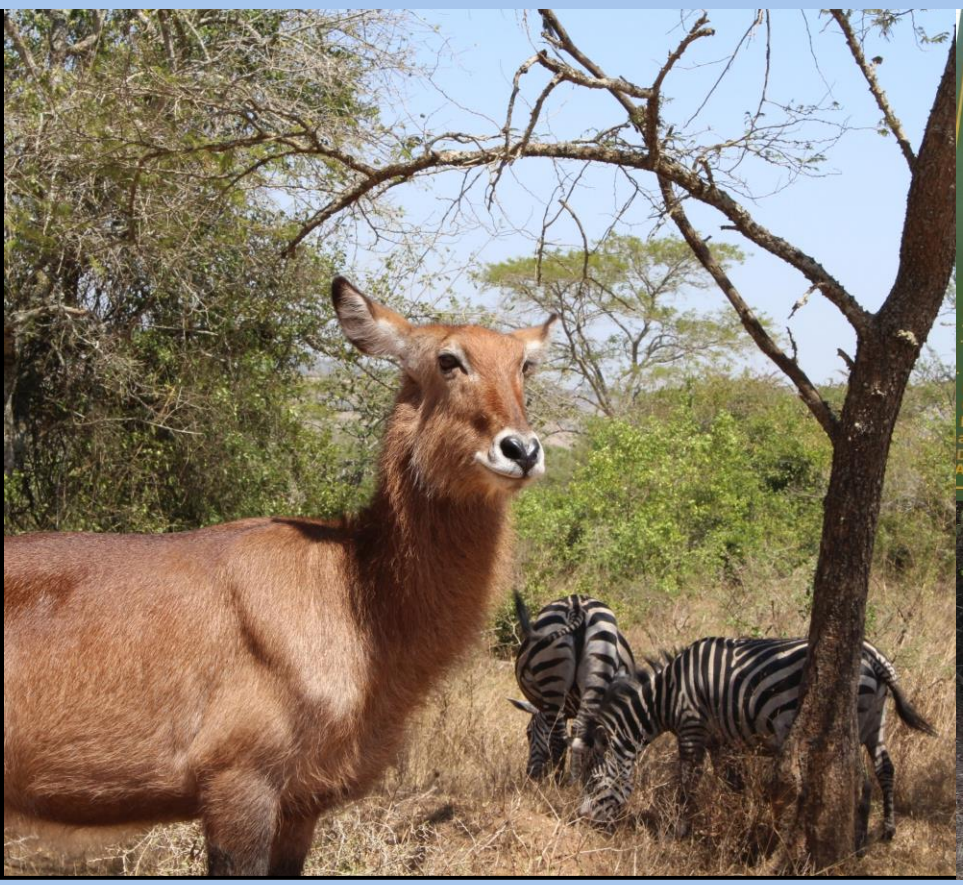
USAID
FROM THE AMERICAN PEOPLE

TECHNICAL REPORT

CLIMATE RISKS TO CONSERVATION IN UGANDA

AN ASSESSMENT OF SELECTED REGIONS



May 2017
This document was produced for review by the United States Agency for International Development. It was prepared by Chemonics for the ATLAS Task Order.

This document was produced for review by the United States Agency for International Development. It was prepared by Chemonics for the Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013, under the Restoring the Environment through Prosperity, Livelihoods, and Conserving Ecosystems (REPLACE) IDIQ.

Chemonics contact:
Chris Perine, Chief of Party (ATLASinfo@chemonics.com)-
Chemonics International Inc.
1717 H Street NW
Washington, DC 20006

ATLAS reports and other products are available on the ClimateLinks website (*https://www.climatelinks.org/projects/atlas*).

Cover Photo: ATLAS.

CLIMATE RISKS TO CONSERVATION IN UGANDA

AN ASSESSMENT OF SELECTED REGIONS

May 2017

Prepared for:

United States Agency for International Development

Climate Change Adaptation, Thought Leadership and Assessments (ATLAS)

Prepared by:

Chemonics International Inc.

This report is made possible by the support of the American people through the United States Agency for International Development (USAID). The contents of this report are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States government.

CONTENTS

LIST OF TABLES AND FIGURES

ACRONYMS

ARCC	African and Latin American Resilience to Climate Change project
ATLAS	Climate Change Adaptation, Thought Leadership and Assessments project
BINP	Bwindi Impenetrable National Park
BMCA	Bwindi-Mgahinga Conservation Area
CDCS	Country Development Cooperation Strategy
CWMA	Community Wildlife Management Area
DRC	Democratic Republic of the Congo
ECFR	Echuya Central Forest Reserve
ETOA	Environmental Threats and Opportunities Assessment
GMP	General Management Plan
HWC	Human-wildlife conflict
KVNP	Kidepo Valley National Park
LMCA	Lake Mburo Conservation Area
LMNP	Lake Mburo National Park
LNRS	Lake Nakivale Ramsar Site
MFNP	Murchison Falls National Park
MFPA	Murchison Falls Protected Area
MGNP	Mgahinga Gorilla National Park
PA	Protected Area
QENP	Queen Elizabeth National Park
QEPA	Queen Elizabeth Protected Area
RMNP	Rwenzori Mountains National Park
UWA	Uganda Wildlife Authority
USAID	United States Agency for International Development
WR	Wildlife Reserve
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

Effective biodiversity conservation requires understanding and addressing a range of challenges including natural resources management, human-wildlife conflict (HWC), traditional use of land and natural resources, population growth and urbanization. Climate change adds another challenge to the list, and is in some ways the greatest challenge, given the uncertainty of climate science and the consequent uncertainty of projections of specific climate change in particular geographic areas and for specific flora, fauna and ecosystems.

Despite this uncertainty, making best efforts to understand and describe climate change in specific geographic areas, predict its impacts and distinguish those impacts from impacts caused by factors other than climate change is clearly important to effectively investing in biodiversity conservation interventions. When designing biodiversity conservation programs, a critical element of their durability is their resilience to climate change.

PURPOSE

To this end, the Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) project is working with USAID's Bureau for Africa and the USAID/Uganda mission to assess the vulnerability of biodiversity in a set of protected areas and their surrounding landscapes. The aim is to identify climate risks to the biodiversity in those landscapes and to the livelihoods of people living in and around them. It is critical that livelihoods are examined along with biodiversity in the context of this analysis because the two are so inextricably linked. People in these areas rely on the natural resources and ecosystem services provided by these landscapes, so climate change impacts that affect one inevitably affect the other, directly or indirectly.

METHODOLOGY

This assessment was completed by using existing climate information, including both historical climate trends and future climate projections, to extract climate risks and make judgments about the impacts that those risks will have on biodiversity and livelihoods in select landscapes. Based on identified climate impacts, the assessment suggests a set of adaptation responses to reduce them. The assessment also includes a set of ratings for each landscape (see below), providing expert judgment about the efficacy of taking action to address climate change in each landscape. These ratings are inherently qualitative but provide a rational basis for the recommendations provided at the end of this report.

RELATIVE CLIMATE RISK RATINGS OF LANDSCAPES

Table ES1 summarizes the climate risk per landscape. These ratings are intended to help identify climate versus non-climate stressors, the current vulnerability of landscapes to climate change, the relative importance of biodiversity to livelihoods, and opportunities the landscape

offers to invest successfully in adaptation interventions. The approach, rating system and criteria used are described in detail in section 1.2 and in the "Climate Change Risk Significance Rating" section of each landscape analysis.

Table ES1. Relative Climate Risk Ratings of Landscapes

Region	Landscape	Risk Rating	Explanation
Dry Cattle Corridor	1. Kidepo Valley National Park (KVNP), Pian Upe Wildlife Reserve (WR), Lake Bisina and Lake Opeta Wetlands Systems and Surrounding Communities	High	Climate change risk is significant and landscape provides high potential for implementing successful model adaptive responses.
	2. Lake Mburo Conservation Area (LMCA) and Surrounding Communities	High	Climate change risk is significant and landscape provides high potential for implementing successful model adaptive responses.
	3. Bwindi-Mgahinga Conservation Area (BMCA) and Echuya Central Forest Reserve (ECFR) and Surrounding Communities	High	Climate change risk is less significant and landscape provides moderate potential for implementing successful adaptive responses that could be usefully applied elsewhere. However, given the uniqueness and fragility of the endemic mountain gorilla population and lack of available habitat into which gorillas could migrate to avoid projected warming, this landscape is rated "high" risk.
Albertine Rift	4. Rwenzori Mountains National Park (RMNP) and Surrounding Communities	Medium	Climate change risk is moderately significant and landscape provides lower potential for implementing successful adaptive responses that could be usefully applied elsewhere.
	5. Queen Elizabeth and Murchison Falls Protected Areas (QEPA and MFPA), Lake George and Albert Nile Delta Wetlands Systems and Surrounding Communities	Medium	Climate change risk is not as immediately significant as non-climate stressors, but landscape provides potential for implementing successful adaptive responses that could be replicated elsewhere.

KEY FINDINGS

Based on the landscape analyses, the study team identified the key findings below, which in turn form the basis for the assessment recommendations.

1. Climate change is one of many stressors, often not the most immediate, affecting biodiversity in Uganda. Non-climate stressors include: rapid population growth; human-caused fire; oil exploration, drilling and other energy development; industrialization, urbanization and infrastructure development; agricultural encroachment and demand for productive land; charcoal making/fuelwood demand; and illegal and unsustainable legal harvesting of resources, such as timber, non-timber forest products, water and wildlife (poaching for food).

2. It is very likely that non-climate stressors such as those mentioned under #1 are themselves being exacerbated by climate factors, therefore indirectly creating risks to biodiversity. Trends including urbanization, agricultural expansion into fragile areas (e.g., protected areas) and wildlife poaching may in part be reactions to climate impacts to livelihoods. However, the data available to make these causal links are extremely limited.

3. Based on trend data (notably higher temperatures, more erratic rainfall and more intense rainfall events), climate change impacts on biodiversity, livelihoods and ecosystem services appear to be significant. These include: decreased quality of tourism experience and revenue; fewer Protected Area (PA) resources for community use; increased human-wildlife conflict (HWC); increased disease transmission between wildlife and livestock and wildlife and people; reduced livelihood options, including livelihoods that rely on tourism, fishing and plant collection; and reduced water quality and quantity.

4. Trends of higher temperatures, more erratic rainfall and increased frequency of extreme rainfall events are the primary climate change stressors throughout the study area; by their nature these stressors pose a significant climate threat to biodiversity.[1] These current trends in climate variability are fairly pronounced and represent a substantial challenge to biodiversity and underlying ecosystems throughout the study area.

5. The most pronounced indirect climate impacts on biodiversity include increased intensity and spread of fires. These fires result in changes in plant and animal species composition, distribution movements and abundance, and in increased spread of invasive species.

6. Fire-induced changes in plant and animal species composition, distribution movements and abundance and increased spread of invasive species affect habitat quality of Uganda's PAs. They cause drying and shrinking of wetlands and open water bodies, affecting aquatic life and wildlife that rely on aquatic resources; increase disease incidence in wildlife; and increase risks from flood events.

[1] In the BMCA-ECFR and QEPA-MFPA landscapes, an increase in extreme events and flooding is expected after 2050, which is beyond the scope of this assessment.

7. Significant gaps in climate change knowledge exist. The trend data available are based on a limited number of years and this short time period makes it difficult to distinguish the climate change signal from typical interannual and decadal variability. Overall, in Uganda, analysis of the potential impact of climate change on biodiversity suffers from a pervasive lack of long-term, robust meteorological record and climate data to determine changes at varying temporal and spatial scales. For example, adequate attribution on the role played by non-climate stressors and climate change in shifting vegetation belts in RMNP and BMCA does not exist. How climate change may alter the distribution and abundance of invasive species is also difficult to determine. The resulting effects of these habitat changes on specific species, including the mountain gorilla, are uncertain as well.

8. Knowledge gaps also exist regarding effective adaptation responses to climate change impacts on biodiversity. For example, experimental pilot programs have been in place for management of invasive species, yet due to funding shortfalls or other constraints, invasive species management has mainly been ad hoc. The effectiveness of management actions, especially in the long term, is unknown. Similarly, measures to effectively address HWC, one of the greatest challenges of Uganda's PAs, fall short, in part due to the pilot and experimental nature of many interventions.

9. Climate variability and change may halt or reverse the sustainability of traditional conservation actions unless adequately considered. While stakeholders seem to place greater emphasis on the role of non-climate stressors in understanding vulnerability, it is clear that without considering climate risks, the potential success of traditional conservation activities may be compromised.

10. Climate change risks and impacts are already evident and significant and should be prioritized in the drier, savanna landscapes (the two dry landscapes in the cattle corridor, KVNP, Pian Upe, Bisina Opeta and Lake Mburo National Park-Lake Nakivale Ramsar Site (LMNP-LNRS). See "Relative Climate Risk Ratings of Landscapes" table above.

11. Non-climate stressors should be given higher priority in developing investment strategies in the Albertine Rift. Given the relatively high pressure from human activities surrounding the landscapes in this region, climate stressors are likely less a driver of landscape degradation than non-climate stressors. See "Relative Climate Risk Ratings of Landscapes" table above.

RECOMMENDATIONS

The available evidence base identifying climate stressors and related potential climate impacts and capacity for adaptation response must be considered when designing and implementing climate-resilient biodiversity conservation and related livelihood security interventions in biodiversity conservation programming. Adaptation interventions to help the country's PAs address existing risks to both biodiversity and livelihoods are prioritized below. While these

recommendations are based on a thorough desktop analysis and limited complementary field consultations, they could be strengthened by a more grounded assessment in each landscape.

Recommendations are divided into immediate, medium term and longer term depending on the urgency of undertaking action (i.e., designing and implementing interventions), as judged by the study team, based on identified climate risk:

- Immediate recommendations are immediate needs for high-risk landscapes 1, 2 and 3.
- Medium-term recommendations are those that offer high potential for buffering these landscapes from risks posed by climate changes that are judged likely but not yet at a critical point.
- Longer-term recommendations focus on the lower-risk landscapes 4 and 5, with an eye toward monitoring climate risks and providing opportunities to intervene in an orderly manner.

Table ES2 provides a summary set of selected recommendations for all five landscapes, grouped into governance, information and pilots. The interventions included in this table are considered to be among the most practical, representing a subset of the interventions articulated in each of the landscape-specific tables. Many focus on research to better understand the complex climatic, ecological and socioeconomic relationships between climate, biodiversity and livelihoods. More robust information about these relationships will improve the evidence base for taking action.

Table ES2. Selected Adaptation Response to Identified Landscape-Specific Climate Impacts

Landscape 1: Kidepo Valley National Park (KVNP), Pian Upe Wildlife Reserve (WR), Lake Bisina and Lake Opeta Wetlands Systems and Surrounding Communities					
Climate Adaptation Building Block	**Recommendation Type**	**Specific Action**	**Timeframe**		
			Immediate	**Medium**	**Longer Term**
Governance	Invest in climate-smart protected area management practices.	Develop and implement a PA fire management plan to address identified climate risk-related water scarcity; update the plan as new climate information is available.		X	
		Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.	X		
	Invest in associations to promote climate-resilient management of limited resources.	Improve access to veterinary services and medications to address identified heat stress and less predictable rainfall.		X	
Information	Promote weather-based information services for livestock holders to adopt or improve climate-resilient management techniques.	Provide accurate weather forecast information to pastoralists/agro-pastoralists by radio and/or SMS to address increasingly variable weather.	X		

Pilots	Undertake climate-sensitive watershed management practices.	De-silt existing wildlife watering points and establish new, well-distributed watering points to serve areas with high animal concentrations but with little water during the dry season.	X		
		Invest in rehabilitation of existing watering points for both wildlife and livestock and promote new watering points to buffer against a more unreliable rainfall pattern.	X		
		Invest in rehabilitation and expansion of physical infrastructure and vegetation to enhance flood protection of gardens, houses and other household assets from intense rainfall events.		X	
Landscape 2: Lake Mburo Conservation Area (LMCA) and Surrounding Communities					
Climate Adaptation Building Block	**Recommendation Type**	**Specific Action**	**Timeframe**		
			Immediate	**Medium**	**Longer Term**
Governance	Invest in climate-smart protected area management practices.	Develop and implement a PA fire management plan to address identified climate risk-related water scarcity; update the plan as new climate information is available.		X	
		Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.	X		
Information	Support landscape inventory monitoring practices that include screening for climate-linked landscape changes.	Establish a monitoring system to control invasive species such as *Acacia* and *Lantana* whose spread is linked to climate change.			X
	Promote weather-based information services for livestock holders to adopt or improve climate-resilient management techniques.	Carry out a resource inventory to collect data on PA resources used by communities to help determine sustainable harvest limits in the face of climate change.	X		
		Provide accurate weather forecast information to pastoralists/agro-pastoralists by radio and/or SMS to address increasingly variable weather.	X		
Pilots	Promote investments in mechanisms to buffer against climate-induced drying of wetlands and reduced water sources.	Support well-distributed construction of valley dams and other methods of catching rainfall within LMNP to provide wildlife with water resources, given increasingly unreliable rainfall patterns induced by climate change.	X		

	Invest in improved watershed management to counter reduced water flows to catchment areas resulting from climate change.	Given increasingly unreliable rainfall patterns induced by climate change, restore landscapes especially in the upstream of rivers and wetland catchment areas. Restore river banks and create buffer zones around wetlands, particularly in cultivating communities.	X		
Landscape 3: Rwenzori Mountains National Park (RMNP) and Surrounding Communities					
Climate Adaptation Building Block	**Recommendation Type**	**Specific Action**	**Timeframe**		
			Immediate	**Medium**	**Longer Term**
Governance	Invest in social organization (e.g., social capital) to catalyze livelihood diversification where traditional livelihoods are threatened by climate change.	As a buffer against livelihood insecurity for households and communities whose primary livelihoods depend on resources adversely impacted by climate change, promote sustainable tourism development as an alternative income source.		X	
	Invest in climate-smart protected area management practices.	Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.	X		
Information	Support landscape inventory practices that include screening for climate-linked landscape changes.	Establish a monitoring system to document the spread (and control) of invasive species that are exploiting climate changes like higher temperatures.	X		
	Promote weather-based information services for livestock holders to adopt or improve climate-resilient management techniques.	Provide accurate weather forecast information to pastoralists/agro-pastoralists by radio and/or SMS to address increasingly variable weather.	X		
Pilots	Invest in strategies that promote livelihood diversification, especially those related to ecosystem services threatened by climate change.	To reduce non-climate stress on flora and fauna experiencing climate stress, promote domestication and on-farm production of those PA resources used most by surrounding communities, in particular, bamboo.		X	
	Invest in improved watershed management to counter reduced water flows to catchment areas resulting from climate change.	Invest in rehabilitation and expansion of physical infrastructure and vegetation to enhance flood protection of gardens, houses and other household assets from intense rainfall events.		X	
Landscape 4: Bwindi-Mgahinga Conservation Area (BMCA) and Echuya Central Forest Reserve (ECFR) and Surrounding Communities					
Climate Adaptation Building Block	**Recommendation Type**	**Specific Action**	**Timeframe**		
			Immediate	**Medium**	**Longer Term**

Governance	Explore design options to establish climate-resilient buffer zones outside of park boundaries and study design options for wildlife corridors.	Update sustainable use agreements between PAs and communities that take into account emerging climate-induced fire regimes.		X	
	Invest in climate-smart protected area management practices.	Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.	X		
Information	Establish monitoring regime to track health of key species adversely impacted by changing climate.	Integrate climate screening into existing gorilla health monitoring programs to correlate changes in gorilla health and changing climate.	X		
	Promote weather-based information services for livestock holders to adopt or improve climate-resilient management techniques.	Provide accurate weather forecast information to pastoralists/agro-pastoralists by radio and/or SMS to address increasingly variable weather.	X		
Pilots	Invest in improved watershed management to counter reduced water flows to catchment areas resulting from climate change.	To reduce the adverse impacts of climate change, support payment for ecosystem services with a fund that would benefit improved catchment management and promote water conservation.		X	
Landscape 5: Queen Elizabeth and Murchison Falls Protected Areas (QEPA and MFPA), Lake George and Albert Nile Delta Wetlands Systems And Surrounding Communities					
Climate Adaptation Building Block	**Recommendation Type**	**Specific Action**	**Timeframe**		
			Immediate	**Medium**	**Longer Term**
Governance	Develop adaptation plans to promote sustainable climate-resilient use of limited resources in nearby communities adjacent to the PAs.	Update sustainable use agreements between PAs and communities that take into account emerging climate-induced fire regimes.		X	
	Invest in climate-smart protected area management practices.	Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.	X		
Information	Undertake an inventory of invasive plant and animal species (baseline and regular time series monitoring) to determine their climate change-induced range expansion.	Scale up invasive species management measures to control invasive species that are exploiting climate change-induced variability in temperature and rainfall patterns.	X		
	Promote weather-based information services for livestock holders to adopt or improve climate-resilient management techniques.	Provide accurate weather forecast information to pastoralists/agro-pastoralists by radio and/or SMS to address increasingly variable weather.	X		

Pilots	Support participatory buffer zone management planning to improve climate resilience in close collaboration with communities.	Scale up HWC reduction interventions such as beekeeping along PA boundaries, chili growing and spraying, and planting of unpalatable cash crops (coffee, tea and trees) to counter climate stress on PA resources.		X	

1. ASSESSMENT PURPOSE AND METHODOLOGY

To support sustainable biodiversity conservation and livelihood security for communities dependent on natural resources, consideration of climate risk is critical. This assessment, based on selected landscapes in Uganda, analyzes biodiversity resources and livelihoods dependent on biodiversity, as well as the ecosystem services on which they both rely. Based on available climate projections for each of five landscapes, the study outlines potential climate impacts and adaptive responses to protect biodiversity and related livelihoods.

