices and incentives faced by both producers and consumers, which shape their day-to-day economic opportunities and livelihood decisions. For example, it frequently remains cheaper or more profitable for people to engage in activities that degrade biodiversity and ecosystems, even when the associated costs and losses to the economy, or for other groups, far outweigh the immediate gains to the immediate resource user or investor responsible for the damage. A catalogue of data deficiencies and lack of analysis all along the resource use chain perpetuate this situation.

The other serious consequence of undervaluation is more closely related to the purpose for development of PINs and CIPs for the BSAs. It is manifested in the perennial shortage of funds and investment financing for conservation. In all the countries of the region, conservation tends to be accorded low budgetary priority compared with other sectors. This is because it is considered either a low productivity sector or one that makes a low contribution to development and economic goals. For the same reasons, it is often difficult to mobilize private capital and investment for conservation. Equally important, the incentives normally afforded to other sectors of the economy are yet to be extended in an appreciable magnitude to ecosystem-friendly products, technologies, and activities.

Numerous factors account for the above scenario. For a start, markets and prices simply do not exist for many ecosystem services. This means that it is difficult, if not impossible, for resource custodians, land managers, and investors to capture the considerable economic opportunities and potential of conservation. It became apparent during the EPA process that resource-dependent enterprises-ranging from fisheries to tourism operators and hydroelectric power producers-are willing to engage with upstream communities, but the enterprises and the communities do not have solid data required for this to happen objectively.

Any assumption that biodiversity and ecosystems have no value-much as this is manifestly ill informed-leads to what are seen as perfectly rational policies, decisions, and market signals from an economic point of view. In reality, however, biodiversity and ecosystems have inherent economic value that is poorly understood and frequently omitted from decision making. Decisions made based on partial or inadequate information tend to favor short-term, often unsustainable development imperatives. They also lead to conservation and development choices that do little to optimize economic benefits. In a worst-case scenario, a substantial misallocation of resources occurs and goes unrecognized. Immense economic costs are also incurred without being directly associated with such decisions.

If economic valuation is to fulfil the promise it holds for providing a powerful tool for placing biodiversity on the decision tree, then it is essential for greater efforts to be directed toward collecting qualitative and quantitative data in its support. Clearly, the data gap must be continually filled to uphold the actions and actors that secure biodiversity conservation on the agendas of LVB planners and decision-makers. The data specifically needed in this respect are those that support the basic aim of valuation, which is the underlying factor that determines people's preferences for or against conservation and sustainable use.

Economic data serve another important purpose. By expressing preferences-relating them to measures of human well-being and how much better or worse off people would consider themselves to be because of changes in the supply of ecosystem services-valuation presents an opportunity for making the natural environment directly comparable with other sectors. This at least permits natural ecosystems to be considered as economically productive systems, alongside other possible uses of land and allocation of funds. This holds true even if calculation of economic value does not necessarily favor conservation.

7.3.4 DATA SOURCES

The sources of both the biophysical and economic data will vary from country to country, but these entail generally the national and local government institutions, conservation authorities, development partners, and conservation NGOs. Maps and geographic data are usually the responsibility of land ministries, cartographic units, and departments charged with spatial planning. A good amount of this is also available from a variety of international sources, but national agencies remain the authoritative sources of first resort.

Ministries responsible for the environment, natural resources, agriculture, and PAs' management dockets primarily hold data on biodiversity. Conservation agencies are also best placed to provide data on staffing levels and on other fixed and variable expenses associated with day-to-day operations.

Social and economic data are more dispersed, with ministries of finance and economic planning being the first points of contact for data on budget allocations, prices, and market projections. Most of these are readily available from a wide variety of institutions. Table 25 lists the main data-holding institutions identified by the EPA, including at the validation stage of this report. It is emphasized, however, that this list is not exhaustive, and a complete compilation can only be achieved through intense exploration of local sources.