1.1 PURPOSE

The United States Agency for International Development (USAID) Uganda Mission is producing a Country Development Cooperation Strategy (CDCS) for 2016–2021. Concurrently, USAID/Uganda's Environment Unit, within the Economic Growth Team, is undertaking analyses to inform future biodiversity conservation and climate change programming. As part of these activities, the Uganda Mission Environment Unit asked the USAID Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) project to assess the following:

- **Direct and indirect impacts of climate change on biodiversity**
- **Direct and indirect impacts of climate change-induced biodiversity impacts on livelihoods dependent on natural resources**
- **Indirect impacts to biodiversity resulting from climate-induced impacts to livelihoods**

The aim of this assessment is to 1) create landscape analyses describing the status and risks for biodiversity and livelihoods in targeted areas (described below) based on climate change projections, and 2) use these analyses to support USAID/Uganda decision making on integrating biodiversity and climate change programming. The overarching goal is to consider the current risks for biodiversity while also taking into account the changing climate and related climate stresses affecting human livelihoods and the ecosystem services on which they rely.

USAID/Uganda CDCS

The new CDCS (2016–2021) is organized around thematic areas. The Mission's technical focus areas are integrated under each thematic area. Climate change and biodiversity figure prominently in two thematic areas: Development Objective 1. Resilience, including resilience to climate change (countrywide, community, household); and Development Objective 3. Systems, such as market, health and natural resources (includes biodiversity, how people use the environment and adaptation).

The assessment results are intended to provide actionable recommendations to make investments in biodiversity conservation and related livelihood security as climate-resilient as possible, regardless of the activity funding source.

1.2 METHODOLOGY

The assessment is primarily a desk study, with follow-up in-country consultations. It builds on existing information to examine the direct and indirect impacts of climate change on biodiversity and livelihoods. The study examines key components of ecosystems like water bodies, forests and grasslands and their relationship to biodiversity, and key ecosystem services like water supply, crops and fuel wood and their relationship to livelihoods. For both biodiversity and livelihoods, the causal links between key ecosystems and ecosystem services on one hand and climate stressors on the other are then examined.

Importantly, the methodology uses all available climate information to identify climate risks and disaggregate them from more general development risks. The rationale for disaggregating this way is to help program developers and managers use funding designated for specific purposes in the most effective and defensible manner possible. For example, a landscape or portion of a landscape may be expected to experience increasing water scarcity over the next 30 years. However, it will be classified as a climate risk in this report only when available information indicates that climate variability and change, such as increased average temperatures or decreased annual rainfall, is a contributing factor in water scarcity. If available information does not link increased water scarcity to climate variability, it is attributed to non-climate risks, such as increased population or lack of coordinated watershed management. It is acknowledged that disaggregating risks into climate-related and non-climate related is inherently inexact, given the limitations of ecological and climate science. However, we have used the available climate information, both trend and projection data, to determine whether risks and potential impacts have causal links to climate risks. Ultimately, it is likely that climate and non-climate risks contribute to most or all impacts to ecosystems, biodiversity and livelihoods. However, attribution of these risks within the limits of available information is the boundary for this study.

RESEARCH QUESTIONS

The following questions guided the study:

- How certain and immediate are climate impacts, based on available science?
- What are the climate stressors on biodiversity and the relative magnitude of those stressors versus non-climate stressors on biodiversity?
- What are the impacts of climate stressors on biodiversity for people who depend on this biodiversity and the underlying ecosystem services for their livelihoods?
- To what extent are climate-induced impacts to livelihoods likely to produce new indirect impacts to biodiversity versus exacerbating identified direct impacts to biodiversity?
- What adaptation interventions can be undertaken to respond to current and projected climate variability and change on (a) biodiversity and (b) livelihoods that are biodiversity-dependent?
- In which regions are adaptation actions most likely to be effective for conservation of biodiversity and support for related livelihoods?

SELECTION OF STUDY LANDSCAPES

Because its purpose was to examine the impacts of climate change on biodiversity in Uganda with specific attention to how climate risks affect biodiversity and livelihoods, this study focuses on a limited number of highly biodiverse areas in and around protected areas (PAs) and their surrounding human communities. These areas encompass a variety of climates and socioeconomic profiles. This assessment's target geographies fall within two distinct regions in Uganda: the Dry Cattle Corridor and the Albertine Rift.

Landscape 1: (*Dry Cattle Corridor)* Kidepo Valley National Park (KVNP), Pian Upe Wildlife Reserve (WR), Lake Bisina and Lake Opeta wetlands systems and surrounding communities

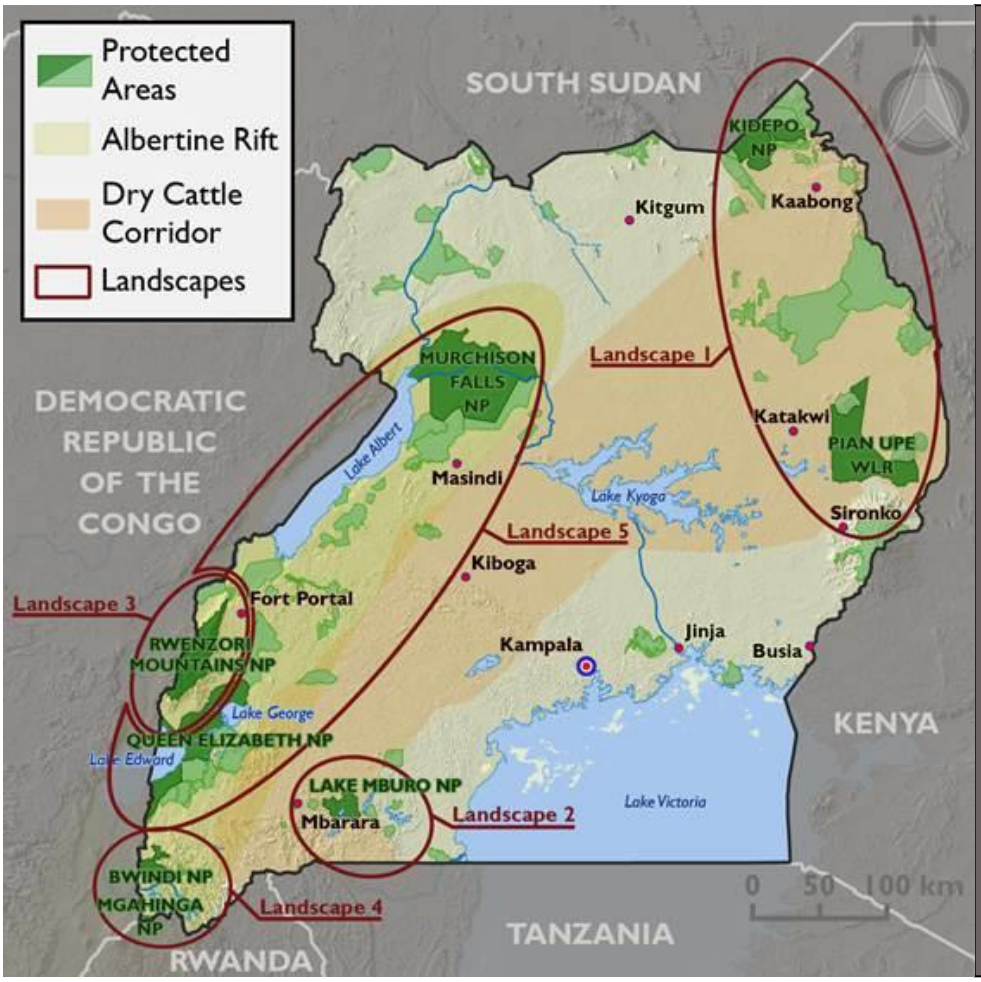
Landscape 2: (*Dry Cattle Corridor)* Lake Mburo Conservation Area (LMCA) and surrounding communities

Landscape 3: (*Albertine Rift)* Rwenzori Mountains National Park (RMNP) and surrounding communities

Landscape 4: (*Albertine Rift)* Bwindi-Mgahinga Conservation Area (BMCA) and Echuya Central Forest Reserve (ECFR) and surrounding communities

Landscape 5: *(Albertine Rift)* Queen Elizabeth and Murchison Falls Protected Areas (QEPA and MFPA), Lake George and Albert Nile Delta wetlands systems and surrounding communities

Figure 1. Map of Approximate Locations of the Five Study Landscapes and Two Study Regions



Study regions

The Dry Cattle Corridor is made up of Uganda's drylands area, which stretches from the southwest to the northeast and encompasses 84,000 square kilometers (km^2). Dominated by pastoral and agro-pastoral livelihoods, this area experiences low, irregular rainfall and periodic, extreme drought. It includes some of the country's most fragile ecosystems.

The Albertine Rift is one of the most biodiverse regions on the continent, home to 50 percent of Africa's birds, 40 percent of its mammals and 20 percent of its amphibians and plants. The Albertine Rift has a dense rural human population that relies on subsistence farming. The region has seen decades of conflict and poverty. Conservation efforts have been challenging.

TEAM AND STUDY DESIGN

A three-person assessment team, comprising a Climate and Conservation Team Leader, a Climate Change and Livelihoods Specialist and a Governance and Evaluation Advisor, developed and executed the following approach, described in detail in Annex B. The team:

- Conducted a literature review and gap analysis.
- Developed analyses for each of the five landscapes that describe (a) the current functions that ecosystem services perform for the biodiversity and livelihoods in the landscape; (b) the risks that climate change stressors pose for these services and the direct and indirect impacts of climate change on biodiversity; (c) the effects of biodiversity impacts on livelihoods and community vulnerabilities; and (d) potential adaptive responses. Non-climate stressors are also taken into account.
- Conducted in-country consultations (see Annex A) to fill gaps and confirm validity of landscape analyses. The team conducted site visits to Lake Mburo National Park (LMNP) and Lake Nakivale Ramsar Site (LNRS).
- Finalized the landscape analyses and applied ratings criteria to each landscape (see below).

- Made recommendations for immediate, medium-term and long-term climate change adaptation interventions.

RATINGS OF LANDSCAPES ON SEVERAL CRITERIA

To facilitate prioritization of landscapes for investment, risks were categorized using a simple "high to low" rating system. The risk criteria capture:

- Current vulnerability to climate change;
- Relative importance of biodiversity to livelihoods; and
- Opportunities the landscape offers to invest successfully in adaptation interventions.

Table 3 describes the criteria and the method used to assign a rating of high or low risk (1 = low; 2 = medium; 3 = high). A medium ranking was applied when a landscape did not fall on either extreme. The combined value of these ratings was used to offer an overall risk ranking for each landscape. A cumulative score of 7–10 = low; 11–15 = medium; 16–21 = high. While the categorization is inherently subjective and based on the team's expert judgment, it offers a way to compare priorities systematically across landscapes.

Table 3. Definition of Criteria and Explanation of Ranking

CRITERIA	DEFINITION	EXPLANATION OF RANKING	
		High	Low
1. Importance of biodiversity	The richness of biodiversity in the landscape in terms of diversity, endemism and quality	Well-above-average diversity and high number of endemic or threatened species are present	PA was created more for its ecosystem services than for biodiversity or the actual richness of biodiversity present has changed since PA was created
2. Significance of climate change impacts on biodiversity	The degree to which biodiversity is vulnerable to projected climate changes	Species in the area are endemic or adapted to specific conditions (i.e., less adaptable to change)	Species appear in various areas and/or have higher tolerance for changing temperature and precipitation
3. Importance of natural resources to livelihoods	The degree to which the landscape provides communities with ecosystem services that support livelihoods (water, herbal medicine, etc.)	A large number of people directly depend on the landscape to support livelihoods	A relatively small number of people depend directly on landscape, and/or they have accessible alternatives
4. Significance of climate change impacts on livelihoods	The degree to which livelihoods are vulnerable to projected climate changes	Projected changes will significantly impact livelihoods, reducing economic and/or food security of population	Projected changes will not significantly impact livelihoods, or population has sufficient adaptive capacity to respond
5. Significance of indirect impacts on biodiversity resulting from climate-related direct impacts on livelihoods	The degree to which available data provide the analytical basis for making causal links between livelihood changes and impacts on biodiversity	Projected climate change will create change in livelihoods that will in turn create significant impacts on biodiversity	Projected climate change will create change in livelihoods for which it is unclear whether any significant impacts on biodiversity will occur
6. Relative impact of climate stressors compared to non-climate stressors	Assessment of whether climate stressors are a relatively greater threat than non-climate stressors	Climate stressors (temperature, rainfall, etc.) are the main threat to biodiversity and livelihoods	Non-climate stressors are the main threat to biodiversity and livelihoods
7. Imminence of climate impacts	The projected timescale of climate impacts	Climate impacts are being felt now; immediate action is necessary to prevent or slow irreparable damage	The situation is stable in the short term; threats exist but are not causing permanent damage
8. Potential value in piloting adaptation response	Based on visibility of the landscape to public or decision makers, as well as the degree to which adaptive responses could provide a useful example for other landscapes in similar conditions	The landscape is high profile and/or the adaptive responses could serve as a model for other landscapes	The landscape is of a lower profile and/or is so unique that any lesson learned could not be directly applied to other situations

STUDY LIMITATIONS AND ASSUMPTIONS

- The assessment relies on a rapid screening of risks based on available literature and information, and is limited in scope with regard to climate information and projections data.

- Field verification of desk analysis assumptions and qualitative assessment of community perceptions regarding biodiversity, natural resources and livelihoods was limited to a short field visit to a small subset of the study geography.
- Information about the impacts of climate change on biodiversity and livelihoods is limited; the science regarding the causal links is nascent and evolving rapidly. This constrains well-informed decision making. For example, information about invasive species management, in particular some species of *Acacia* and *Lantana*, is lacking (Onsite interview, Uganda Wildlife Authority (UWA), August 23, 2016).
- The links between climate change and livelihoods are better understood than those between climate change and biodiversity.
- Information regarding the links between climate-induced changes to livelihoods and how those livelihood changes affect biodiversity is limited.

Table 4 outlines these limitations in terms of gaps and uncertainties. For the most part, these apply across landscapes, but it is noted when relevant for a specific landscape.

Table 4: Gaps and Uncertainties

GAPS AND UNCERTAINTIES	NEEDS
Scientific data on climate and climate change and their relation to ecosystem changes	Installation of weather stations in the PAs and a system to monitor ecosystem changes correlated with climate change
Scientific data linking climate-induced changes to livelihoods and how those livelihood changes affect biodiversity	A long-term study focused on communities located adjacent to PAs or other sensitive landscapes to track the causal relationship between climate change, livelihoods and biodiversity conservation
Reasons for invasive species spread and most effective management measures	A study on invasive species and management measures
Location-specific information about effective human-wildlife conflict (HWC) management options and potential for establishing new wildlife corridors	Research into effective, sustainable HWC management based on climate change projections, and research into the potential for wildlife corridors to mitigate climate change effects on vegetation zone shifts
Appropriate tourism activities and infrastructure based on climate change projections	Research to identify and test alternative types of and locations for tourism infrastructure
Limited human resources to monitor, analyze and disseminate climate change data (USAID, 2011)	Strengthened institutional capacity (data, skills, infrastructure and financial resources) in responsible institutions, especially local governments, to undertake systematic monitoring of ecosystem changes due to climate change, and to facilitate or support implementation of adaptation and mitigation interventions
The impact of climate change on vegetation zones and species ranges	Installation of weather stations to develop detailed baseline climate change data at the regional level (McGahey et al., 2013) and increased capacity to analyze climate data so they can be linked to species data from comprehensive monitoring programs (Seimon et al, 2012)
The impact of climate change on disease transmission among humans, livestock and wildlife	More research on disease transmission
In landscape 2 (LMCA), information on the extent and effects of future upstream development in Mbarara and along the River Rwizi	A communication system between LMNP authorities and the districts so they can share information and together develop sustainable development approaches and plans
In landscape 3 (RMNP), unanalyzed multi-year records from weather station on the slopes of the Rwenzori massif	Trend studies on weather conditions in the park in relation to vegetation type cover changes (WWF, 2015; Seimon and Phillips, 2009; Barihaihi, 2010)
In landscape 4 (BMCA/ECFR), the impact of climate change on mountain gorillas (current research is conflicting on gorillas' adaptive capacity) and response options for UWA	Management-oriented climate change research so that UWA can make management decisions taking into account the potential impacts of climate change on mountain gorillas

2. LANDSCAPE ANALYSES

In the coming century, climate change in Uganda has the potential to reverse development gains, in particular by exacerbating food insecurity, creating damage from extreme weather events such as floods and droughts, altering agricultural productivity and creating shifts in the occurrence of diseases such as malaria. Given Uganda's existing development challenges and its heavy reliance on natural resources for livelihood security and economic growth, climate variability and change make this East African nation highly vulnerable to climate risks.

This section provides climate information on Uganda overall, while the landscape analyses and recommendations present a more detailed picture of the historical and projected climate for each landscape. The landscape-specific analyses also describe the non-climate and climate stressors, outline important biodiversity resources and provide insight on the practicality of specific adaption interventions in those landscapes in the short, medium and long term.

GENERAL BACKGROUND

The main climate threats to Uganda are rising temperatures, rainfall variability and extreme events. Table 3 summarizes the current climate of Uganda, trends over the past few decades and projections.

Table 3. Climate Observations, Trends and Projections for Uganda

	CLIMATE OBSERVATIONS	CLIMATE TRENDS SINCE 1950s	CLIMATE PROJECTIONS BY 2030
Temperature 	• Moderate throughout the year and varied by altitude • Falls below 0°C in the mountain ranges of Rwenzori and Mount Elgon • Reaches 30°C in northern and northeastern areas of Gulu, Kitgum and Moroto	• Increase of minimum temperatures between 0.5°–1.2°C • Increase of maximum temperatures between 0.6°–0.9°C	• Increase of 2°C in average temperatures • Projected rates of warming are greatest in the coolest season, June–September • Increase in the frequency of days and nights that are considered hot
Rainfall 	• Two rainy seasons in the south (March–May and September–November) and one season in the north (April–October) • Average annual rainfall ranges from 800–1500 mm, with the south receiving slightly more than the north.	• Naturally dynamic with high temporal and spatial variability (mainly due to large-scale oscillations); these make it challenging to find significant trends in the onset or length of the rainy season • No significant change in average annual rainfall • High variability in timing: the onset of rainy seasons can shift 15–30 days (earlier or later), while the length of the rainy season can	• Potential for increase in precipitation during dry season • Increase in the frequency of heavy rainstorms, flooding, etc.

		change by 20–40 days year to year	
Extreme events	Uganda experienced erratic rainfall over the past few decades, leading to floods, landslides and mudslides. Periods of heavy rainfall in 1961/62, 1997/98 and 2007 caused widespread infrastructure damage, human displacement and destruction of livelihood assets (Uganda Ministry of Water and Environment, 2014). Prolonged dry seasons have also taken a significant toll, as recently as January 2016, when 640,000 people in the Karamoja region faced food shortages due to poor harvests. Existing rainfall variability is intensified under a changing climate, and will continue to increase the intensity and occurrence of extreme events such as floods and droughts.		

Sources: USAID, 2014; Uganda Ministry of Water and Environment, 2014; Baastel Consortium, 2015; FEWS NET, 2012

CLIMATE STRESSORS

These current and projected climate changes directly impact ecosystems, natural resources and biodiversity (i.e., decline in Afro-alpine vegetation at higher altitudes or drying of wetlands), which indirectly impacts livelihoods that depend on services provided by ecosystems (tourism, food security, agriculture, etc.). The country's ecological zones – the mountains, lowlands and cattle corridor – include a range of climates, biodiversity and livelihood systems. Each varies in its exposure, sensitivity and ability to respond to climate risks. For example, mountain ecosystems such as those of the Rwenzori range are home to endemic species whose unique range and habitat demands make them less able to migrate or adapt to rapidly changing temperatures. Similarly, livelihood systems in the cattle corridor (agriculture, fishing, etc.) that are heavily dependent on natural resources are susceptible to changing rainfall patterns. A more variable rainfall regime and higher temperatures could increase the contact between wildlife and local communities, potentially triggering increased disease transmission and human-wildlife conflict (HWC). Climate variability will also negatively affect agriculture and livestock production, forcing more people to supplement their reduced incomes by extracting resources from PAs (timber, wildlife, etc.).

DISEASE TRANSMISSION

Wildlife might move outside PA boundaries more frequently in response to climate stressors such as shifting range of vegetation and prey, increased fire risk and reduced water resources. This dynamic would increase human-wildlife contact, resulting in increased transmission of Ebola, scabies, influenza and other viral and bacterial diseases that can be passed between humans and other animal species (UWA, 2016).

NON-CLIMATE STRESSORS

Climate impacts will exacerbate existing non-climate stressors on biodiversity and livelihoods, such as high population growth (3.3 percent annually), conflict (e.g., in Karamoja) and environmental degradation from agricultural expansion, mining, oil exploration, use of timber for fuel and poor regulation of PAs. These stressors have important indirect impacts on PAs and their management. Eight-four percent of the country's population lives in rural areas, where poverty rates are high (20 percent) and livelihoods rely on climate-sensitive rainfed agriculture and pastoralism (World Bank, 2016). Population growth puts pressure on PAs through border encroachment, unsustainable extraction of natural assets, conversion of wetlands to agriculture and other uses, and unplanned and unsustainable urban and peri-urban growth. These activities resulted in a decline in forest cover from 24 percent in 1990 to 18.3 percent in 2005 (Uganda Ministry of Water and Environment, 2014). The relative abundance of natural resources found in

PAs also creates demands to reverse their protected status; these come primarily from communities who historically used these lands and investors who want to extract their resources at commercial scale.

2.1 LANDSCAPE 1 ANALYSIS

Kidepo Valley National Park (KVNP), Pian Upe Wildlife Reserve (WR), Lake Bisina and Lake Opeta Wetlands Systems and Surrounding Communities

REGION: DRY CATTLE CORRIDOR

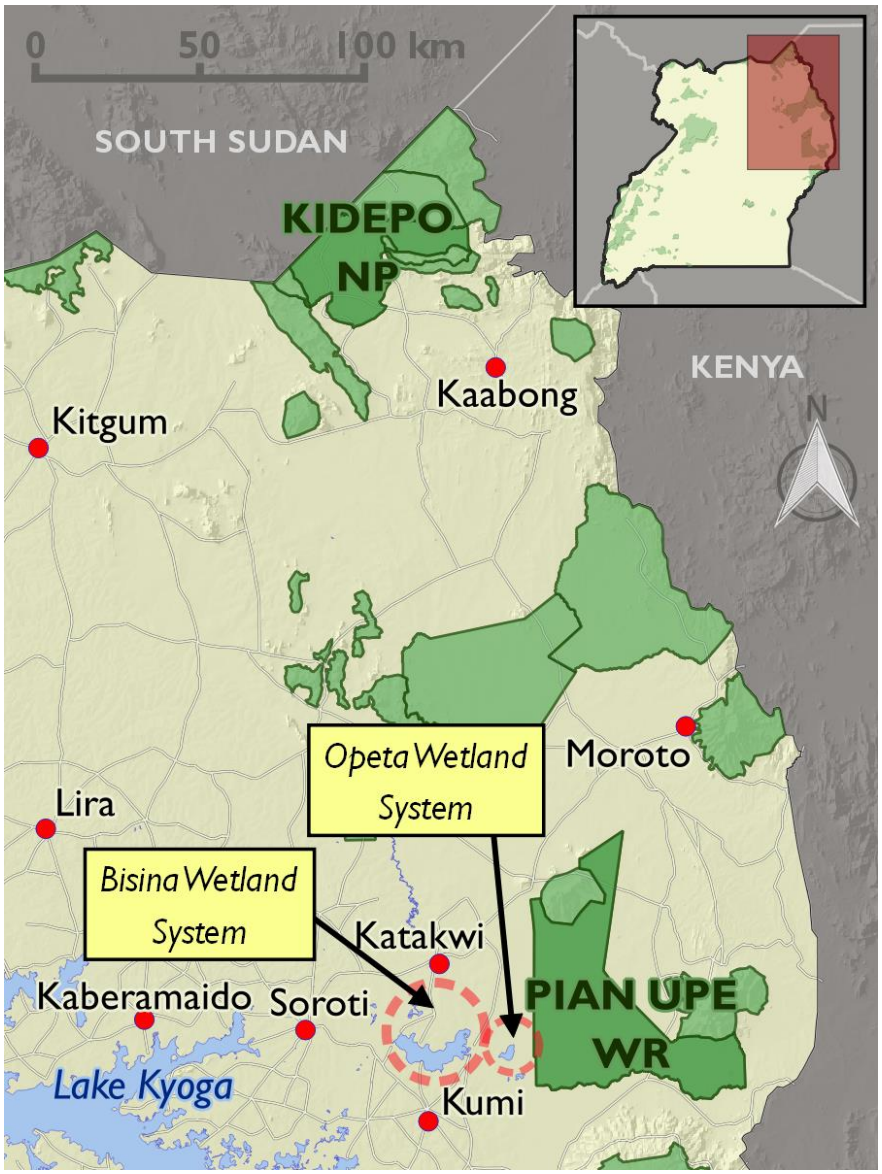


Figure 2. Landscape 1: KVNP, Pian Upe WR and Surrounding Communities

2.1.1 LOCATION AND DESCRIPTION

This landscape covers areas of northeastern and eastern Uganda. KVNP, established as a national park in 1962, covers 1,442 km^2 of savanna landscape that extends far beyond the officially demarcated area. The Narus River Valley in the south and west of the park and the Kidepo River Valley in the east and northeast divide the park in two. At 2,304 km^2, Pian Upe Wildlife Reserve (WR) is Uganda's second largest WR, stretching from the foothills of Mount Kadam westwards to Lake Kyoga and Moroto District in the north. The Bisina-Opeta lakes and wetlands complex, an extensive flat grassland floodplain, comprises the Lake Bisina and Lake Opeta Ramsar Sites and other adjacent lakes and swamps, all of which drain Mount Elgon and south Karamoja into Lake Kyoga.

2.1.2 UNIQUE CLIMATE CHARACTERISTICS

Unlike most of Uganda, which has a bimodal rainfall pattern, this landscape has a single, long rainy period between April and October/November. In KVNP, average rainfall is 800 mm annually. Rainfall is characteristically episodic, alternating with a prolonged severe dry season and considerable variation from year to year. Cyclic droughts occur every two to three years. The episodic nature of these events means that most of the region's population is typically affected by long dry periods and heavy rainy periods. The dry season is characterized and dominated by very hot northeasterly monsoon winds, which result in extreme drought with no green vegetation and temperatures that average 30°C but can reach over 40°C. Extended dry periods over the last 10 years have exerted pressure on water availability in most parts of the landscape (Mubiru, 2010; UWA, 2012).

2.1.3 CLIMATE PROJECTIONS

Climate change projections for Landscape 1 include:

- Increase of 2°C in average temperatures by 2030 (USAID, 2014).
- Higher temperatures for the periods corresponding to projected reductions in rainfall, with the highest increases projected for Moroto, Kaabong, Amudat and Nakapiripirit Districts.
- Rainfall projections are less certain than temperature projections, but assuming a persistence of current trends, predictions suggest a 50–150 mm reduction in rainfall between 2010–2039, with pronounced inter- and intra-annual variability (FEWS NET, 2012). Some models suggest that rainfall is projected to increase in total amount but with pronounced interannual variability.

2.1.4 NON-CLIMATE STRESSORS

- *Population pressure*: Population growth, at 3 percent annually in this landscape, is leading to conflicts over land and water rights between crop farmers and pastoralists.
- *Overstocking and overgrazing*: Of Uganda's 11.4 million cattle population (counted in the 2008 national livestock census), the majority are concentrated in Kotido, Nakapiripirit, and Kaabong Districts (Uganda Ministry of Agriculture, Animal Industry and Fisheries et al., 2010).

- *Open access of wetlands*: Wetland resources are accessible and available to all users. Wetlands are being drained for cultivation and used by pastoralists as grazing and watering points.
- *Cutting trees for fuel wood*: As woody biomass disappears in other parts of Uganda, charcoal making is becoming a lucrative enterprise in this landscape.
- *Incursions into the PAs and wetlands to access pasture and water*: Dinkas, Toposa and Mening tribes from South Sudan and the Dodoth and Napore cattle-keeping communities in Uganda illegally enter the Kidepo-Pian Upe PAs and Bisina-Opeta wetlands. Pokot Karamojong clans drive their livestock into Pian Upe and to the Lake Opeta wetland system adjacent to the WR. While in the PAs and wetlands, they poach game for food (UWA, 2012), compete with wildlife for water and pasture, and may kill or chase wildlife so their livestock can safely access resources.

2.1.5 BIODIVERSITY RESOURCES OF IMPORTANCE

Biodiversity resources of importance for Landscape 1 are found in Table 4.

Table 4. Landscape 1 – KVNP-Pian Upe Landscape Biodiversity Resources

AREA	HABITATS	BIODIVERSITY
KVNP	• 1,442 km^2 of savanna, with rugged arid and semi-arid valleys and plains interspersed with hills, rocky outcrops and forested mountain ranges. • The forested mountains of Morungole, Zulia and Nyagea, all part of Napore Central Forest Reserve (CFR) and Karenga Community Wildlife Management Area (CWMA), stretch from the park southwards covering an area of 956 km^2. They provide dispersal areas and migratory corridors for wildlife from KVNP.	• Over 462 species of birds, 86 species of mammals and 192 tree species. • 28 mammal species currently found nowhere else in Uganda, including striped hyena, aardwolf, caracal, greater and lesser kudu and Bright's gazelle. • Exceptional for its 58 species of birds of prey, including Verreaux eagle and Pygmy falcon. • The park has some of East Africa's rarest birds, sought by birdwatchers, adapted to the dry eastern habitat and found in no other national parks in Uganda. • Flagship species present, such as elephants, buffalo, lion, giraffe, zebra and various antelope.
Pian Upe WR	• 2,304 km^2 of savannah grassland in the north and a wetland ecological system in the south.	• UWA 2014 wildlife surveys found most surviving large mammals (waterbuck, gazelle, hartebeest, Uganda kob, buffalo and eland) in the south of the reserve along the Greek River, which drains into Lake Opeta. • Migratory route for birds moving southwards from Europe during winter.
Lakes Bisina and Opeta wetland systems	• Lake Opeta wetland system is a shallow freshwater lake with a thin strip of fringing papyrus swamp. • Only significant permanent wetland in this landscape and one of the few remaining intact wetlands in Uganda. • Water lilies, a declining habitat in most of Uganda's water bodies, dominate the shallow areas of Lake Bisina, and provide feeding grounds for wading birds.	• Important for conservation of both resident and migratory birds: Nature Uganda's 2009 ecological survey recorded 194 species of birds, including 41 migratory species, 26 threatened species of conservation concern, 6 threatened species of global concern and 20 species of regional concern (Nature Uganda, 2009). • Critical for bird species such as globally vulnerable shoebill stork and Fox's weaver, Uganda's only endemic bird; critical habitat for migratory bird species from Europe. • Important refuge for fish species that have gone extinct in the main lakes, including Lakes Victoria and Kyoga.

Sources: UWA 2012; UWA, 2015b.

2.1.6 LIVELIHOODS OF IMPORTANCE

Local communities in Landscape 1 include pastoral Karamojong people of the Dodoth subgroup and the Ik, a hunter-gatherer tribe whose survival is threatened by poverty, food insecurity and lack of access to services. Cattle herding is the livelihood of the Karamojong, who rely on the landscape for pasture and water for livestock. The Ik rely on the landscape for plants, water and wildlife. According to the 2014 Uganda National Census, the six districts that share the Lakes Bisina and Opeta wetlands complex support over 1.5 million people. The surrounding communities also rely on the wetlands complex for fishing, transport, supply of water for domestic use and livestock, seasonal grazing and cultivation of crops including paddy rice, maize, millet and plantain.

2.1.7 ECOSYSTEM SERVICES

Ecosystem services of importance for Landscape 1 biodiversity and livelihoods are found in Table 5.

Table 5. Landscape 1 – KVNP-Pian Upe Landscape Ecosystem Services

TYPE	SERVICES
Provisioning Services	The Morungole and Zulia mountain ranges, together with the Nyangea-Napore hills, are an important water catchment for the Karamoja region. Rivers flowing from these mountains include Nalakas, Kidepo and Narus. These provide water for wildlife inside the park and adjacent communities. The Narus Valley provides the only permanent water source in the KVNP and Lake Opeta wetland complex, a permanent wetland. The Narus Valley is the only part of the park that has water throughout the dry season; wildlife congregate there for water and pasture. The park is an important source of firewood, honey, herbal plants, salty grass and ordinary grass, sand and stones for building, and water for domestic use and livestock. It is also used for grazing livestock and artisan gold mining. Communities rely on wetland resources such as fish, craft materials, thatching, herbal plants and vegetables, especially plant resources used for food in the dry seasons, such as rhizomes (*Nymphea* genus) critical for human nutrition during droughts.
Cultural Services	The KVNP provides direct and indirect employment opportunities through tourism-based enterprises. Pian-Upe WR has potential for big game viewing and bird watching. A shared concession between UWA and a private sector partner is enhancing revenue generation and local employment opportunities, while strengthening conservation of the WR. The expansive rangelands in Karenga CWMA have great potential for community-based tourism enterprise development.

2.1.8 CLIMATE STRESSORS, RISKS, IMPACTS AND ADAPTIVE RESPONSES

Table 6 details climate stressors based on projected climate changes for Landscape 1, associated climate risks and potential impacts to biodiversity and livelihoods. Also included are potential adaptive responses for biodiversity and livelihood impacts.

Table 6. Landscape 1 – Climate Stressors, Climate Risks, Impacts and Potential Adaptive Responses for Kidepo Valley National Park (KVNP), Pian Upe WR, Lakes Bisina-Opeta Wetlands and Surrounding Communities

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts (generally between April and June) Severe dry spells and erratic rains (particularly between May and July)	Increased incidence and spread of fire; the savanna grassland ecosystem that dominates KVNP is highly susceptible to fire.	• Destruction of vegetation; additionally, regeneration of vegetation will be slower due to the increased length of dry periods. Most affected wildlife are: ostrich (breeding grounds) and grazers such as zebra, kudu, hartebeest and eland. Since these animals are prey for lion, cheetah and leopard, predator populations would be affected. (KVNP GMP, 2012). • Animal mortality. • Relocation of wildlife outside of PA boundaries (may be temporary). • Additional loss of habitat for the last population of the roan antelope, which is threatened with extinction.	• Decreased quality of tourism experience and decreased revenue due to increased dispersal and decreased number of animals and diversity of species. • PA resources, such as honey, herbal plants, salt grass for grazing and vegetables could be destroyed; communities that rely on these resources would be affected.	• As droughts intensify, rainfall patterns change and temperatures increase, undercutting traditional pastoralist, fishing and farming livelihoods practiced, populations will be compelled to accelerate draining of wetlands and cutting of trees, both adjacent to PAs and to encroach on the PAs themselves, exacerbating biodiversity impacts noted in the “Direct Impacts to Biodiversity” column.	*Responses to biodiversity impacts:* • Integrate PA fire management planning into GMPs to address fire threats. • Train PA staff in fire management/ controlled burning. *Responses to livelihoods impacts*: • Identify alternative locations as tourism destinations within the PAs. • Support tourism infrastructure development at alternative sites. • Support domestication/on-farm production of resources used by communities. • Update sustainable use agreements between the PA and communities that take into account effects of the new fire regime on PA resources. • Undertake collaborative PA

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts (generally between April and June) Severe dry spells and erratic rains (particularly between May and July)					management for communities to access resources like water, pasture, fruits and honey during climate shocks.
	Increased spread of woody invasive species.	• *Harrisonia abbysinica,* a fire-/drought-resistant plant species, is currently colonizing the Narus Valley and other parts of KVNP (KVNP GMP, 2012). • Transition of pasture to woody vegetation forces wildlife to move away from water in search of food, and move away from food in search of water. The increased movement raises the risk of poaching. Grazing populations could be compromised due to these stresses. • Reduction in the area of mating grounds, such as for Uganda kob, which need large open areas (Onsite	• Decreased quality of tourism experience and revenue. If wildlife disperses in search of pasture, the Narus Valley, KVNP's main tourist attraction, may no longer be ideal for game viewing. • Increased HWC as a result of wildlife, especially grazers, moving outside the PAs in search of more palatable food. Already antelope commonly raid crops (as do buffalo, elephant and baboon) around KVNP (UWA, 2012).		*Responses to biodiversity impacts:* • Support promising invasive species control measures, especially in the Narus Valley. *Responses to livelihoods impacts*: • Identify alternative locations as tourism destinations within the PAs. • Support tourism infrastructure development at alternative sites. • Scale up the Karenga CWMA planning to cover all subcounties in CWMA and implement the conservancy and other management actions identified in the current management plan for the two sub-counties. A second priority site for