Table 25. Sources of BSA data identified through the EPA

BSA	COUNTRIES	KEY DATA INSTITUTIONAL DATA SOURCES
Nabugabo Lakes Complex	Uganda	• Wetlands Management Department • Directorate of Water Affairs • Masaka District Local Government • Nabugabo Community Development Association • FSSD • Directorate of Water Affairs • NFA • UWA • Ministry of Tourism Wildlife and Antiquities • NaFFIRI
Mara Wetlands	Tanzania	• Lake Victoria Basin Water Board • MNRT – the Wildlife Division • Ministry of State in the Vice President's Office, Union Affairs and Environment • National Environment Management Council (NEMC) • Ministry of State in the President's Office – Regional Administration, Local Government Civil Service and Good Governance • MALF • MLHHS • Ministry of Water • TAFIRI – Musoma sub-center • District councils of Rorya, Tarime, and Musoma Rural • Musoma Municipal Council • LVBWB • TWRUF • Nile Basin Initiative – Nile Equatorial Lakes Subsidiary Action Program (NBI-NELSAP) • WWF –Tanzania Country Office

BSA	COUNTRIES	KEY DATA INSTITUTIONAL DATA SOURCES
Mara-Serengeti Ecosystem	Tanzania	• Association of Hotels • MNRT • TANAPA • Tanzania Wildlife Research Institute • Ikorongo, Maswa, and Grumeti Game Reserves [under the authority of TAWA)] • TFS • NGOs, such as the Tanzania Tour Operators • NEMC • Lake Victoria Basin Water Board • WMA committees • FZS
	Kenya	• Narok County Government • MENR • SORALO • Ministry of Lands • Kenya Land Commission • Association of Hotels • KWS • NEMA-Kenya • NGOs, including MMWCA, Kenya Wildlife Conservancies Association, Mara–Serengeti Hoteliers Forum, African Conservation Centre
Mwanza Gulf	Tanzania	• MNRT • LVBWB • MOWI • MALF • MLHHS • Ministry of State in the Vice President's Office, Union Affairs and Environment • Ministry of State in the President's Office – Regional Administration, Local Government, Civil Service and Good Governance • NEMC • TAFIRI – Mwanza Center • TANAPA – Saa Nane Island National Park • BMUs • Mwanza City Council • District Councils of Ilemela, Nyamagana, Ukerewe, Misungwi, Sengerema, and Magu

BSA	COUNTRIES	KEY DATA INSTITUTIONAL DATA SOURCES
Sango Bay – Minziro Swamp	Tanzania	• LVBWB • MOWI • MNRT • NEMC • MALF • MLHHS Ministry of Environment, Water and Natural Resources • TFS • Ministry of State in the Vice President's, Office Union Affairs and Environment • Ministry of State in the President's Office – Regional Administration, Local Government, Civil Service and Good Governance • WWF (Tanzania Country Office)
	Uganda	• Wetlands Management Department • Rakai District Local Government • Local District Forest Offices • NFA
Nyungwe – Kibira Complex	**Rwanda**	• Ministry of Natural Resources (MINIRENA) • Rwanda Water and Forestry Authority • RDB • REMA • Various District Authorities and CBOs • NGOs, including WCS, ARCOS, DFGFI, ITFC, IGCP, and WWF
	Burundi	• Ministry of Water Environment, Land Management, and Urban Development • OBPE • Ministry of Environment • ISABU • REGIDESO • WCS
Yala–Nzoia Wetlands	Kenya	• MENR • LBDA • NEMA-Kenya • WRMA • Busia, Siaya, Nandi, and Mount Elgon County Governments • KEMFRI • KWS • NMK • KFS • NGOs and CBOs, including Nature Kenya, Friends of the Yala, Wetlands International, RSPB, GIZ • Dominion Farms Ltd.

BSA	COUNTRIES	KEY DATA INSTITUTIONAL DATA SOURCES
Rweru–Mugesera Complex and Northern Burundi Protected Aquatic Landscape	Rwanda	• MINIRENA • Ministry of Agriculture • LVEMP II • Kagera TAMP • RDB • REMA • NBI-NELSAP • Districts and CBOs
	Burundi	• Ministry of Environment • OBPE • LVEMP II • Kagera TAMP • Bugesera Project
Mount Elgon Ecosystem	Uganda	• UWA • NFA • NEMA-Uganda • Local Government in Uganda (Mbale, Bududa, Manafwa, Kapchorwua, Bukwo, and Kwen districts)
	Kenya	• KWS • KFS • NEMA-Kenya • LVBC –MERECP • Bungoma and Trans-Nzoia County Governments • NGOs and CBOs, including the IUCN, ICRAF, World Vision, Action Aid, Greenbelt Movement, Mount Elgon Forest Network, and SOET

7.4 FUNDING OPTIONS FOR THE INVESTMENT FRAMEWORK

Conservation investment funding options span a range of sources, including central and local governments and parastatals, extra-budgetary co-funding from international development partners, and NGOs. Government budgets are the most direct avenue for funding conservation, utilizing revenue generated through taxes, concessions, conservation trust funds, bioprospecting payments, resource extraction and use fees, and various other mechanisms. These sources of funding are self-explanatory and form the bedrock of support to PAs.

Funding conservation outside the conventional PAs depends on a range of innovative methods including private funding, PES, and debt-for-nature swaps. These are less well known, and therefore briefly described below with a view to guide deliberations on potential conservation investments in the BSAs.

7.4.1 CONSERVATION TRUST FUNDS

These represent a relatively familiar mechanism for providing long-term support for biodiversity and usually depend on endowments and sinking and revolving funds. Endowments are particularly popular because the principal investment amount is maintained as a permanent asset and only the income generated is used to finance conservation activities. A sinking fund is a fund established by setting aside revenue over a period to fund a future expense. On the other hand, revolving funds are replenished on a regular basis (such as from grants) with the possibility that the original principal investment amount continues to grow.

One good example of a conservation trust functioning in East Africa is the Maasai Wilderness Conservation Trust (MWCT)[16]. The MWCT funds and operates programs that facilitate lease payments for conservancy land; carbon credits; payments for watershed protection; sustainable ecotourism; wildlife monitoring: security; and employment from conservation and tourism.

Of particular interest is the Lake Victoria Environmental Trust Fund (LVETF)[17] proposed by the LVBC. The LVETF is similar to other trust funds in Kenya (e.g., Water Towers Conservation Fund) and Rwanda (e.g., National Fund for the Environment in Rwanda), but the intention is not to duplicate their work.

The LVETF is envisaged to focus on transboundary natural resources management and to prioritize transboundary biodiversity conservation issues in five areas:

- Land, wetland, and forest degradation;
- Weak governance, policy, and institutional framework on transboundary environment and natural resources management;
- Decline and loss of habitats and biodiversity;
- Pollution and eutrophication; and
- Unsustainable LVB transboundary water resources management, declining water levels in Lake Victoria, and climate change.

7.4.2 ECOTOURISM FEES

Eco-tourism is driven by millions of tourists from around the world who travel to destinations for pristine nature-based experiences. While tourism expenditure is mostly captured in economic sectors such as travel, accommodation, and retail trade, PAs themselves typically capture very little of the total economic benefits. Tourism user fees are most appropriately tapped, as biodiversity is associated with an eco-tourism destination. The Maasai Mara-Serengeti Ecosystem provides ample opportunity for this, but the other BSAs, where there is a much lower visitor demand, present an even more fertile ground for ecotourism.

7.4.3 CONSERVATION CONCESSIONS

This mechanism works through a conservation organization mimicking a resource extraction company by allowing parties to bid on resource rights, then protect rather than extract the resource. Such an arrangement serves to protect the services provided by an area at the cost of provisioning services. In the Mara, through such an approach, private land can be brought under conservation through the granting of ecotourism concessions to operators who would otherwise make other land use choices.