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		interview, UWA, August 2016).			management planning and conservancy implementation is the Iriri/Amudat CWMA adjoining Pian Upe WR. • Scale up measures to control wildlife movement outside the PA (physical boundaries, vegetation boundaries, unpalatable crops, re-vegetating areas in the PA with palatable grasses, etc.).
	Increased drying of wetlands and other water sources.	• The Narus Valley may no longer provide dry season water for wildlife. • Exacerbated by unsustainable utilization, reduction in breeding and feeding areas for avifauna, fish and wildlife that rely on wetlands. • Drying of the Bisina-Opeta wetland complex could degrade or destroy this globally important habitat for migratory birds.	• Increased HWC, affecting livelihoods of livestock keepers in the surrounding communities and/or pastoralists. • Reduction of wetland resources, such as craft materials, thatching, herbal plants, vegetables and other plants used for food in the dry seasons. This could in turn diminish community support for the PAs and for		*Responses to biodiversity impacts:* • De-silt existing wildlife watering points in the KVNP to make them functional. • Establish new, well-distributed watering points (to serve areas with high animal concentrations but with little water during the dry season, e.g., the northern sector in the KVNP) to keep wildlife inside the PA.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		• Increased poaching in dry seasons, when pasture and water is scarce outside the PAs.[2]	wetland conservation. • Reduced livelihood options, especially in the Bisina wetland, due to reduced fish catch. • Reduced water and pasture for cattle, threatening cattle survival and cattle herding, the livelihood of the Karamojong people. • More frequent clashes between pastoralists and park management with incursions of pastoralists into the park to access pasture and water (UWA, 2012). Tensions also often occur between tribes, or even across districts as they compete for water and pasture		• Construct physical barriers and drainage structures to improve/ increase drainage to wetlands. • Promote integrated watershed management approaches *Responses to livelihoods impacts:* • Promote regulated wetlands access and resource use through zoning and enforcement of bylaws, particularly among fishermen and the pastoral and agro-pastoral communities that use the Bisina-Opeta wetlands complex. • Reduce overstocking and overgrazing. • Install automatic weather stations and Provide timely & accurate weather forecast

2 Dinkas, Toposa and Mening tribes from South Sudan, often armed and in large numbers, invade the KVNP-Pian Upe landscape for grazing during dry seasons. As they move in the park they poach game for food. During prolonged dry seasons, with scarce pasture and water outside the PAs, tribes would remain in the PAs for a longer period, with poaching likely to increase. The Dodoth and Napore cattle-keeping communities in Uganda also move their livestock into the PAs during severe dry conditions. They also poach wildlife there (UWA, 2015b). Similarly, the Pian, and Pokot Karamojong clans around Pian Upe WR drive their livestock into the reserve to graze and water their animals in the Lake Opeta wetland complex adjacent to the WR, where they poach wildlife.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					information to pastoralists/agro-pastoralists by radio and/or SMS. • Carry out a resource inventory in the PAs to collect data on salt grass, honey harvesting, firewood, local vegetables and local herbs to determine sustainable harvest limits based on drier conditions. • Promote wetland-based, ecologically friendly enterprises that contribute to household incomes while helping to conserve the Bisina-Opeta wetlands.
Increased intensity of extreme events Floods, particularly between July and September	Increased siltation of wetlands and water sources.	• Degraded habitat for fish and wildlife. • Flooding could somewhat balance the drying, but overall, wetland surface area is expected to shrink (Government of Uganda, 2009, in Mubiru, 2010).	• Reduced quality and quantity of water for domestic use and for supplying the River Nile. • Impacts on croplands that are irrigated from these systems. • Reduced fish catch resulting from degraded water quality; would		*Responses to biodiversity impacts:* To control sedimentation: • Construct physical barriers • Plant vegetation barriers • Construct drainage structures *Responses to livelihoods impacts:*

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			especially affect livelihoods of fishermen in the Bisina wetland. • Adverse impacts for craft makers and other livelihoods dependent on wetland resources.		• Restore landscapes especially in the upstream of rivers and wetland catchment areas. Restore river banks and create buffer zones around wetlands, particularly in cultivating communities. • Improve water harvesting and storage mechanisms for irrigation, domestic use and livestock within communities outside the PAs, including rainwater harvesting, micro-irrigation schemes and other water-saving technologies to minimize demands on PAs for water. • Construct aquaculture ponds. • Invest in rehabilitation and expansion of physical infrastructure and vegetation to enhance flood protection of gardens, houses

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					and other household assets from intense rainfall events. • Support environmentally sound alternative livelihood options (see above).

2.1.9 CLIMATE CHANGE RISK SIGNIFICANCE RATING

Landscape 1 – Kidepo Valley National Park, Pian Upe Wildlife Reserve (WR), Lakes Bisina-Opeta Wetlands, and Surrounding Communities

CRITERIA		RATING*	NOTES
1	Importance of biodiversity	**3**	When taken as a whole, the three contrasting major ecosystems of this landscape present extraordinary diversity. Dozens of species occur only in this park, accompanied by stocks of large mammals such as elephant, lion and giraffe, as well as migratory birds and endemic fish.
2	Significance of climate change impacts on biodiversity	**3**	Destruction and slower growth of vegetation. Changes in climate favoring invasive species. Increasingly, fire has been affecting wildlife and vegetation. Drying of water sources and human-wildlife competition increases.
3	Importance of natural resources to livelihoods	**3**	Very important for many livelihoods. Resources include: food, firewood, grazing, mining, raw materials and water. Bisina-Opeta wetlands support over 1.5 million people.
4	Significance of climate change impacts on livelihoods	**3**	Projected higher temperatures and rainfall variability will significantly increase the vulnerability of pastoralists in this major cattle area. Heavy and unpredictable rains pose threats to non-irrigated agriculture and to the use of wetlands in droughts. Reduction in tourism and income likely.
5	Relative impact of climate stressors compared to non-climate stressors	**3**	Climate change is more significant than non-climate change stressors.
6	Imminence of climate impacts	**3**	Area has already been experiencing higher temperatures and increased unpredictability of rain. Failure of crops and decline in livestock productivity cause population to turn to other income-generating activities which can include cutting trees for charcoal as well as entering PAs for extraction of resources such as honey.
7	Potential value in piloting adaptation response	**2**	Can be applied to other ecosystems in the cattle corridor but not necessarily all of Uganda.
Overall Significance**		**High** (20)	**Climate change risk is significant and landscape provides high potential for implementing successful model adaptive responses.**

*Ratings: **High (3),** **Medium (2),** **Low (1)**
**Overall Significance: Sum of criteria scores; 7–10=low; 11–15=medium; 16–21=high.

2.2 Landscape 2 Analysis

Lake Mburo Conservation Area (LMCA) and Surrounding Communities

REGION: DRY CATTLE CORRIDOR

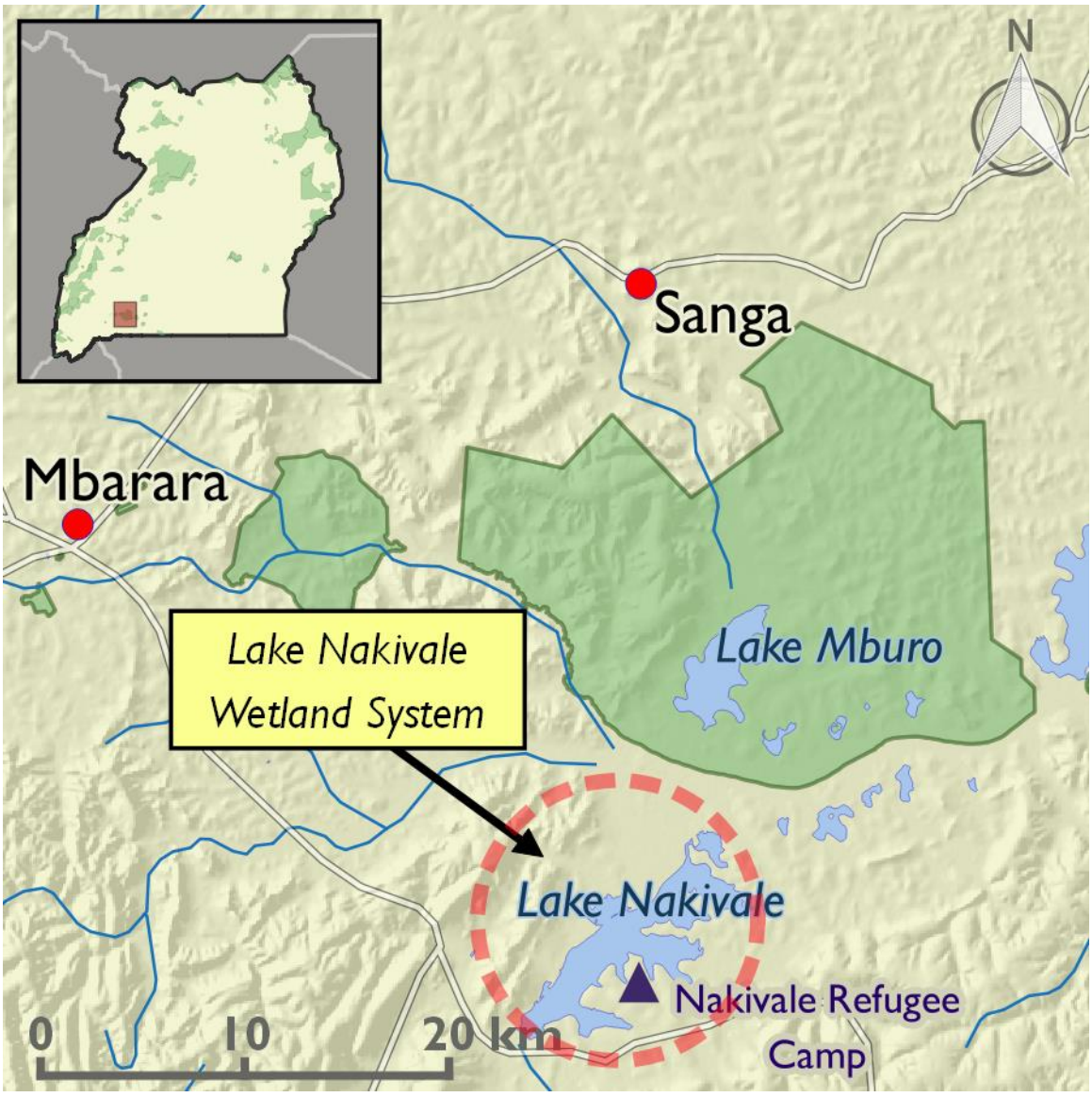


Figure 3. Landscape 2: LMCA and Surrounding Communities

2.2.1 LOCATION AND DESCRIPTION

UWA recognizes Lake Mburo National Park (LMNP) and the Lake Nakivale wetland system, part of a large wetland complex, as the Lake Mburo Conservation Area (LMCA). LMNP is a demarcated National Park covering 370 km^2. Although the Lake Nakivale wetland system does not have designated boundaries, it includes a designated Ramsar Site. Together with 13 other lakes, the LMCA is part of a 50 kilometer-long wetland system.

Lake Mburo is a critical component within the River Rwizi catchment. During dry periods, it is the only source of permanent water for wildlife and livestock in the area. The River Rwizi, the main river in this landscape, flows eastward through and from Mbarara which, at nearly 200,000 people, is the second largest city in Uganda and the second fastest growing. Sanga is growing fast and is another large urban area in the vicinity. From Sanga to the north along the Masaka-Mbarara highway, a string of small but growing villages continue along the paved and unpaved road to the park gate.

2.2.2 UNIQUE CLIMATE CHARACTERISTICS

LMNP has the tropical climate found in the Ankole-Southern climatic zone. It lies in a rain shadow area between Lake Victoria to the east and the Rwenzori Mountains to the west. The park has two marked seasons, a rainy and a dry season, and receives annual rainfall of 500 to 1,000 mm. Temperatures range from 23° to 25°C.

2.2.3 CLIMATE PROJECTIONS

Projections for Landscape 2 by 2030 include[3] (USAID, 2014):

- Increase in average temperatures by 2°C, with rates of warming greatest in the coolest season, June–September.
- Increases in the frequency of days and nights that are considered hot.
- Potential for increase in precipitation during the dry season.
- Increase in the frequency of heavy rainstorms, flooding, etc.

2.2.4 NON-CLIMATE STRESSORS

- *Population pressure*. Mbarara, previously a smaller urban conglomeration, is now a major city with all of its demands on resources: water, land and fuelwood. Other communities around LMNP are also growing and placing pressure on the park. The population around the Lake Nakivale Ramsar Site (LNRS) continues to grow and management authorities are called upon regularly to remove people who are encroaching on the wetland.
- *Upstream development.* Development upstream, such as soda and beer bottling and dairies, requires water, decreases the flow in Rwizi River and reduces water quality by introducing nutrients that are byproducts of the production process into the water courses.

[3] No specific climate projections are available for this landscape, so the general climate projections from the 2013 USAID ARCC Vulnerability Assessment were used.

- *Livestock production.* This is the dominant livelihood in the landscape; the high stocking rate causes competition for limited resources.
- *Lack of local community buy-in to PA creation and management.* This leads to a culture of distrust and, at times, conflict and/or ignoring of rules.
- *Wetland encroachment and conversion.* The wetland has been encroached on and turned into farmland or used for pasture or settlements. Lower water quality and quantity and eutrophication of the lake result.
- *Refugee camp.* Nakivale has the added pressure of being adjacent to the very large refugee camp, which has about 60,000 people who place demands on wetland resources.
- *Fire risk*. Poachers and refugees from Oruchinga and Nakivale set fires to hunt or clear agricultural land.

2.2.5 BIODIVERSITY RESOURCES OF IMPORTANCE

The LMCA wetland system was designated a Ramsar Site and an Important Bird Area. Biodiversity resources of importance for this landscape are found in Table 7. A variety of ecosystems including lakes, wetlands, open grasslands, forests and woodlands support high biodiversity, according to the LMCA General Management Plan (GMP) (2015–2025).

Table 7. Landscape 2 – LMCA Landscape Biodiversity Resources

AREA	HABITATS	BIODIVERSITY
LMNP	• Once covered by open savanna, LMNP now contains extensive woodland. • In the western part of the park, the savanna is interspersed with rocky ridges and forested gorges. • Patches of papyrus swamp and narrow bands of lush riparian woodland line many lakes. • Wetland habitats comprise 20% of the park's surface. • Smallest of Uganda's savanna national parks.	• *Acacia* is increasingly one of the dominant tree species though it is considered invasive. • Five species of wetland-dependent plants belonging to five genera have been recorded in the Lake Mburo area. • Home to 350 species of birds as well as zebra, impala, eland, buffalo, oribi, Defassa waterbuck, leopard, hippo, hyena, topi and reedbuck. • Only park in Uganda with significant populations of impala, eland and topi; the only one in southern Uganda with zebra.
Lake Nakivale wetland system	Unique habitat, lying at the convergence of two biological zones, giving it very high biodiversity.	• Supports globally threatened bird species such as the papyrus yellow warbler and shoebill stork. • Provides refuge for 22 species of Palaearctic and Afro-tropical migrant birds, especially during adverse conditions. • Supports two of the endangered cichlid fish species that have gone extinct in the main lakes of Uganda. • Habitat for other animal species such as hippopotamus, sitatunga and Nile crocodile.

Source: UWA, 2003.

2.2.6 LIVELIHOODS OF IMPORTANCE

Tourism is important to the region. Given that LMCA is the only national park in the Ankole region, substantial opportunity exists for further tourism development (UWA, 2003). UWA reports the number of visitors in 2013 as nearly 25,000, split about evenly between Ugandans

and foreigners. The benefits of tourism, however, are said to accrue mainly to private sector tourism operators and lodge owners rather than to communities.

2.2.7 ECOSYSTEM SERVICES

Ecosystem services of importance for Landscape 2's biodiversity and livelihoods are found in Table 8.

Table 8. Landscape 2 – LMCA Landscape Ecosystem Services

TYPE	SERVICES
Provisioning Services	During dry periods, cattle ranchers request access to Lake Mburo, the area's only permanent water source. PA management allows access specifically by permit and only for watering, not grazing. LMNP now employs community members to remove *Acacia* and grants permits for removal and sale of the wood biomass, including for making charcoal. This benefits the livelihoods of local people, while also benefitting biodiversity by removing this invasive plant that is changing the overall landscape from grassland to woodland. LMNP contributes directly to fishermen's livelihoods. UWA park management oversees fishing, monitors catch and licenses boats. UWA allows local communities to collect plants and wood, which are used for thatch, fuelwood and handicrafts, as well as for caps for milk containers, important for both nutrition and culture. Surrounding communities, including inhabitants of the Nakivale refugee camp, use Lake Nakivale wetland resources, such as fish, pasture for domestic animals, papyrus reeds for crafts and construction, water for livestock and domestic use, firewood and medicinal plants and as cultural sites.
Regulating Services	Wetlands, through which the River Rwizi passes before Mburo, provide ecosystem services such as filtration of silt (and perhaps toxins) as well as flood control. These activities improve the quality of the river and lakes for cattle, fishing and other uses. As a critical water body within the River Rwizi catchment area that drains into Lake Victoria, Lake Mburo provides direct and indirect values, including moderating the climate in the surrounding environment and communities.
Cultural Services	Traditional and cultural relationships between the protected fauna and flora and the surrounding communities.

2.2.8 CLIMATE STRESSORS, RISKS, IMPACTS AND ADAPTIVE RESPONSES

Table 9 details climate stressors based on projected climate changes for Landscape 2, associated climate risks and potential impacts to biodiversity and livelihoods. Also included are potential adaptive responses for biodiversity and livelihood impacts.

Table 9. Landscape 2 – Climate Stressors, Climate Risks, Impacts and Potential Adaptive Responses for Lake Mburo Conservation Area and Surrounding Communities

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts Severe dry spells Erratic rains	Increased incidence and spread of fires due to hotter, drier conditions.	• Destruction of vegetation; additionally, regeneration of vegetation will be slower due to the increased length of dry periods. • Animal mortality. • Relocation of wildlife beyond the PA boundaries, perhaps only temporarily.	• Reduced pasture for grazers. • Decreased quality of tourism experience and revenue. Wildlife could move to more favorable areas to access food and water, which could be across the border to Tanzania, to agricultural fields or to swamps, thus making the LMNP less attractive to tourists. • Reduced PA resources for community use. Plant resources that communities rely on and that are found in the PA could be destroyed.	• As droughts intensify, rainfall patterns change and temperatures increase, the needs of substantial and increasing populations surrounding the conservation area will compel these populations to increase the cutting of trees within the conservation area, accelerate draining of wetlands surrounding the conservation area for conversion to farmland and increase poaching within the conservation area, exacerbating biodiversity impacts noted in the “Direct Impacts to Biodiversity” column.	*Responses to biodiversity impacts:* • Integrate PA fire management planning into GMPs to address fire threats. • Train PA staff in fire management/ controlled burning. *Responses to livelihoods impacts:* • Support tourism infrastructure development at alternative sites, such as at conservancies. • Strengthen institutional and technical capacities of conservancies. The African Wildlife Foundation Biodiversity Project has made progress, but continued support is needed for these nascent institutions. • Support domestication/on-farm production of resources used by communities.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts Severe dry spells Erratic rains					• Update sustainable use agreements between the PA and communities that take into account effects of the new fire regime on PA resources. • Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.
	Increased spread of invasive species (e.g., *Acacia*, *Lantana camara)*.[4]	• Reduced habitat for grazers. The western part of LMNP, which provided habitat for grazers such as zebra, buffalo and eland now has become *Acacia* forest, and only supports monkeys. This trend would be expected to continue, and the transition may be more rapid with higher temperatures and drier conditions.	Increased HWC due to spread of invasive species. Since wildlife is unable to get through *Lantana* thickets, they may go outside the park in search of easier grazing and watering. This can result in HWC especially since cattle ranchers and farms are now located adjacent to park boundaries. Wildlife eat from farm plots, especially banana, a staple crop in the landscape. At LMNP, with drier conditions, zebra are		*Response to biodiversity impacts:* • Support promising invasive species management measures. • Support the introduction and reintroduction of certain species, such as giraffe, recently translocated, which browse *Acacia*. *Response to livelihoods impacts:* • Scale up best measures to

4 Palatable grasses are currently transitioning to unpalatable woody vegetation, such as *Acacia* (whose seeds need fire to sprout). The LCMA GMP reports that invasive species have increased in LMNP in recent years, mostly *Acacia* species (*A. hockii* and *A. geradii*).