7.4.4 PAYMENTS FOR ECOSYSTEM SERVICES

These involve payments offered by beneficiaries of ecosystem services to parties who provide some form of management to the ecosystems that produce those important services. The beneficiaries are defined by the use of particular provisioning or cultural services. The service provider is usually a community, individual, or organization either that cedes its right to land or a natural resource, or that refrains from damaging or polluting land or water in return for a payment.

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16 http://www.maasaiwilderness.org/

17 LVBC. Proposed options for establishing Lake Victoria Environmental Trust Fund and Sources of Financing. http://library.lvbcom. org:8080/handle/123456789/193

These schemes provide a source of income for land management, restoration, conservation, and sustainable use activities, and thus have significant potential to promote sustainable ecosystem management, thus ensuring the flow of ecosystem services. The key characteristic of PES is a focus on maintaining the flow of a specified service-such as clean water, biodiversity habitat, or carbon sequestration.

7.4.5 BIOPROSPECTING PAYMENTS

Genetic resources are a source of new chemical compounds that may have commercial value as sources of food, chemicals, industrial enzymes, or other products. A community could license a company to collect plants for commercial exploitation. Governments may allow companies seeking access to genetic resources to do so on mutually agreed terms, which might include benefit-sharing in the form of technology transfer, collaborative research, upfront or milestone payments, or royalties on eventual commercial sales.

7.4.6 DEBT-FOR-NATURE SWAPS

Debt-for-nature swaps involve the purchase of a portion of a country's public debt by a third party in exchange for an investment in conservation by the country. The proceeds generated by debt-for-nature swaps may be administered by appropriate conservation trust funds.

In the LVB, Tanzania is the only country that has benefited from such a mechanism when, in 1993, US$ 37.6 million were availed through a debt-for-nature swap in return for a US$ 18.7 million investment in conservation (Sheikh, 2006).

7.5 DETERMINANTS OF BIODIVERSITY CONSERVATION INVESTMENT OUTCOMES AT THE BSAS

Table 26, developed from literature obtained via structured searches and information provided by EPA team members, summarizes the important biodiversity attributes, major threats, community benefits, and the conservation status that would have strong bearing on the choice of priority interventions for each BSA. This information will inform the investment packages to be developed for each BSA. These packages are then expected to help the LVBC attract financing from various funding sources.

Table 26. Summary of biodiversity features that influence the prioritization of interventions for the BSAs

ATTRIBUTES	LAKE NABUGABO COMPLEX	MARA WETLANDS	MARA–SERENGETI ECOSYSTEM	MWANZA GULF	SANGO BAY – MINZIRO SWAMP FORESTS	NYUNGWE–KIBIRA COMPLEX	YALA–NZOIA WETLANDS	RWERU–MUGE-SERA COMPLEX AND NBPALS	MOUNT ELGON ECOSYSTEM
Species of concern	• Important bird species • Haplochromines • Important plant species	• Important bird species • Important fish species	• Important bird species • Important mam-mal species	• Important bird species • Important fish species	• Important bird species • Important mammal species	• Global biodiversi-ty hotspot	• Important fish species • Important bird species	• Important bird species	• Plant species endemic to the Afro-montane region • Globally threatened mammals, birds, and insects
Ecological functions	• Refugia for haplochromines	• Buffer for Lake Victoria	• Habitat refugia • Habitat intactness • Provisioning and regulation of water	• Satellite lake, refugia for hap-lochromine	• Large tracts of swamp forest • Important ecotone	• Habitat for key primate species • Provisioning and regulation of water	• Refugia for haplochromines species	• Important habitat for migratory birds	• An important watershed for Lakes Victoria, Kyoga, and Turkana, as well as the Nile
Threats	• Human encroachment • Overfishing • Poor agricultural practices	• Agricultural runoff • Agricultural encroachment • Poaching • Fluctuating hydro-logical regimes • Gold mining upstream • Uncontrolled fires	• Poaching • Overgrazing and illegal cattle grazing • Reduced and degraded water resources • Uncontrolled fires • Population pressure • Relatively new invasive species	• Pollution from urban and agricultural runoff • Overfishing • Unsustainable agriculture, fisheries, and grazing • Unsustainable harvesting of other wetland-related products	• Human encroachment • Grazing • Heavy dependency of the neighboring community • Exotic species of floating plants	• Human encroachment • Poaching • Agriculture expansion • Bush meat • Mining • Fires • Spread of highly competitive plant species	• Agricultural activities • Sedimentation • Eutrophication • Clearing (drainage or burning) for cultivation • Overgrazing and tree removal for local fuel wood • Agrochemical pollution • Fish poisoning • Invasive alien species	• Overfishing, • Inappropriate fishing • Poor agricultural practices	• Weak governance and conflicting institutional mandates • Illegal logging • Forest fires • Invasive species and pests

ATTRIBUTES	LAKE NABUGABO COMPLEX	MARA WETLANDS	MARA–SERENGETI ECOSYSTEM	MWANZA GULF	SANGO BAY – MINZIRO SWAMP FORESTS	NYUNGWE–KIBIRA COMPLEX	YALA–NZOIA WETLANDS	RWERU–MUGESERA COMPLEX AND NBPALS	MOUNT ELGON ECOSYSTEM
Community Benefits	• Fishing, • Medicinal plants • Building material • Tourism	• Fishing • Medicinal plants • Building material	• Tourism and ecotourism	• Fishing	• Fishing • Medicinal plants • Building material • Tourism	• Tourism	• Fishing • Medicinal plants • Building material • Tourism	• Fishing • Medicinal plants • Building material • Agriculture	• Fresh water provisioning • Food • Genetic Resources • Recreation & ecotourism
Conservation status	Ramsar Site, IBA	IBA	IBA, Game Reserve/ National Park	IBA	Ramsar Site, IBA	IBA, National Park	IBA	IBA	• National parks/ forest reserves on both sides of border, biosphere reserve on the Kenya side
Management Plans	Yes	No	Yes	No	Yes	Yes	No	No	-

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APPENDIX 1: STAKEHOLDERS CONSULTED IN THE EPA

MAASAI MARA, KENYA

- James Sindiyo, Chief Warden, Maasai Mara National Reserve
- Moses Olekuyion, Deputy Chief Warden, Maasai Mara National Reserve
- KWS veterinary support team in Maasai Mara
- Mr Kimutai, Senior Scientist, KWS Research Station
- Vaso, KWS Research Station
- Denis, KWS Research Station
- Kennedy, KWS Research Station
- Patrick Naisweku, Ranger, Maasai Mara
- Sand River Gate (Maasai Mara Reserve) staff
- Dr. Judith Nyunja, KWS Wetlands Manager – KWS HQ, Nairobi
- Dr. Dorothy Nyingi, Freshwater Fish Expert, Kenya Wetlands Biodiversity Group

SERENGETI, TANZANIA

- Dr. Simon Mduma, Director General, TAWIRI
- Dr. Maurus Msuha, Head, Wildlife Information and Education Unit, TAWIRI
- Dr. Robert Fyumagwa, Director, Serengeti Wildlife Research Centre, TAWIRI
- Mr Mtahiko, MGG, Chief Park Warden, TANAPA
- Thadeus Binamungu, AWF, Tanzania
- Librarian and Library of TAWIRI