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts Severe dry spells Erratic rains		• Decreased accessibility of water sources. *Lantana camara,* a perennial shrub, has spread into LMNP. It forms dense thickets, blocking tracks that animals take down to the lake (the only water source in dry seasons) which is now inaccessible in many areas of the park. Animals instead go outside the park or go to the swamps, where they get stuck in the mud and sometimes die.	more often found in ranches, resulting in increased HWC. The typically shy eland, which had never before gone to banana plantations to feed, now are found eating matoke (Onsite interview, August 2016). *Disease transmission*. When wildlife wander outside PA boundaries, they come into contact with livestock, and disease transmission can result. Wildlife carry ticks and tick-borne diseases that can be transferred to wildlife and treating livestock to kill ticks is expensive. Tick-borne disease in livestock are already a problem for livestock keepers in the surrounding communities, and would be expected to continue and possibly worsen.		control wildlife movement outside the PA (removal of *Lantana* around PA water sources, physical boundaries between the PA and communities at risk, vegetation boundaries, unpalatable crops, revegetating areas in the PA with palatable grasses, etc.). • Support district veterinary officers to monitor and manage tick-borne diseases and other diseases transmissible from wildlife to livestock.
	Disruption of seasonal patterns.	• Disruption of birth and movement of wildlife, previously attuned to changes in vegetation and the start and end of the rainy and dry			

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Droughts Severe dry spells Erratic rains		seasons that may be unable to adapt to new regimes. • Decreased prevalence of bees, which may be in part attributable to climate change. Colonization of hives is slower, which could be linked to flowers that used to bloom in May but now bloom at different times (Onsite interview, District Natural Resources Officer, August 2016).			
	Increased drying of wetlands and other water sources. LMNP and LNRS wetlands may dry up and shrink and Lake Mburo's water level may drop.[5] Ecosystem services typically provided by healthy, intact wetlands will be adversely affected (water source, flood attenuation, filtering contaminants).	• More movement of wildlife due to drier conditions. As a dry season coping strategy, many wildlife species in LMNP migrate to Tanzania or undertake more localized movements to swamps. Wildlife is at risk during migration, as well as during shorter	• Increased human-wildlife conflict due to wildlife movement in search of water. • Disease transmission from wildlife to livestock (as a result of wildlife movement). • At LNRS, reduced livelihood options for fishermen, craft makers, and other livelihoods		*Response to biodiversity impacts:* • Support well-distributed construction of valley dams and other methods of catching rainfall within LMNP to provide wildlife with water resources, especially during the dry season. • Continue the buffer zone demarcation

[5] In LNRS, the wetland level has dropped (this is also attributed to reasons other than climate change, such as unsustainable uses).

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		movements; they are more susceptible to poaching and being hit by vehicles, and once outside of LMNP, they may be killed by farmers or livestock keepers. • At LMNP, even localized movement is becoming more hazardous since swampy areas are drying, and when animals move toward these water sources, they get stuck in the mud. Unless PA staff rescue them, they die. • Overgrazing, diminished food availability and animal mortality as a result of animals converging in smaller areas where water is available. • Fish and wildlife that breed, feed and hide along shorelines will be affected if the level of Lake Mburo drops. Catfish	dependent on wetland resources. • Fewer PA resources for community use. Among other plants used by community members (thatch and material for handicrafts), a plant used to cap milk containers is less common due to drying of wetlands. This is a livelihood and vulnerability issue linked to nutrition. • Adverse impacts on quality and quantity of water for domestic use and for croplands that are irrigated from this landscape's water sources.		and protection program that was started in 2013 around LNRS to mitigate lower water levels in the lake. • For LNRS, develop and implement more strictly enforced land use planning along with an awareness-raising program on the value of ecosystem services that the lake provides. • Evaluate pilot programs and scale up successes that restore fragile riverine ecosystems. A public-private partnership of Ugandan and donor entities in Mbarara District has shown some success. *Response to livelihoods impacts:* • Support construction of valley dams and other water conservation

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		numbers are already declining because of decreased rainfall, which is drying swamps and affecting catfish reproduction (Onsite interview, August 2016). • Impacts on fisheries, bird life and other animals that rely on LNRS.			schemes in communities surrounding LMNP. • Restore landscapes especially in the upstream of rivers and wetland catchment areas. Restore river banks and create buffer zones around wetlands, particularly in cultivating communities. • Improve water harvesting and storage mechanisms for irrigation, domestic use, and livestock within communities outside the PAs, including rainwater harvesting, micro-irrigation schemes and other water-saving technologies to minimize demands on PAs for water. • Construct aquaculture ponds. • Invest in rehabilitation and expansion of physical infrastructure and vegetation to

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					enhance flood protection of gardens, houses and other household assets from intense rainfall events. • Support district veterinary officers to monitor and manage tick-borne diseases and other diseases transmissible from wildlife to livestock. • Promote wetland-based, ecologically friendly enterprises related to ecotourism, fish farming and craft making that contribute to household incomes while helping to conserve the LNRS wetlands. • Carry out a resource inventory to collect data on PA resources used by communities to help determine sustainable harvest limits. • Support domestication and on-farm production of PA resources

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					that are most used by communities. • Promote regulated wetlands access and resource use through zoning and enforcement of bylaws, particularly among fishermen and the communities that use LNRS. • Promote the health and productivity of land outside the PA, including good farming practices, crop-livestock integration (e.g., establishment of field borders and more effective use of manure) and soil and water management.
Increased intensity of extreme events Floods	Increased silting of wetlands, lakes and rivers.[6] Ecosystem services typically provided by healthy, intact wetlands are being affected (water source, flood attenuation, filtering contaminants).	• Degraded habitat for fish and wildlife.	• At LNRS, livelihoods of fishermen, craft makers and others dependent on wetland resources will be adversely affected. • Reduced water quality and quantity.		*Response to biodiversity impacts:* To control sedimentation: • Construct physical barriers. • Plant vegetation barriers. • Construct drainage structures.

[6] This is worsened by upstream development. Hard rainfall will bring sediment off of the formerly forested agricultural lands and developed hard surfaces.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			• Fewer PA resources for community use.		*Response to livelihoods impacts:* • Evaluate pilot programs and scale up successes that restore fragile riverine ecosystems (see above). • Promote wetland-based, ecologically friendly enterprises (see above). • Support environmentally sound alternative livelihood options, such as: fish farming, alternatives to illegal firewood and charcoal production, such as certification of charcoal producers and wood lot enterprises; and wildlife and other biodiversity-based enterprises, such as ecotourism and support for conservancies. • Carry out a resource inventory to collect data on PA resources used by communities to help determine

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					sustainable harvest limits. • Support domestication and on-farm production of PA resources that are most used by communities.

2.2.9 CLIMATE CHANGE RISK SIGNIFICANCE RATING

Landscape 2 – Lake Mburo Conservation Area and Surrounding Communities

CRITERIA		RATING*	NOTES
1	Importance of biodiversity	**2**	LMNP is the only park in Uganda with significant populations of impala, eland, topi and zebra. LMCA ecosystem includes a Ramsar Site (Lake Mburo itself & parts of Nakivale) that is an Important Bird Area for endemic, threatened and migratory species.
2	Significance of climate change impacts on biodiversity	**2**	Projected change in temperature and variability of rainfall will cause additional stress on animals and loss of flora to which they are adapted. Because of the very small size of the PA (370 km^2) and the fact that it is completely surrounded by communities, migration of species is constrained.
3	Importance of natural resources to livelihoods	**3**	LMNP is the only source of permanent water in the area, providing water for both wildlife and livestock. It is thus very important for pastoralists, agro-pastoralists and fishermen. In addition to the nearly 50,000 people living in communities bordering LMNP (UWA 2003), as many as 60,000 people live in the Nakivale refugee camp. Nearly all residents are directly dependent on the local natural resources.
4	Significance of climate change impacts on livelihoods	**3**	Projected change in temperature and in variability of rainfall will cause additional stress on animals and loss of flora to which they are adapted.
5	Relative impact of climate stressors compared to non-climate stressors	**2**	Non-climate change stressors such as population growth, upstream industrial development and refugees are as significant as climate change stressors at present.
6	Imminence of climate impacts	**3**	Impacts of delayed and diminished rainfall and higher temperatures on water availability, crops and animals are currently affecting population.
7	Potential value in piloting adaptation response	**3**	Other landscapes in Uganda have many of the same issues and this is a well-circumscribed, high-visibility example.
Overall Significance**		**High** (18)	**Climate change risk is significant and landscape provides high potential for implementing successful model adaptive responses.**

*Ratings: **High (3),** **Medium (2),** **Low (1)**
**Overall Significance: Sum of criteria scores; 7–10=low; 11–15=medium; 16–21=high.

2.3 LANDSCAPE 3 ANALYSIS

Rwenzori Mountains National Park (RMNP) and Surrounding Communities

REGION: ALBERTINE RIFT

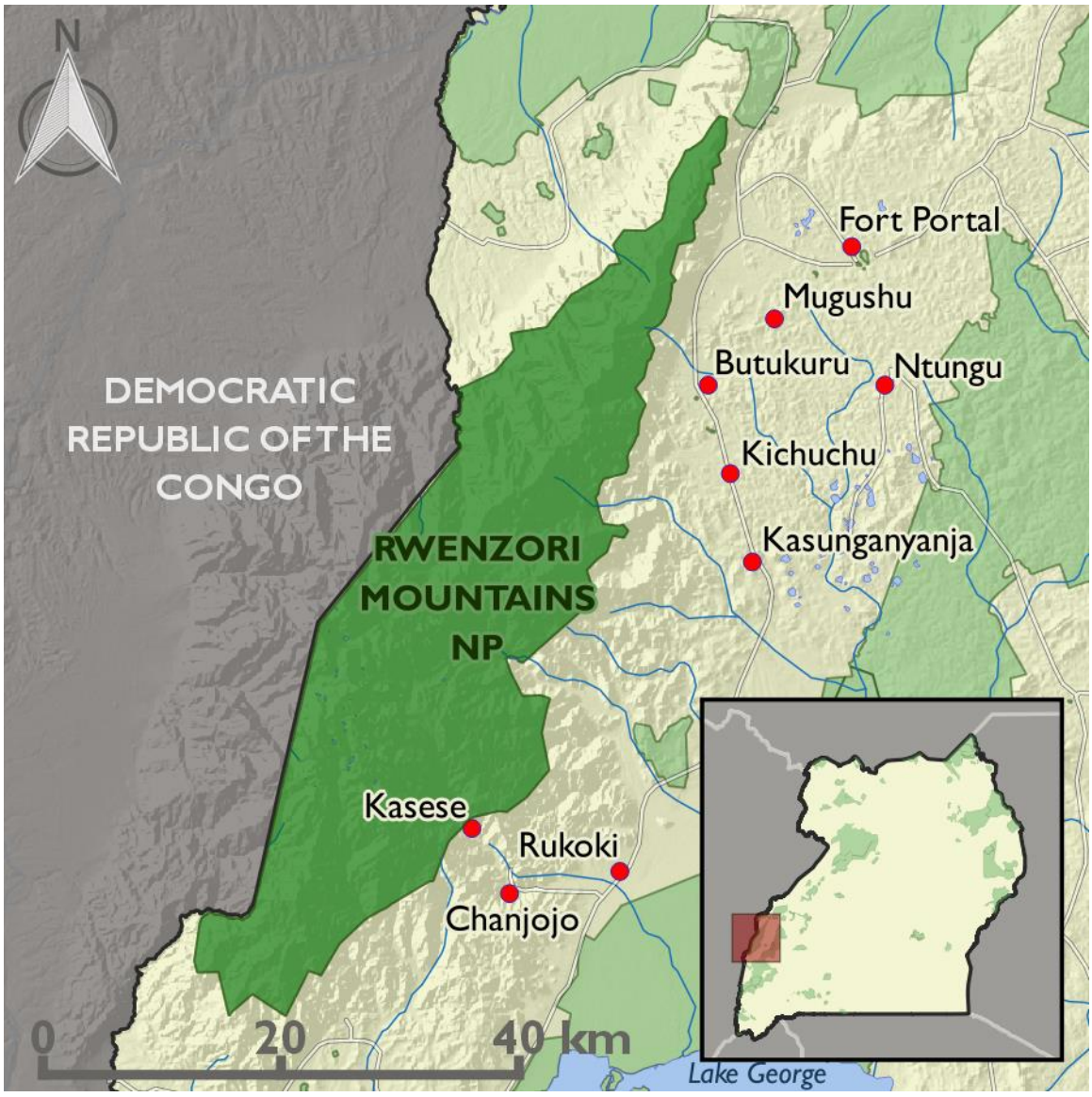


Figure 4. Landscape 3: RMNP and Surrounding Communities

2.3.1 LOCATION AND DESCRIPTION

This landscape encompasses the Rwenzori Mountains National Park (RMNP), a constituent PA of the Queen Elizabeth Conservation Area, and surrounding communities. A World Heritage site, RMNP covers nearly 100,000 hectares in western Uganda and comprises the main part of the Rwenzori Mountain chain, which includes Africa's third highest peak (Mount Margherita, 5,109 meters). The Rwenzori Mountains is a cross-border ecosystem shared with the Democratic Republic of the Congo (DRC). It is one of the largest and most important water catchment areas in western Uganda.

2.3.2 UNIQUE CLIMATE CHARACTERISTICS

The climate of Landscape 3 is tropical, affected by seasonal movements of the intertropical convergence zone, altitude and topography. The two rainy seasons are from March to May and August to December. The daily temperature range is small, ranging from a maximum of 7°C to a minimum of ⁻1°C, with lower temperatures during the rainy season (UWA, 2016).

2.3.3 CLIMATE PROJECTIONS

Using Albertine Rift-wide data,[7] projections by 2050 include (Seimon and Phillips, 2011):

- Rising temperatures.
- Variability in rainfall seasonality, with slight decreases in monthly rainfall averages; when combined with warming trends, could be indicative of increasing threat of drought.
- Increase in rainfall by 2050 and beyond.

2.3.4 NON-CLIMATE STRESSORS

- *Population pressure*. The area around RMNP is one of the most densely populated rural areas in Africa, with 150 to 450 people per km^2 (UWA, 2016). In 1992, approximately 300,000 people lived in the area but by 2002 the population around the mountain had increased to 1 million people (UWA, 2016). The high levels of poverty, low literacy rates, limited income-generating activities and high levels of unemployment for people living around the park translate into a significant demand for park resources.
- *Fire*. During the dry season, cultivators set fires, as do illegal honey collectors and regular footpath users. Fires spread into RMNP.
- *Illegal activities*. These include:
    - Cutting of trees: Boundary trees, especially in Mbata, Mukumba and Kasangali areas, and trees inside the park are harvested for domestic and commercial purposes. The species most commonly harvested are *Podocarpus*, mahogany and bamboo.
    - Collection of raw material for pharmaceuticals: demand for *Prunus africana* bark is now threatening the existence of this species in RMNP.
    - Poaching: Communities living around RMNP believe that wild meat is medicinal and a delicacy. The most poached animals are rock hyrax, duiker and primates.

[7] Weather data are collected on a quarterly basis from automatic weather stations installed at different altitudes in RMNP; however, no projections specific to RMNP are available.

- Livestock grazing.
- Collection of traditional medicinal plants and plants for cultural use.

- *Mining*. In 2013, the government signed a 25-year concession deal with Chinese Tibet Hima Limited to extract approximately 4.5 million tons of copper still underground within Kilembe geographical area. The concession area is adjacent to RMNP and mining could affect park resources.
- *Hydropower development*. Greenewus Energy Africa Ltd. submitted a proposal to develop the Kakaka Mini Hydropower Project along the River Rwimi at Kakaka Falls inside RMNP. (The falls are about 500 meters long and 50 meters wide.) The feasibility study report conducted by VS Hydro, a Sri Lankan firm, recommended that the intake weir (mini flow diversion dam) and part of the headrace channel/canal, which directs the water to the power house downstream, be located inside the forest, 300–500 meters inside RMNP. A detailed environmental impact assessment was conducted to address and mitigate the potential environmental and social impacts of the proposed hydropower project (UWA, 2016).
- *Other development*. Other development projects are planned for RMNP and the surrounding area, including over 30 gravity flow water schemes and tourist developments such as tourist camps, bridges and boardwalks along trails in the park (UWA, 2016).
- *Boundary/buffer zone issues*. The park has a total boundary of 218 km and most of this is a hard edge with community gardens next to the park boundary. The lack of buffer between park boundary and community gardens often leads to encroachment by communities into the park. Most of the park boundary is marked with pillars and 70 percent of it is reinforced with planted eucalyptus trees. However, some sections of the boundary do not have live markers reinforced with concrete pillars (UWA, 2016), making these areas more at risk of incursions. The park also has a 56-km border with DRC running from the Itako River in Kasese to Malindi in Bundibugyo. The international boundary is porous and unmarked; as a result, the park has experienced incidences of insurgency. Insecurity is still a threat.

2.3.5 BIODIVERSITY RESOURCES OF IMPORTANCE

Biodiversity resources of importance for Landscape 3 are found in Table 10.

Table 10. Landscape 3 – RMNP Landscape Biodiversity Resources

AREA	HABITATS	BIODIVERSITY
RMNP	• Forest (78%), savanna (11%), grassland (2%) and other artificial and unknown habitats. • Nine identified vegetation zones within the Rwenzori Mountain range: i) high altitude moorland with heather, ii) high altitude forests including bamboo, iii) medium altitude semi-deciduous forests, iv) forests/savanna mosaics, v) moist *Acacia* savanna, vi) moist *Combretum* savannas, vii) dry *Combretum* savannas, viii) dry *Acacia* savannas, and ix) grass savannas.	• Close to 200 tree species (about 18% of the country's known tree species) have been recorded in the Afromontane forest region of the park. • *Prunus africana*, important for many uses, is common throughout the forest, though its status is vulnerable. • Of the 278 woody plant taxa found in the Afro-alpine zone, 81% are endemic to East Africa. • Fifty-four Albertine Rift endemic species: 18 species of mammals, 21 species of birds, 9 species of reptiles and 6 species of amphibians. • Five species found in the RMNP are endangered, 14 are threatened and 4 have restricted ranges. • Restricted range species in the park include the Rwenzori/Kivu climbing mouse, the Rwenzori duiker

AREA	HABITATS	BIODIVERSITY
	• Above the Afromontane forest is a bamboo forest, gradually transitioning to *Mimulopsis elliotii* flowering shrub. At higher altitudes, *Ericaceous* forest grows on the narrow ridges and beyond this, *Helichrysum* begin to appear.	and the Uganda clawed frog. Threatened animals include the Rwenzori black-fronted duiker, African elephant (found in the Rwenzori forest up to 2,440 m), L'Hoest's monkey, chimpanzee and the dwarf otter-shrew. • One of the most important bird communities in Uganda, with between 214 to 240 species.

Sources: Carr et al., 2013; Barihaihi, 2010; Lush, 1993, in Barihaihi, 2010; UWA, 2016.

2.3.6 LIVELIHOODS OF IMPORTANCE

Communities around RMNP mainly rely on agriculture for their livelihoods. Cassava, banana, maize, Irish potato and vanilla are the most common crops. Coffee is the main cash crop. Some community members are involved in ecotourism/community-based tourism and trekking activities; local people mainly serve as porters, guides and cooks. Hima Cement Factory employs a significant number of people. The proposed reopening of the old Kilembe Copper Mines in the Rwenzori Mountains is projected to provide employment for over 3,500 people.

The potential for community-based tourism around RMNP has not been fully developed (UWA, 2016). Mountain guiding is a main source of income for the Bakonzo and other communities. The Rwenzori Mountains Community Tourism Development Association, an umbrella organization uniting all community tourism operators in the Rwenzori region, is trying to organize and build the capacity of community-based tourism organizations.