MWANZA GULF, TANZANIA

- Dr. Robert Kayanda, Centre Director, TAFIRI, Mwanza
- Enock Mlaponi, Researcher, TAFIRI, Mwanza
- Godfrey Ngupula Researcher, TAFIRI, Mwanza
- Benedict Kashindye Researcher, TAFIRI, Mwanza
- Batman Msuku Researcher, TAFIRI, Mwanza
- Omari Myanza, National Project Coordinator, LVEMP II, Tanzania
- Mr Obura from Lake Victoria Fisheries Organization, Jinja, aquaculture expert
- Librarian and Library of TAFIRI Mara Swamp and Musoma Gulf
- Ibrahim Ole Nguyaine, DED Rorya
- Mr Goroi, DC, Rorya
- Andreas Madundo, Fisheries Officer, Rorya
- Isaac Kizonde, Wildlife Officer, Rorya and Tarime
- Head, Musoma Monitoring and Surrveilance Unit DED
- Director and staff, TAFIRI Musoma

LAKE NABUGABO AND SANGO BAY, UGANDA

- Paul Mafabi, Director of Environment, Uganda
- Lucy Iyango, Head of the Uganda Wetlands Management Department
- Valentine Barugahare, Wetlands Management Officer
- Richard Kyambadde, Wetlands Management Officer

- Rose Nakyejwe, Regional Wetlands and Environment Officer (based at Masaka)
- Wilson Behwera, Masaka District Wetland Officer
- Kingwal Jamil, District Natural Resources Officer, Raakai District
- Fishermen at Lake Kayugi
- Fishermen at Lake Nabugabo
- Tourist operator, Lake Nabugabo
- Security officer in charge of water hyacinth clearing equipment, Kasensero (Kagera River in Uganda)
- Issa Katwesige, Natural Resources Management Expert responsible for biodiversity, biosafety/ Convention on International Trade in Endangered Species of Fauna and Flora (CITES) focal point, Uganda
- Kabi Maxwell, Economic Value Assessment Specialist, NFA

RWERU-MUGESERA COMPLEX AND NYUNGWE NATIONAL PARK/ FOREST, RWANDA

- Telesphore Ngoga, Conservation Division Manager, RDB
- Dr. Antoine Mudakikwa, Research, Monitoring and Evaluation Officer (CITES Focal Point), RDB
- Louis Rugerinyange, Chief Park Warden – RDB, Nyungwe National Park
- Ndikubwimana Innocent, Planning, Research and Monitoring Warden – RDB, Nyungwe National Park
- Fred Daniel Nzasabimana, Environment Expert/LVBC Desk Officer
- Francoise Kayigamba, Environment Management Specialist, Nile Basin Initiative/NELSAP
- Godfrey Sengendo, Assistant Regional Project Manager, Nile Basin Initiative/NELSAP/Kagera River Basin Management Project
- Muhayimana Annette Sylvie, Coordinator for LVEMP II in Rwanda
- Dr. Mitchel Masozera, Country Program Director, WCS Rwanda
- Chloe Cipolletta, Nyungwe Conservation Programme Director, WCS Rwanda

KIBIRA NATIONAL PARK/FOREST/NORTHERN PROTECTED AQUATIC LANDSCAPE, BURUNDI

- Ir. Mohamed Feruzi, Director General, INECN
- Leonidas Nzigiyimpa, Former Chief Warden, Kibira NP, INECN
- MASABO Onesphore, Biodiversity Research Officer, INECN
- Nikobagomba Nestor, BTF member, Ministry of Water, Environment, Land and Urban Planning
- Claude Hakizimana, Chief Warden, Kibira NP
- Deomede Manariyo, Chief Warden, Northern Protected Aquatic Landscape
- Rangers/local villagers, Kibira forest, Lake Rweru, Lake Rwihinda, Lake Cohoha
- Batwa indigenous forest-dependent community, Busekera Cultural/tourist village, Kibira forest

YALA SWAMP AND MOUNT ELGON, KENYA

- Elijah Obadha, Nature Kenya, Yala Swamp KBA
- Tim Mwanzia, KWS Kisumu Station
- Dr. Paul Matiku, Nature Kenya
- Dr. Paul Muoria, Nature Kenya
- Fred B. Munyekenye, Nature Kenya
- Peris Oduor, Yala Wetland Environmental Volunteers
- Wellington Oduor, Yala Wetland Environmental Volunteers