2.3.7 ECOSYSTEM SERVICES

Table 11. Landscape 3 – RMNP Landscape Ecosystem Services

TYPE	SERVICES
Provisioning Services	The population supplements livelihoods (mainly agricultural) with resources from the park. Sustainable use agreements between communities and UWA allow access to RMNP plant resources and help strengthen relationships and minimize conflicts between RMNP and surrounding communities. *Prunus africana*, important for its many uses (traditional medicine, a hardwood used for axes, hoes, construction), is common throughout the forest, though its status is vulnerable. For the Bakonzo, who live on the slopes of the mountains, RMNP is an important source of resources such as bamboo (the most important resource), fibers (smilax and acalpha for basket making), medicinal plants, mushrooms, building materials, water and honey.
Regulating Services	Glaciers and wetlands are important for water provision and flood attenuation. The Rwenzori Mountains are one of the largest and most significant water catchment areas in Uganda. More than 50 rivers emerge from these mountains, flowing through the neighboring communities and beyond. Their glaciers supply clean water to over 1 million people in the DRC and Uganda (Kaggwa et al., 2009) and the catchment area provides irrigation water to communities surrounding the PA. Agricultural lands surrounding the park are fed partly by mountain runoff and partly from direct rainfall regulated by the Rwenzori forest. The mountain's water catchment benefits the fisheries of Lakes George and Edward, irrigation schemes, hydroelectric power generation and domestic water supply to adjacent communities (UWA, 2016). According to the RMNP GMP 2016–2025, the RMNP serves as a carbon sink and helps with climate amelioration.
Cultural Services	The history, culture and beliefs of the Bakonzo are tied to the Rwenzori Mountains, including Kingdom rituals and management of sacred sites. *Nzururu* –

TYPE	SERVICES
	glacial ice – is the father of the spirits Kitasamba and Nyabibuya, who are responsible for the continuity and welfare of human life. Mountain climbing and snow-capped glaciers are the main tourist attractions in this landscape. Existing community-based tourism initiatives around RMNP include nature trails, eco-lodges, campsites, village walks, cultural performances and craft enterprises.

2.3.8 CLIMATE STRESSORS, RISKS, IMPACTS AND ADAPTIVE RESPONSES

Table 12 details climate stressors based on projected climate changes for Landscape 3, associated climate risks, and potential impacts to biodiversity and livelihoods. Also included are potential adaptive responses for biodiversity and livelihood impacts.

Table 12. Landscape 3 – Climate Stressors, Risks, Impacts and Potential Adaptive Responses for Rwenzori Mountains National Park (RMNP) and Surrounding Communities

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Longer dry periods	Increased incidence and spread of fires. Fire is a particular threat in the alpine zones and bogs due to drying conditions associated with climate change (Fredric, 2014).	• Death and/or dispersal of animal life. Animals that are unable to escape will die. Relocation of some wildlife beyond the PA boundaries (perhaps only temporarily). • Degradation and possible destruction of vegetation, including the fragile vegetation of the alpine zones and bogs, which provide habitat for several endemics and other species of biodiversity importance. These require significant recovery time. • Destruction of ground cover resulting in increased erosion and possibly landslides, which could result in increased siltation	• Decreased tourism revenue, tourism livelihood options and community support for RMNP. With increased incidence and spread of fires, tourism infrastructure would be at risk; this would affect income-generation potential of RMNP (UWA, 2016) and of surrounding communities, as well as community support for RMNP.[8] • Reduction of already limited livelihood options. • Fewer PA resources for community use. Plant resources used by surrounding communities could be destroyed by fire, and this could decrease community support	• As droughts intensify, rainfall patterns change and temperatures increase, the needs of substantial and increasing populations surrounding the conservation area will compel these populations to increase the cutting of trees within the conservation area, accelerate draining of wetlands surrounding the conservation area for conversion to farmland and increase poaching within the conservation area, exacerbating biodiversity impacts noted in the "Direct Impacts to Biodiversity" column.	*Responses to biodiversity impacts:* • Integrate PA fire management planning into GMPs to address fire threats. • Train PA staff in fire management/ controlled burning. • Develop and implement a habitat restoration plan with a focus on re-vegetating/restoring fragile areas. • Install automatic hydro-met monitoring stations for flood and drought early warning systems *Responses to livelihoods impacts:* • Support tourism infrastructure development at alternative, less vulnerable sites. • Support alternative tourism activities, such as cultural

8 The number of tourists visiting RMNP has been steadily increasing since the park reopened, from about 500 in 2003 to almost 3,000 in 2014 (UWA, 2016). This trend would be expected to continue; however, climate change impacts could neutralize or reverse the trend, with significant opportunity costs.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Longer dry periods		of the Semiliki River catchment, affecting fisheries and other aquatic resources, and the wildlife that rely on these species for food. • Spread of vegetation adapted to fire regimes; these are most often invasive species. (The RMNP GMP mentions no specific invasive species or invasive species management actions.) • Given the high number of endemics and restricted range species, fires and the resulting erosion and possible landslides could destroy whole populations in the RMNP.	for RMNP and increase conflict between the PA and communities. • Increased contact between humans and wildlife, resulting in disease transmission through the remains of damaged crops, injuries to domestic animals, and killing and eating of primate meat. Primates may be carriers of zoonotic diseases, such as Ebola, scabies, influenza and other viral and bacterial diseases (UWA, 2016).		tourism, birding, adventure tourism and caving. • Update sustainable use agreements between the PA and communities that take into account effects of the new fire regime on PA resources. • Promote domestication and on-farm production of those PA resources used most by surrounding communities, in particular, bamboo. • Undertake collaborative PA management for communities to access resources like water, pasture, fruits and honey during climate shocks.
Higher temperatures Longer dry periods	Reduced snow cover, disappearance of glaciers. Reduced year-round water flow in rivers and streams draining the mountain.	• Affects the hydrological cycle of the Rwenzori	• Reduced water flow in the catchment would affect: – Quality and quantity of potable water		*Responses to biodiversity impacts:* • Construct physical drainage structures and re-vegetate/restore habitat to control

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		Mountains catchment.[9] • This would adversely affect downstream habitats, aquatic biodiversity and the wildlife that rely on aquatic species for food.	available for communities; – Amount of irrigation water available for crops; – Hydroelectric power generation; – Livelihood options, especially income generation from fisheries; – Available protein source for surrounding communities (fish). • Projected disappearance of glaciers will impact tourism experience and revenue. The decline in ice cover also makes mountain guiding more treacherous and requires improved mountain safety measures. • The projected loss of glacial ice,		water flow into rivers and streams. *Responses to livelihoods impacts:* • Support payment for ecosystem services with a fund that would benefit improved catchment management and promote water conservation. • Support the development and implementation of district land use plans to better manage resources throughout the catchment. • Support water conservation and rainwater collection measures.

9 According to the RMNP GMP (UWA, 2016), field research in the 1950s by Menziel, in the 1990s by Kaser and in 2006 by Tailor indicate that the area covered by alpine glaciers reduced from 7.5 km^2 in 1906 to less than 1.0 km^2 in 2003. Within the next two decades, glaciers could disappear at the current rate of recession of approximately 0.7 km^2 per decade (Kaser, 2002, and Taylor, 2006, in UWA, 2016).

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			Nzururu, is highly significant to the traditional belief system of the Bakonzo.		
	Vegetation belts may be shifting. Animal ranges may constrict due to hotter, drier conditions. (Research into the causes of vegetation belt shifts is inconclusive.[10])	• Wildlife habitat, especially for species that prefer higher elevations, may shrink as vegetation belts move upslope. As wildlife moves upslope to preferred vegetation, they will move into habitat of other species, which could result in increased competition. Elephants and other mammals may move out of the park in search of preferable habitat, potentially coming into contact with	• Increased risk of disease transmission if wildlife move outside PA boundaries in response to fire. • Increased HWC resulting from wildlife moving outside PA boundaries. According to the RMNP GMP, communities around the park are already experiencing crop damage and loss due to wildlife roaming out of the park. Vervet monkeys, red colobus monkeys, baboons, chimps		*Responses to biodiversity impacts:* • Support development of wildlife corridors based on climate change projections of vegetation belt shifts. *Responses to livelihoods impacts:* • Support collaborative efforts between health and veterinary sectors, UWA, and the communities to monitor and control zoonotic diseases. • Scale up best measures to control wildlife

10 Shifts have been noted in the distribution ranges of some of the plant species within the RMNP. For example, Eilu and Galabuzi (2015) found *Prunus africana* was recorded as high as 2,560 meters, while *Hagenia abyssinica* now grows in a considerably wider area (100 meters up the slope and 200 meters down). In addition, the distribution of *Hypericum* spp. appeared to have reduced by 80 meters, whereas *Dendrosenencio* spp. increased by 157 meters. The distribution of *Lobelia* spp. increased by 180 meters, while *Helichrysum* spp. was recorded as high as 4,280 meters. The upward shift in the geographical ranges for some of the plant species that are commonly found growing in warmer environments could suggest that the mountain is becoming warmer. Eilu and Galabuzi state that historical climate data show that this is the trend, although available current climate data are not sufficient to suggest climate change.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		human settlements. Wildlife that live at higher altitudes would be most affected by this shift. • The Rwenzori leopard and the Rwenzori red duiker (only found in the Rwenzoris) are at risk from hotter temperatures since they usually live at altitudes above 3,000 m at colder climates (MWE, 2007, in UNDP-UNEP, 2004). • Ranges of unique species of chameleons, including the three-horned chameleon, are already at risk. Their range is shifting upwards, possibly as a result of rising temperatures. • Areas that support bamboo may be reduced.	and blue monkeys are the species most often responsible for crop damage and loss. HWC in communities adjacent to RMNP would further damage community-park relations. • Shifting vegetation belts could reduce the types and amount of plant resources used by surrounding communities.		movement outside the PA.[11] • Update sustainable use agreements between the PA and communities that take into account effects of shifting vegetation belts. • Promote domestication and on-farm production of those PA resources used most by surrounding communities, in particular, bamboo. • Support alternative tourism activities, such as cultural tourism, birding tourism, adventure tourism and caving. • Support training in first aid and other safety precautions for UWA and community tourism enterprises. • Strengthen the UWA revenue-

11 Currently, RMNP management promotes growing crops in the buffer zone that are unpalatable to wildlife, such as green pepper, onions and garlic and planting of Mauritius thorn as a live fence barrier to stop incursions. Some of these crops are successful, but with climate change, wildlife may eat these less palatable crops.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		Muhweezi (2014) notes that the bamboo die-back (possibly climate change-related) occurring in Echuya Forest (see BMCA Landscape) could occur in the Rwenzoris as well. According to the RMNP GMP (UWA, 2016), the bamboo belt is already shifting as a result of climate change.			sharing fund program to partially mitigate the loss of cultural resources.
Changes in rainfall patterns, increased intensity and number of flood events Increased amount of precipitation	Increased volumes of water flowing into the Semiliki River. Increased incidence of landslides triggered by torrential rains compounded by melting snow.	• Flooding of permanent and seasonal wetlands and possibly destruction of wetland habitats (WWF, 2015). • Destruction of vegetation, and possibly death of animals from landslides. This is especially a concern given the high number of endemics and restricted range species found in RMNP. • If drier and hotter conditions (resulting in	• Increased flood events could place tourism infrastructure at risk, leading to decreased tourism revenue, tourism livelihood options and community support for RMNP.		*Responses to biodiversity impacts*: • Construct physical drainage structures and re-vegetate/restore habitat to control water flow into rivers and streams. *Responses to livelihoods impacts:* • Support the development and implementation of district land use plans to better manage resources throughout the catchment. • Invest in rehabilitation and

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		increased incidence and spread of fires, creating bare ground) alternate with increased intensity of flood events, significant erosion and landslides could occur.			expansion of physical infrastructure and vegetation to enhance flood protection of gardens, houses and other household assets from intense rainfall events. • Support tourism infrastructure development at alternative, less vulnerable sites. • Support alternative tourism activities, such as cultural tourism, birding, adventure tourism and caving. • Construct physical and vegetation barriers to protect tourism infrastructure. • Install automatic hydro-met monitoring stations for flood early warning systems.

2.3.9 CLIMATE CHANGE RISK SIGNIFICANCE RATING

Landscape 3 – Rwenzori Mountains National Park and Surrounding Communities

CRITERIA		RATING*	NOTES
1	Importance of biodiversity	**3**	Important Bird Area, high number of endemics, endangered and rare species of regional and global importance.
2	Significance of climate change impacts on biodiversity	**3**	Changes in temperature will shift vegetation zones and, since this is a mountainous area, zones will move up and constrict, particularly affecting endemics. Loss of glaciers and water will change downstream conditions for fish and aquatic animals. With temperature rise and changing rain, fires will increase, further changing vegetation.
3	Importance of natural resources to livelihoods	**3**	The glaciers of the Rwenzori Mountains supply clean water to over 1 million people in the DRC and Uganda. Agriculture is dependent on water generation and communities' access resources under agreements. Tourism, while still not completely developed, is a more important industry in the Albertine Rift and directly dependent on the condition of the natural resources. Most communities around RMNP are agricultural for both subsistence and also cash crops such as coffee.
4	Significance of climate change impacts on livelihoods	**2**	Loss of water and changing vegetation have already caused wildlife to move outside of PAs, which increases conflicts with agriculturalists and transmission of diseases between wildlife and humans. Loss of glaciers and unique landscape will directly affect tourism income.
5	Relative impact of climate stressors compared to non-climate stressors	**2**	Non-climate stressors are as significant in this sub-landscape as climate stressors. The area is under development for mining, hydropower, harvesting of valuable trees in industrial/market development as well as poaching and other raw material extraction that go with proximity to fast-growing and relatively poor local populations.
6	Imminence of climate impacts	**2**	The extent and role of climate change is unclear. The retreat of the glaciers is documented but the nature of the area is of unique microclimates; not enough study has been conducted to know what is happening now and in the near future in other aspects.
7	Potential value in piloting adaptation response	**2**	The Rwenzoris are unique in Uganda, which could more likely provide a model; possible applications exist outside the country.
Overall Significance**		**High** (17)	**Climate change risk is moderately significant and landscape provides lower potential for implementing successful adaptive responses that could be usefully applied elsewhere.**

*Ratings: **High (3),** **Medium (2),** **Low (1)**
**Overall Significance: Sum of criteria scores; 7–10=low; 11–15=medium; 16–21=high.

2.4 LANDSCAPE 4 ANALYSIS

Bwindi-Mgahinga Conservation Area (BMCA), Echuya Central Forest Reserve (ECFR) and Surrounding Communities

REGION: ALBERTINE RIFT

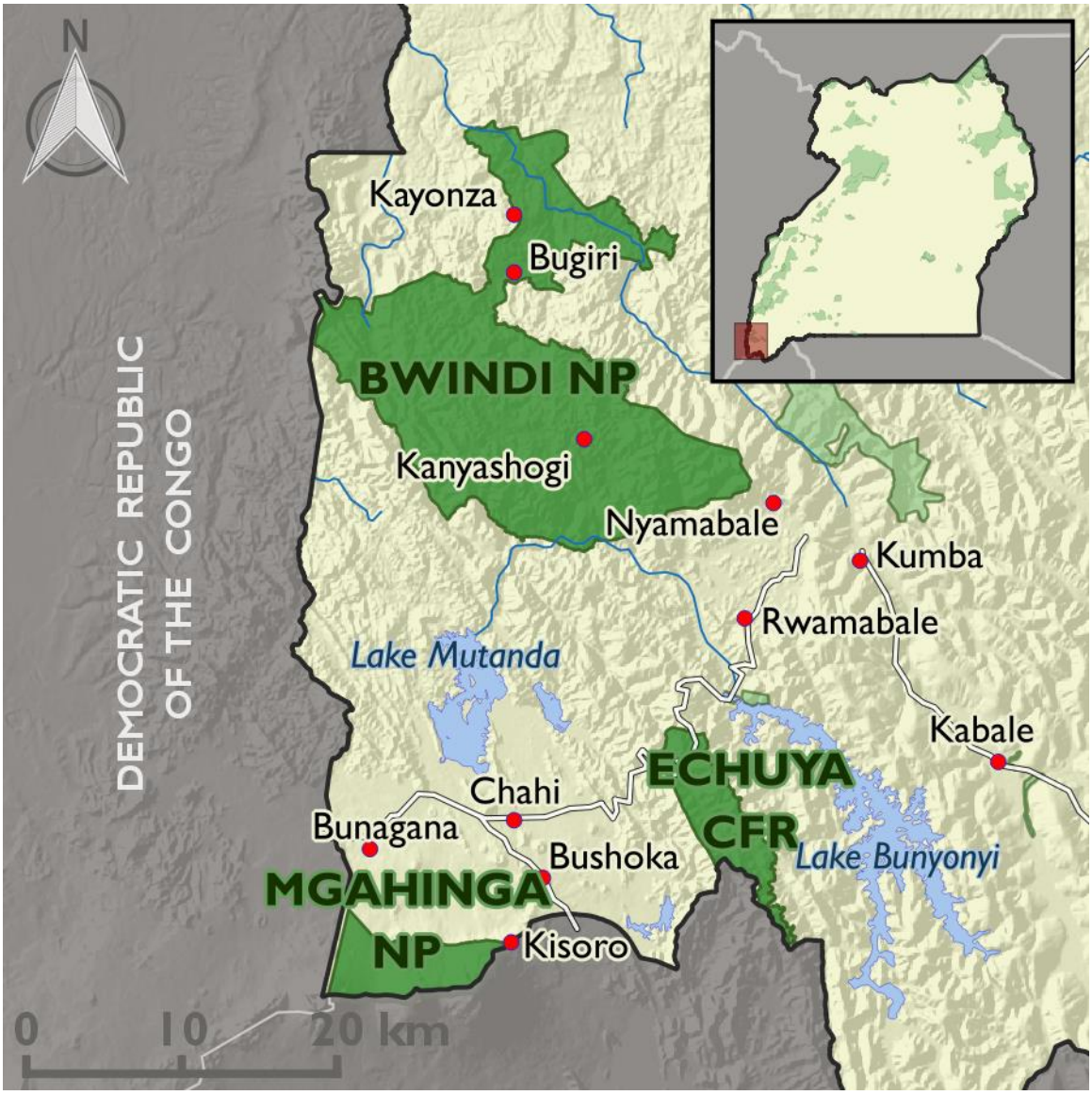


Figure 5. Landscape 4: BMCA-ECFR and Surrounding Communities

2.4.1 LOCATION AND DESCRIPTION

UWA has placed Bwindi Impenetrable National Park (BINP) and Mgahinga Gorilla National Park (MGNP) under one management unit, referred to as Bwindi-Mgahinga Conservation Area (BMCA). BINP, a World Heritage site, consists of a large primeval forest covering an area of 3,270 km^2; MGNP is 33.7 km^2. Echuya Central Forest Reserve (ECFR), encompassing 40 km^2, is considered the most important forest in Uganda for its rare flora and fauna.

2.4.2 UNIQUE CLIMATE CHARACTERISTICS

Annual precipitation in BINP ranges from 1,130 mm to 2,390 mm. The heaviest rains occur from March to April and September to November. The coldest period is June to July. Overall temperatures range from about 7°C to 20°C. The Mgahinga area is characterized by two rainy seasons, March to April and September to December, and two dry seasons, January to February and May to August. The Virunga Mountains (which include Mgahinga), generally receive higher rainfall than the surrounding areas. MGNP temperatures range from 4°C at the highest elevations to 18°C at the lowest points (UWA, 2008).

2.4.3 CLIMATE PROJECTIONS

Using Albertine Rift-wide data, projections by 2050 include (Seimon and Phillipps 2011):

- Rising temperatures.
- Variability in rainfall seasonality, with slight decreases in monthly rainfall averages; when combined with warming trends, could be indicative of increasing threat of drought.
- Increase in rainfall by 2050 and beyond.