- Mathews Okoth, Yala Wetland Environmental Volunteers
- Isaac Opondo, Yala Wetland Environmental Volunteers
- George Otieno, Yala Wetland Environmental Volunteers
- Peter Okumu, Yala Wetland Environmental Volunteers
- Walter Tende Oloo, Chairman, Beach Management Unit, Goye
- Fishermen at Usenge Beach and Goye

GOVERNMENT FOCAL POINTS

- Aggrey Rwetsiba, Monitoring and Research Coordinator, Uganda Wildlife Authority
- Esther Makwaia, Principal Environmental Officer, Division of Environment, Vice President's Office, United Republic of Tanzania
- Administrative Secretary, Tanzania Wildlife Protection Fund
- François Bizimungu, Research and Monitoring Manager, Protected Areas, Ministry of Environment and Lands, Kigali, Rwanda
- Innocent Musabyimana, Director of Planning, Monitoring and Evaluation of MINIRENA, Ministry of Natural Resources
- Samuel Kasiki, Deputy Director, Biodiversity Research and Monitoring Division, Kenya Wildlife Service, Nairobi, Kenya
- Sarah K. Kerandi, Finance Unit Head, Ministry of Environment, Water and Natural Resources, Department of Environment and Natural Resources
- M. Benoît Nzigidahera, Chef, Service de la Recherche en Biodiversité, Gestionnaire, Site Web National en matière de Biodiversité, INECN, Gitega, Burundi

BIODIVERSITY TASK FORCE

- Nikobagomba Nestor, Advisor Ministry, INECN, Burundi
- Njebarikanuye Aline, Monitoring and Evaluation, INECN, Burundi
- Richard Ndikuriyo, Desk Officer of LVBC, Ministry of EAC, Burundi
- Charles Ngunjiri, EAC Ministry Kenya, Ministry of EAC, Kenya
- Joseph Mung'ere, State Department of East African Affairs, Ministry of EA Affairs, Commerce and Tourism; Kenya
- David Kioko Mutisya; Ministry of Environment, Water and Natural Resources; Kenya
- Ojwang William, Assistant Director, KEMFRI, Kenya
- Mbithi Daniel, Assistant Director, Kenya Forest Service, Kenya
- Mworia Paul, Species Site Program Manager, Nature Kenya, Kenya
- Fredrick Kihara, Water Fund Manager, The Nature Conservancy, Kenya
- Gichangi Kevin, Project Manager, WWF-ESARPO, Kenya
- Nzasabimana Fred, Ministry of EAC, Rwanda
- Deogratius Paul Nyangu, Principal Forest Officer, Vice President's Office, Tanzania
- John Kaaya, Principal Game Officer, Ministry of Natural Resources and Tourism, Tanzania
- Diana John Kiambute, LVBC Focal Point, Tanzania
- Hariet Rushekya, Ministry of Natural Resources and Tourism, Tanzania
- Kayanda Robert, Director, TAFIRI, Tanzania
- Wivine Ntamubano, PENRO, EAC Secretariat, Tanzania
- Brian Otiende, Climate Change Coordinator, EAC Secretariat, Tanzania
- Dismas Mwikila, Climate Change and Adaptation Specialist, EAC Secretariat, Tanzania

- Gisele Umuhumuza, Research Officer, REMA-RWANDA, Rwanda
- Charles Byaruhanga; Senior Forestry Officer/Policy, Standards; Ministry of Water and Environment; Uganda
- Mbabazi Dismas, Principal Research Officer, NaFIRRI NARO, Uganda
- Sewagudde Sowed, Ministry of Water and Envionment, Uganda
- Wycliffe Tumwebaze, MFPO, MWEL DWRM, Uganda

MAP RESOURCES

- http://due.esrin.esa.int/globcover/ (source of Global Landcover)
- http://glovis.usgs.gov/ (source of Landsat 8 data for the mapping)

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