2.4.4 NON-CLIMATE STRESSORS

- *Population pressure*. The 1991 population census indicated densities at 301 people/km^2 in Kisoro District, 246 people/km^2 in Kabale District and 151 people/km^2 in Rukungiri District. These densities are higher in some areas immediately adjacent to the parks. For example, a density of 639 people/km^2 was recorded for Gisozi Parish, 330 people/km^2 for Rukongi Parish and 274 people/km^2 for Gitenderi Parish, all adjacent to MGNP. Population density is much higher now, given the estimated annual average increase since 1991 of about 2.7 percent in the three districts around BINP and 3.5 percent in Kisoro District. Dependence on park resources has increased with a growing population; illegal access for hunting, logging and plant collection has risen.
- *Land shortage, coupled with intensive use for subsistence agriculture without any buffer zone*. With increased population, there may be increased pressure to remove the area's protected status and convert it to agriculture and other uses.
- *Fuelwood and other resource use*. The communities around BMCA account for the highest consumption of wood for fuel in Uganda.
- *Unsustainable agriculture practices*. Low use of inputs, in combination with the growing, unskilled population, results in increasing demand for productive land to grow crops.

2.4.5 BIODIVERSITY RESOURCES OF IMPORTANCE

Biodiversity resources of importance for Landscape 4 are found in Table 13. Of note, approximately 880 mountain gorillas remain and are located in two isolated populations in Central/East Africa. One is the Virunga Volcanoes region of Rwanda and the MGNP. The other is the Democratic Republic of the Congo and BINP (McGahey et al., 2013).

Table 13. Landscape 4 – BMCA-ECFR Landscape Biodiversity Resources

AREA	HABITATS	SPECIES
BINP	• Large primeval forest[12] covering 327,000 hectares. • Vegetation is a continuum from lowland in the north to montane forest in the southern sector (2,607 m). • Forest is broadly classified as medium altitude, moist evergreen and high altitude forest. • Over 200 tree species identified, 10 of which occur nowhere else in Uganda; 17 others have a limited distribution in the country.	• Home to 120 species of mammals, 346 species of birds, 310 species of butterflies and 27 species of frogs. • Endangered species include mountain gorilla, chimpanzee, Demidoff's galago and needle-clawed galago. • Elephants in the southern sector, but reduced by poaching. • Other southern sector species include: bush pig, giant forest hog, black-footed duiker, yellow-backed duiker, clawless otter, side-stripped jackal, civet, genet and numerous bat and rodent species.
MGNP	• 4,750 hectares, of which approximately 3,000 hectares are forest. • Only a small area of pure montane forest remains (at base of Mt. Muhabura) due to encroachment in the 1950s. • Bamboo zone (*Arundinaria alpine)* located above the mountain forest belt.	• Thirty-nine recorded mammal species, but possibly 89 species occur in park. • Larger mammals include mountain gorilla, buffalo and elephant. The rare golden monkey and the blue monkey are found in MGNP. • Seventy-nine recorded bird species, including several endemic to the East Congo Montane region.
ECFR	• Encompasses 4,000 hectares. • Includes a permanent high altitude swamp, Muchuya, which stands at 2,300 m in a narrow valley surrounded by steep forested hillsides.	• High species diversity, including 152 bird species, 18 of which are endemic to the reserve; 54 butterfly species, 43 moth species and 127 species of trees and shrubs, some of which are endangered.

Sources: UWA, 2008

2.4.6 LIVELIHOODS OF IMPORTANCE

Subsistence farming is the most common livelihood in this landscape, with some livestock and banana, tea and, to a lesser extent, coffee planted as a cash crop. Above 1,800 meters, only annual crops are planted, mainly sorghum, sweet potatoes, millet and Irish potatoes; on higher slopes, peas and wheat are planted. Irish potatoes, peas and wheat are also important cash crops. Cultivated land covers most hilltops. Wetlands have been drained to grow crops; very little of the original forest outside the parks still remains.

To a lesser extent, communities adjacent to these national parks rely on ecotourism, with most activities connected to the two national parks and less so to ECFR, which is starting to become a popular tourist destination. However, according to the BMCA GMP, except for the two community campgrounds located at Buhoma in Bwindi and at Ntebeko in Mgahinga, little

[12] Afromontane forest according to UWA (2008).

attempt has been made to help the communities adjacent to BMCA play a larger role in tourism, though UWA makes a concerted effort to hire many of the staff involved in gorilla tracking from the adjacent communities.

2.4.7 ECOSYSTEM SERVICES

Ecosystem services of importance for Landscape 4's biodiversity and livelihoods are found in Table 14.

Table 14. Landscape 4 – BMCA-ECFR Landscape Ecosystem Services

TYPE	SERVICES
Provisioning Services	The surrounding communities, particularly the indigenous forest Pygmies, the Batwa, have requested access to fish in the Ivi and Ishasha Rivers within BINP. The Batwa have also requested access to harvest wild yams and wild honey from BMCA. These requests by the Batwa have been rejected because of the unsustainable ways of harvesting these resources (UWA, 2008). Communities around BINP have requested access to park streams for clean water: the Buhoma community accesses water from a stream in the park, and Rubuguri, in the southern part of BINP, has a water supply system with intake and reservoir in the park. The ECFR is a crucial livelihood resource for the surrounding densely populated communities, who depend on it for fuel, water, soil conservation, and building and handicraft materials. Bamboo from the ECFR is used as live fencing material, for construction, in handicrafts and for furniture. Its range of other uses is just becoming known in Uganda, such as pipe for irrigation and in stoves for fuel.
Regulating Services	Due to the extremely porous soils in parishes adjacent to MGNP, communities often face water shortages. UWA and partners rehabilitated the Kabiranyuma gravity water scheme (originally built in the 1950s) to supply water to about 35,000 people living in nine parishes at the base of MGNP. The water is drawn from a permanent swamp in a saddle between Muhabura and Gahinga Volcanoes. Water collection from Rugezi swamp (saddle between Sabyinyo and Gahinga) supplies water to Ntebeko village (UWA, 2008) In the saddles between MGNP's three volcanoes are swamps that retain water year-round. River Kabiranyuma drains the swamp, is an important source of water for the surrounding population, and is the only river that does not dry up completely in the driest months of June to August.
Cultural Services	Most tourism activities are connected to the two national parks and less so to ECFR, though it is now starting to become a popular tourist destination. The effect of climate change on mountain gorillas is uncertain, but if mountain gorillas disperse, tourism revenue could be adversely affected. Since BINP provides much of the budget for the UWA PA system, revenue for all PAs would decline. This could have a significant impact on the entire PA system of Uganda and the wildlife therein. Impacts to gorilla tourism will affect the entire PA network in Uganda, not only the BMCA; tourism revenue is pooled at UWA Headquarters from where it is disbursed back to PAs. MGNP provides cultural resources to the Batwa.

2.4.8 CLIMATE STRESSORS, RISKS, IMPACTS AND ADAPTIVE RESPONSES

Table 15 details climate stressors based on projected climate changes for Landscape 4, associated climate risks and potential impacts to biodiversity and livelihoods. Also included are potential adaptive responses for biodiversity and livelihood impacts.

Table 15. Landscape 4 – Climate Stressors, Risks, Impacts and Potential Adaptive Responses for Bwindi-Mgahinga Conservation Area (BMCA), Echuya Central Forest Reserve (ECFR) and Surrounding Communities

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Decreased precipitation Longer dry periods	Increased incidence and spread of fires due to higher temperatures and less precipitation.	• Animals unable to escape fires will die; some will be temporarily or permanently relocated beyond the PA boundaries. • Destruction of ground cover, resulting in increased erosion and possibly landslides, which could result in increased siltation of streams, rivers and wetlands, including the swamps that hold water year-round, affecting fisheries and other aquatic resources, and the wildlife that rely on these species for food. • Fires could destroy whole populations in BMCA and the ECFR, especially those with restricted ranges.	• Decreased quality of tourism experience, revenue and tourism livelihood options. If mountain gorillas and other wildlife disperse, tourism revenue would decrease, and this would affect livelihoods of local people who rely directly and indirectly on tourism.[13] • Fewer PA resources for community use. Plant resources used by surrounding communities could be destroyed by fire, and this could decrease community support for the BMCA and ECFR and	Given the extremely small size and unique climatic, topographic and ecological characteristics of the MGNP, encroachment by humans into the park have grave implications for the endangered mountain gorilla. If climate change causes human populations living adjacent to the park to encroach upon the park to extend farming for example, this will put substantial pressure on the gorilla population, forcing gorillas into smaller and potentially unviable habitat within MGNP and/or permanent migration into adjoining protected land in Rwanda. Such encroachment also will exacerbate other biodiversity impacts noted in the “Direct	*Responses to biodiversity impacts:* • Integrate PA fire management planning into GMPs to address fire threats, and include PA staff training and real-time fire monitoring in gorilla habitat. • Develop and implement a habitat restoration plan with a focus on re-vegetating/restoring fragile areas. • To raise revenue for the PA system, support gorilla habituation and diversify the tourism products of BMCA to be compatible with the potential impacts of climate change. • Integrate climate screening into

13 Assuming all days and groups are booked, each gorilla group could generate more than US$1 million a year (Onsite interview, Gladys Kalema, August 2016, supported by calculations of cost/gorilla permit x 8 permits per day, per group x 365 days). Currently, 11 groups are allowed per day, with eight permits allowable per group. A permit is currently US$600 for foreign non-residents and US$500 for foreign residents). There is some criticism of how much ecotourism benefits local people. A study in MGNP found that the amount of revenue from gorilla tourism that reaches local communities was not enough to counteract the effects of a loss of farming and grazing land and access to the forest (Adams and Infield, 2003 in Carr et al., 2013). But as tourism numbers increase, community tourism’s share grows as well. Therefore, the future potential for community benefit from tourism could be reduced.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Decreased precipitation Longer dry periods Higher temperatures			increase conflict between the PAs and communities. • Increased disease transmission between people and wildlife as wildlife are forced from the PA. • Decreased revenue in the community revenue-sharing program.	Impacts to Biodiversity" column.	existing gorilla health monitoring programs. *Responses to livelihoods impacts:* • Support alternative tourism activities, such as adventure and cultural tourism, caving, hot springs and water-based activities on lakes. • Update sustainable use agreements between the PAs and communities that take into account effects of the new fire regime on PA resources. • Promote domestication and on-farm production of PA resources used most by communities (e.g., bamboo). • Support collaborative efforts between health and veterinary sectors, UWA and the communities to monitor and control zoonotic diseases. • Undertake collaborative PA

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Decreased precipitation Longer dry periods					management for communities to access resources like water, pasture, fruits and honey during climate shocks.
	Reduced water in wetlands, rivers and streams. Wetlands may dry up and rivers and streams will have lower flow.	• Adverse effects on aquatic life that relies on these resources. • Impacts on wildlife whose diet comprises aquatic resources. • Shift in bamboo cover and bamboo die-back in ECFR linked to an increase in temperature and lower water table.	• Reduced water flow in the catchment, which would affect: – Quality and quantity of potable water available for communities – Amount of irrigation water available for crops – Hydroelectric power generation – Livelihood options, especially income generation from fisheries – Available protein source for surrounding communities (fish resources) • Water provision projects, current and future, could be at risk due to		*Responses to biodiversity impacts:* • Construct physical drainage structures and re-vegetate/restore habitat to control water flow into rivers and streams. *Responses to livelihoods impacts:* • Support payment for ecosystem services with a fund that would benefit improved catchment management and promote water conservation. • Support the development and implementation of district land use/watershed management plans to better manage resources throughout the catchment. • Construct physical and vegetation

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			reduced water in the catchment. This could affect PA relations with surrounding communities. • Reduced livelihood options. In addition to losing income generation from tourism, communities dependent on fisheries resources, particularly the already marginalized Batwa, could be further affected due to reduced flow in this landscape's waters. • If mountain gorillas and other wildlife move outside PA boundaries in search of water, increased HWC is likely.[14]		barriers to control erosion and sedimentation of streams and rivers. • Support environmentally sound alternative livelihood options, such as fish farming and community tourism activities. • Support measures to mitigate HWC, such as construction of live or electric fences, creation of crop protection groups (human-gorilla conflict resolution), planting of more palatable food in the BMCA, creating a buffer zone managed by the park and communities that discourages crossing to farmers' fields and also benefits the community by planting subsistence and cash crops that are

14 Settlements and gardens abut BMCA boundaries, and communities surrounding BMCA already experience extensive crop damage from gorillas, monkeys and elephants. Some gorilla groups spend more time in people's gardens than in the forest. Other wildlife species implicated in HWC around BMCA are porcupines, chimpanzees, buffalo, baboon, vervet monkeys and bush pigs.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					unpalatable to gorillas.
	A large upward displacement of species ranges and vegetation zones of approximately 600–700 m relative to 1990 levels.[15]	• Sensitive species will try to migrate toward available and preferable habitat and food sources, and if unable to adapt, they may die. • An increase in temperature and lower water table is linked to a shift in bamboo cover and bamboo die-back in Echuya Forest. Shift of the bamboo belt and bamboo die back are likely to increase in ECFR and to be seen in BMCA as well.	• Disease transmission is expected to increase due to animals moving outside PA boundaries in search of preferred habitat. • HWC is expected to increase due to shifts in species ranges and vegetation zones (in part attributed to climate change). • Fewer PA resources for community use. Plant resources such as *Smilax anceps* (enshuli) from BMCA used for craft making are likely to be adversely affected by shifting vegetation belts. Bamboo, with its many uses, many of which are only now becoming known and popular, will also		*Responses to biodiversity impacts*: • Support development of wildlife corridors based on climate change projections of vegetation belt shifts. *Responses to livelihoods impacts:* • To raise revenue for the PA system, support gorilla habituation and tourism diversification to strengthen and diversify the tourism products of BMCA compatible with the potential effects of climate change on biodiversity resources. • Support efforts to address disease transmission. • Support efforts to manage HWC. • Promote domestication and

[15] According to the Wildlife Conservation Society, more detailed species distribution models are needed to confirm this.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			be adversely affected by shifting vegetation zones. Fewer resources for community use could decrease community support for BMCA and ECFR and increase conflict between the PAs and communities.		on-farm production of those PA resources used most by surrounding communities, in particular, bamboo. On-farm production of bamboo would minimize incursions into BMCA and ECFR to harvest already stressed bamboo resources.
	Increased disease incidence.	• Increased gorilla (and possibly other animals) morbidity and mortality. (Onsite interview, August 2016.)	• With increased disease incidence in wildlife, mountain gorillas in particular, disease transmission from gorillas to people is more likely to occur.		*Responses to biodiversity impacts*: • Support UWA to monitor disease incidence in mountain gorilla populations and community animal health workers to monitor and treat zoonotic diseases in communities to minimize potential for transmission. *Responses to livelihoods impacts:* • Support efforts to address disease transmission (see above).

2.4.9 CLIMATE CHANGE RISK SIGNIFICANCE RATING

Landscape 4 – Bwindi-Mgahinga Conservation Area (BMCA), Echuya Central Forest Reserve (ECFR) and Surrounding Communities

CRITERIA		RATING*	NOTES
1	Importance of biodiversity	**3**	Mountain gorilla habitat; high species diversity in all families; high endemism; regional and global importance. Echuya Forest is unique with unusual ecosystems and endangered and endemic species.
2	Significance of climate change impacts on biodiversity	**2**	As in Rwenzori and elsewhere in Albertine Rift, upward shifts in vegetation zones with temperature rises and decreases in rain or increases in its variability may also result in and worsen fires.
3	Importance of natural resources to livelihoods	**3**	All populations in the area are directly dependent on natural resources for subsistence. Farming is mostly subsistence with precarious sustainability; most land outside of the PAs is already cleared and farmed.
4	Significance of climate change impacts on livelihoods	**2**	Less reliable water and PAs that suffer in quality would provide fewer resources to local populations who access these both legally and illegally. Loss of gorilla habitat would be a major stress on local population income. Loss of habitat would greatly increase human-wildlife interaction and spread of disease (in this case with gorillas).
5	Relative impact of climate stressors compared to non-climate stressors	**1**	Non-climate stressors, particularly population growth, the shortage of productive land outside of the PAs and poor agricultural practices, are currently more significant in this sub-landscape than climate stressors.
6	Imminence of climate impacts	**2**	The extent and role of immediate climate change and its effects on the gorilla population are unclear.
7	Potential value in piloting adaptation response	**1**	No other comparable sub-landscapes exist in Uganda. However, as gorilla tourism plays a very prominent role in Uganda tourism image and revenue generation, success here could have major positive repercussions, even if there is less utility as a model for Uganda.
Overall Significance**		**Medium** (14)	**Climate change risk is less significant and landscape provides moderate potential for implementing successful adaptive responses that could be usefully applied elsewhere.**

*Ratings: **High (3),** **Medium (2),** **Low (1)**
**Overall Significance: Sum of criteria scores; 7–10=low; 11–15=medium; 16–21=high.

2.5 LANDSCAPE 5 ANALYSIS

Queen Elizabeth Protected Area (QEPA), Murchison Falls Protected Area (MFPA) and Surrounding Communities

REGION: ALBERTINE RIFT

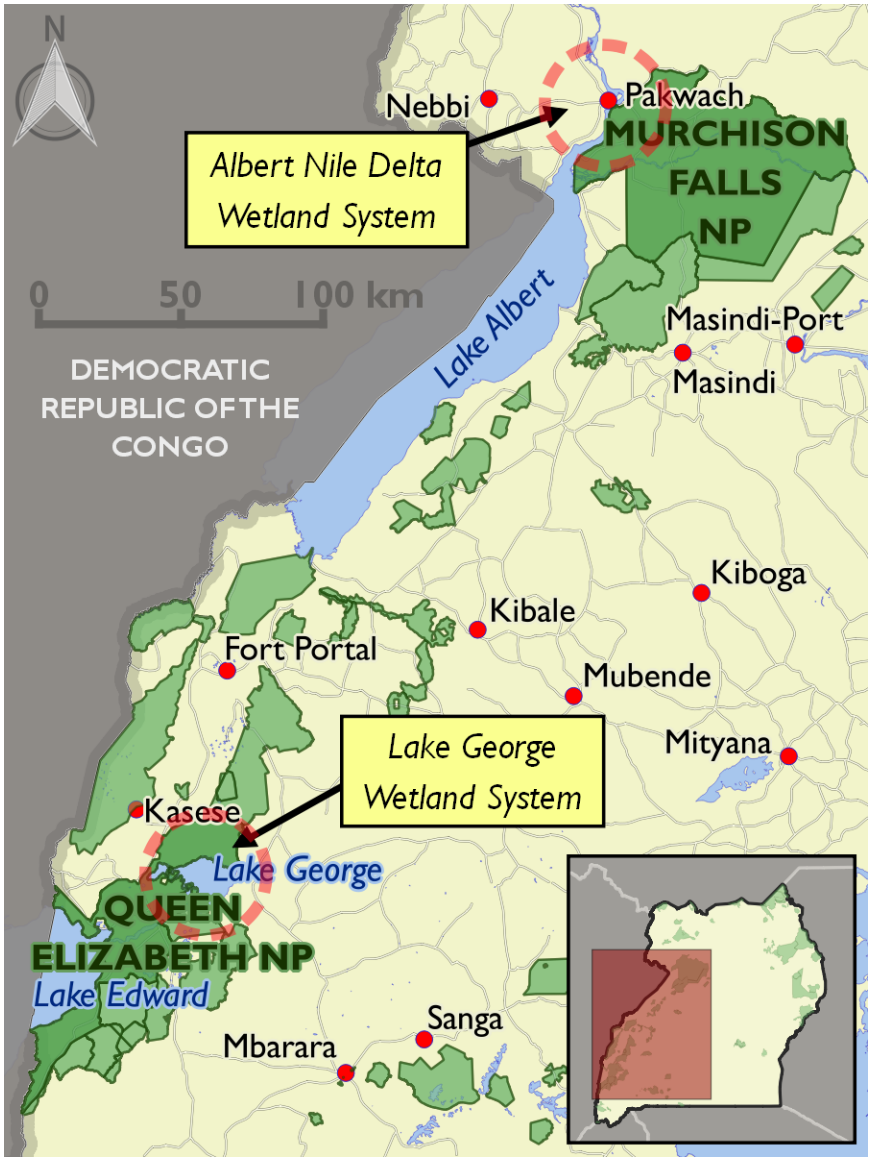


Figure 6. Landscape 5: QEPA-MFPA and Surrounding Communities

2.5.1 LOCATION AND DESCRIPTION

This landscape is composed of two core sites. A biodiversity hotspot, the Queen Elizabeth Protected Area (QEPA) includes Queen Elizabeth National Park (QENP) and Kyambura and Kigezi Wildlife Reserves (WRs) together with the Lake George wetland system. QEPA covers 223,000 hectares. Lake George, a shallow equatorial lake, has around its fringe a wetland designated in 1988 as Uganda's first Ramsar Site. Most of the wetlands around the lake are included within QENP but the open water of the lake is not part of the park.

Murchison Falls Protected Area (MFPA) includes Murchison Falls National Park (MFNP) and Karuma and Bugungu WRs and the Albert Nile Delta wetland system (a Ramsar Site). MFNP covers 39,000 hectares. In the west is Karuma WR; to the south, Bugungu WR. A large medium altitude, semi-deciduous forest, the Budongo Forest Reserve (FR), overlaps with the two WRs. Murchison Falls-Albert Nile Delta wetland system stretches from the top of Murchison Falls, where the River Nile flows through a rock cleft, to the delta at its confluence with Lake Albert. MFPA and the associated Ramsar Site support endangered, rare, endemic and threatened species of flora and fauna.

2.5.2 UNIQUE CLIMATE CHARACTERISTICS

This landscape has a savanna tropical climate with moderate average temperatures of 28°C and high mean annual rainfall of over 1,200 mm. At locations situated near the equator (e.g., the Greater Virunga Landscape), the two rainy seasons are centered on May and September. North of the equator, around MFPA (approximately 0.5°–2° north), a bimodal rainfall pattern exists, but the shifts between wet and dry periods are less pronounced than at QEPA (Carr et.al., 2013).

2.5.3 CLIMATE PROJECTIONS

Using Albertine Rift-wide data,[16] projections by 2050 include (Seimon and Phillips, 2011):

- Rising temperatures.
- Variability in rainfall seasonality, with slight decreases in monthly rainfall averages; when combined with warming trends, could be indicative of increasing threat of drought.
- Increase in rainfall by 2050 and beyond.

2.5.4 NON-CLIMATE STRESSORS

- *Population pressure*. The high population growth rate in the areas adjacent to QEPA and MFCA, and in the Albertine Rift in general, has already resulted in a shortage of affordable land for agricultural production. Over 3 million people live in the districts surrounding the QEPA-Lake George Ramsar Site landscape and adjacent PAs (UBOS, 2014), and they place significant pressure on PA resources, including demand for land, water, timber and non-timber forest products, and bushmeat.
- *Mining*. Extraction of copper, cobalt, limestone and gold results in contaminated drainage and associated wastes containing heavy metals, which are contaminating PA waters.

[16] Weather data are collected on a quarterly basis from automatic weather stations installed at different altitudes in RMNP; however, no projections specific to RMNP are available.

- *Limestone quarrying*. The current extraction site lies along a migratory corridor used by elephants moving between QEPA and Kibale National Park.
- *Hydropower generation*. MFNP is a target for hydropower development on the waterfalls along the River Nile that will involve land takes, contributing to fragmentation, reduced wildlife habitats and interference with corridors (USAID, 2015).
- *Oil exploration and drilling*. Exploration and production activities have several associated negative impacts including: land take for drill sites, camps, seismic surveys, drilling and road networks; habitat/niche destruction; increased human and vehicular traffic; and noise from heavy machinery. Although mitigation is included in oil exploration and drilling plans, these activities will impact wildlife behavior and distribution.
- *Fishing village settlements*. Human populations in the fishing villages are growing. In 1999, the total population was estimated at 30,000 (UWA 2015a). By 2011, the population was estimated at 80,000. This not only places more pressure on fish resources, it also exerts more pressure on other park resources such as wood for fuel, grass, poles, wildlife hunted for food, and medicinal plants. Waste management in fishing villages has also been a challenge and degrades water quality and land.
- *Overharvesting of wetland products and conversion of wetlands*. Unsustainable harvesting of papyrus and ambatch, overexploitation of fish, and drainage and filling of wetlands compound the effects on wetlands of climate change.
- *Poaching*. Poaching is the main problem affecting wildlife populations in the Albert Nile Delta wetland system.
- *Human-wildlife conflict*: Although HWC can be attributed partly to impacts related to climate change (spread of invasive species), HWC around QEPA and MFPA is also attributed to population increase, agricultural plots that abut the PAs and blocked animal migration corridors. In QEPA, bush pig, olive baboon, elephant, buffalo, lion, hyena, crocodile and hippo are most often implicated in HWC. The areas most affected by elephants are 1) the Kyambura corridor between Kashoyi-Kitomi and Kyambura WR in Kyabakara and Katerera, and 2) in the southeast around Kigezi WR and Kichwamba escarpment. Crocodile attacks on fishermen and women and children collecting water are common in Katwe and Kabatoro fishing villages on the shores of Lake Edward. Attacks on livestock by wildlife are a concern in the fishing villages of Kasenyi, Hamukungu, Katwe, Kabatoro, Kahendero and Katurungu. Areas commonly affected by elephant crop raiding are communities to the north of MFNP and on the eastern boundary (UWA, 2013). Crops affected include mainly cassava, maize, rice, sweet potatoes, jack fruit and sugarcane.

2.5.5 BIODIVERSITY RESOURCES OF IMPORTANCE

Biodiversity resources of importance for this landscape are found in Table 16.

Table 16. Landscape 5 – QEPA-MFPA Landscape Biodiversity Resources

AREA	HABITATS	SPECIES
QEPA	• Lies on the convergence zone of two distinct vegetation types: the Central African rainforest and East African grassland biomes. • Range of diverse habitats, including open grassland, grassland with thickets, thick bush, forests, wetlands and 250 km of lakeshore. • Vegetation within the Lake George Ramsar Site consists of grassland, woodland and three major swamp types: papyrus, reeds and grass. Papyrus swamps edged by hippo grass are the dominant wetland type.	• Over 96 species of mammals, including 10 primate species (e.g., chimpanzee, elephant, hippopotamus, buffalo) and 10 predator species (e.g., lion, leopard, hyena). • With over 610 bird species, QEPA supports more than half of Uganda's recorded bird species. • The UWA wildlife censuses of 2006 and 2010 showed a decline in all large mammal populations in QEPA. This was partly attributed to changes in habitats and increased poaching. Although wildlife surveys in 2014 noted increases in the large mammal populations in QENP, elephant and Uganda kob are still declining. • Lake George Ramsar Site supports: – Fauna including elephant, hippopotamus and antelope. – Over 150 species of birds, including the rare saddle-billed stork, wintering Palaearctic water birds and 7 species endemic to papyrus ecosystems. – More than 50 species of fish including tilapia, catfish, lungfish, the electric fish and cichlid. – Two species of rare plants, the cycad and a sedge that are found only at Lake George and in the Kigezi region of southwestern Uganda.
MFPA	• Situated at the northwestern point of the Albertine Rift, consisting of forest, savanna, wetland and shrubland. • Only PA where the tall grass savanna of the Albertine Rift is extensively represented. • The park is the main representation of the Sudanian vegetation form in East Africa, characterized by a mosaic of woodlands often dominated by red bushwillow trees (*Combretum caffrum)* and *Acacia* species extending from Senegal to Ethiopia. • Albert Nile Delta wetland system Ramsar Site is dominated by papyrus swamps on both sides of the Victoria Nile.	• Home to 76 species of mammals, including huge herds of buffalo, increasing elephant populations, leopard, a healthy population of lion, giraffe, hippo and Uganda kob. Also home to the largest population of Jackson's hartebeest in Uganda, a species drastically reduced or entirely eliminated in other Ugandan PAs. • Six species of primates, of which the savanna-dwelling patas monkey is found only in MFNP and KVNP. • The rare soft-shelled turtle is found in MFNP. • Many indigenous and endemic fish species in Lake Albert.[17]. • The stretch of river between Murchison Falls and the Delta has one of the highest concentrations of Nile crocodile in the world and the last viable breeding populations in Uganda of Nile crocodile and Rothschild's giraffe. The wetlands are inhabited by numerous species of water-dependent mammals such as the hippopotamus, kob, waterbuck and Nile lechwe (*Kobus megaceros*). • Due to its large size and wide range of habitats, the Murchison Falls-Albert Nile Delta wetland system supports over 460 species of birds. The Lake George and Murchison-Albert Nile Delta wetlands and watercourses are a major flyway for birds migrating between the Mediterranean Sea and Europe and the equatorial region of Lake Victoria and the Rift Valley lakes.

Sources: UWA, 2015a; Mafabi, P., 1996; UWA, 2013

2.5.6 LIVELIHOODS OF IMPORTANCE

Tourism is important to livelihoods in this landscape. QEPA and MFCA wetlands, lakes and river habitats are some of the most popular tourist destinations. As UWA remits 20 percent of the revenue collected from park entrance to local governments, losses could impact relationships between the PAs and local communities.

QENP was designated as a UNESCO Man and Biosphere Reserve in 1979 in recognition of the role it plays in providing an opportunity to explore and demonstrate approaches to biological diversity conservation alongside sustainable resource utilization in the 13 fishing enclaves on Lakes George and Edward and the Kazinga Channel. Fishing is for both subsistence and commercial use; fish are sold in the neighboring and regional urban areas in the surrounding districts and exported to the DRC. About 18,000 fishermen are involved in the fishing business on Lake Albert.

Plantains and cassava are the main subsistence crops grown in the landscape.

2.5.7 ECOSYSTEM SERVICES

Ecosystem services of importance for this landscape's biodiversity and livelihoods are found in Table 17.

Table 17. Landscape 5 – QEPA-MFPA Landscape Ecosystem Services

TYPE	SERVICES
Provisioning Services	The swamps, rivers and lakes of this landscape are used as a source of water supply for domestic and livestock use and crop production. The PAs and the Ramsar Sites supply many materials and resources for surrounding communities. As required by statute, resource use in the PAs is only allowed once an assessment is completed to determine the availability of the resources within the target area, the amount of offtake that is sustainable, and the ability of PA management and the community to effectively control resource use. Based on the assessment, communities may use PA resources such as papyrus for construction material and for making mats, baskets and fuel briquettes; sediment from wetlands for brick making; dead wood for firewood; medicinal plants; and the plant, ambatch, by fishermen as buoys.
Regulating Services	The Murchison Falls wetland system purifies and maintains water quality by retaining sediments and nutrients from runoff from the escarpments down the Rift Valley. It also helps to control floods during rainy seasons, releasing water slowly to Lake Albert and the Albert Nile. Despite strong seasonal variation in rainfall, storage of water in the extensive wetlands of the Albertine Rift helps to maintain year-round flow in the River Nile and provides water to the communities living within the landscape. The Murchison Falls-Albert Nile Delta wetland system is an important spawning and breeding ground for Lake Albert fisheries. The system contains many indigenous and endemic fish species, several of which are related to the lower Nile species. The fish fauna of Lake Albert are different from that of Lakes Victoria and Kyoga because Murchison Falls is a barrier to fish distribution. The Murchison Falls wetland system therefore supports important endemic fish species of conservation interest. It forms a feeding and watering refuge for wildlife in MFNP during the dry season.
Cultural Services	QEPA and MFPA are the two most visited tourist destinations in Uganda. The two parks are known for game viewing and boat rides on the Kazinga Channel and River Nile, respectively. MFNP has been proposed for UNESCO World Heritage status. The tourism and recreation sector employs people from local

TYPE	SERVICES
	communities, who operate and work in lodges, provide crafts, food, and cultural services to the lodges and directly to tourists as part of community tourism, and provide guiding services.

2.5.8 CLIMATE STRESSORS, RISKS, IMPACTS, AND ADAPTIVE RESPONSES

Table 18 details climate stressors based on projected climate changes for Landscape 5, associated climate risks, and potential impacts to biodiversity and livelihoods. Also included are potential adaptive responses for biodiversity and livelihood impacts.

Table 18. Landscape 5 – Climate Stressors, Risks, Impacts and Potential Adaptive Responses for Queen Elizabeth Protected Area (QEPA), Murchison Falls Protected Area (MFPA) and Surrounding Communities

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
Higher temperatures Decreased precipitation Longer dry periods	Increased incidence and spread of fires.	• Fire will directly affect wildlife by killing animals that are unable to escape and by destroying habitat, especially of species with highly specific niches. • While most grazers, such as Uganda kob, thrive when fire stimulates new grass shoots for grazing, drier and hotter conditions would mean that vegetation will take longer to return and bare ground will remain for longer periods, adversely affecting grazers.	• Decreased revenue and quality of tourism experience due to increased dispersal of wildlife and decreased number of animals within the PAs. • Fewer PA resources for community use. PA resources could be destroyed due to increased incidence and spread of fires; communities that rely on these resources will be affected; and community support for the PAs could decrease.	• As droughts intensify, rainfall patterns change and temperatures increase, undercutting traditional pastoralist, fishing and farming livelihoods practiced, populations will be compelled to accelerate draining of wetlands and cutting of trees, both adjacent to PAs and to encroach on the PAs themselves, exacerbating biodiversity impacts noted in the "Direct Impacts to Biodiversity" column.	*Responses to biodiversity impacts:* • Integrate PA fire management planning into GMPs to address fire threats. • Train PA staff in fire management/ controlled burning. *Responses to livelihoods impacts:* • Support tourism infrastructure development at alternative locations, where wildlife congregates. • Support domestication/on-farm production of resources used by communities. • Update sustainable use agreements between the PAs and communities that take into account effects of the new fire regime on PA resources. • Undertake collaborative PA management for

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
					communities to access resources like water, pasture, fruits and honey during climate shocks.
	Spread of invasive species due to hotter, drier conditions that favor colonization by invasive species, mainly bush and woodland encroachment into savanna habitats.[18]	• Reduction of palatable rangeland, with impacts on wildlife ecology and population dynamics. Invasive species include: – *Lantana camara,* an invasive species that displaces grassland and is resilient to dry conditions; – *Imperata cylindrica*, which germinates quickly after fire and flowers early to seed the soil, and for which older plants are unpalatable to grazers; and	• Increased HWC. Although many HWC incidents in QEPA and MFPA are from reasons other than climate change (see Non-Climate Stressors), the spread of invasive species is transforming savanna habitat to bush and woodland, causing wildlife, especially grazers, to move outside PA boundaries to find palatable food (USAID, 2015). • Increased disease transmission. Livestock numbers in the communities around QEPA and in the fishing villages have been increasing. If wildlife moves outside PA		*Responses to biodiversity impacts:* • Scale up promising invasive species management measures. *Responses to livelihoods impacts:* • Scale up promising HWC management interventions such as beekeeping along PA boundaries, chili growing and spraying, and unpalatable cash crops (coffee, tea and trees). • Support key wildlife corridors around QEPA and MFNP. This would involve re-establishing wildlife corridors and initiating collaborative partnerships with the private sector

18 Already, bush has colonized a large part of the southern area of the MFNP and Karuma Reserve, making these areas uninhabitable for some species, such as the Uganda kob, which require open areas for breeding (Onsite interview, October 2015). Many parts of northern QEPA are being overtaken by invasive species.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		– *Maerwa documens,* which is resistant to fire and drought, is widespread and reduces forage for herbivores. [19]	boundaries in search of pasture, direct contact between wildlife and livestock could result in increased disease transmission. This is already occurring, and has resulted in death of livestock. • *Parthenium hysterophorus* (congress weed) coverage is increasing, linked to drier soil conditions due to increases in temperature, a lowered water table and high-intensity fires. While most invasive species listed here reduce palatable rangeland and affect wildlife ecology and population dynamics, this species is a public health concern because it can		and communities to manage the corridors through tourism-based enterprises; entering into management agreements with local communities for establishment of conservancies; and collaborative management of wildlife in the corridors. • Support district veterinary officers to monitor and manage diseases transmissible from wildlife to livestock.

19 Dense growths of *Lantana*, associated with *Acacia*, are taking over Ishasha sector (QEPA, and the northern parts of QEPA in Nyamugasani, Kamulikwizi and Nyakatonzi areas. *Lantana camara* is mainly dispersed by birds though it may also be dispersed by cattle that graze illegally in the park. *Imperata cylindrica*, commonly known as spear grass, has colonized large sections of QENP, creating a system of *impereta* grasslands. *Maerwa documens* is found in the northern circuit of Ishasha sector and is believed to be dispersed by baboons that feed on the fruit.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
			exacerbate asthma and associated allergies.		
Higher temperatures Decreased precipitation Longer dry periods Higher temperatures Decreased precipitation Longer dry periods	Reduced water in wetlands, rivers, and streams.	• Increased hippopotamus deaths in QEPA and MFPA.[20] • Decreased population numbers of sitatunga, an endangered antelope that lives in papyrus wetlands. • Decreased populations of birds dependent on these habitats, such as the shoebill stork. • Reduced health and increased mortality of crocodile populations in these PAs, already shown during extended dry periods. • Animal mortality or relocation outside of PA boundaries due to water shortages.	• Decreased revenue and quality of tourism experience. QEPA and MFPA wetlands, lakes and river habitats are some of the most popular tourist destinations in the PAs and these could be at risk if water levels are reduced. This would affect income generation for UWA, as well as opportunities for people in surrounding communities, where community-based tourism developments rely on wetland, river and lake tours. • Fishermen, including those who live in QEPA and adjacent areas and fishing communities around Lake Albert and River Nile in		*Responses to biodiversity impacts:* • Construct watering points in priority sites (areas widely used by wildlife but without a permanent source of water, or a source that dries up during dry conditions), including Bugungu WR and northern bank-Tebito areas in MFNP to minimize wildlife movement outside the reserve and the park during the dry season. • Re-vegetate buffer areas of wetlands and construct drainage structures to improve water flow and retention in wetlands. *Responses to livelihoods impacts:* • Identify and support alternative tourism

20 This has happened in Katavi National Park, Tanzania, during years of extreme drought (Kulkarni 2009 in Carr et al., 2013).

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		• Reduced overall breeding and nursery sites for some fish species; may affect the overall productivity of the landscape's lakes (Water Resource Assessment for River Mpanga, 2009, in DWRM, 2011).[21] Falling lake levels will also affect the area covered by wetlands, which serve as a refuge for juvenile and adult fishes, including species such as the lungfish (*P. aethiopicus)*.[22] • Health and distribution of fish and other aquatic life in rivers in the landscape may be adversely affected by reduced runoff. Fish that breed within certain temperature	MFPA, may experience a reduction in fishery yields, and the fishery may be unable to support the current number of fishermen. • Reduced water quality and quantity. Communities around MFPA and QEPA rely on water from the PAs for domestic, livestock and agricultural use. Receding water levels in the lakes and water flows in the rivers, including the River Nile, will affect water quality, particularly on the shorelines and river mouths, such as the Murchison Falls-Albert Nile Delta (DWRM, 2013). • Fewer PA resources for community use.		destinations and activities. • Promote livelihoods other than fishing that are environmentally sound, such as domestication of medicinal and cultural plants, establishment of woodlots to recover degraded areas while providing wood products, fish farming, beekeeping, high-value horticultural crops, poultry and production of energy-saving stoves. • Support water conservation and harvesting systems, such as construction of valley dams and rainwater collection tanks in the communities

21 Shallow inshore waters are the most productive area in lakes, serving as breeding, nursery and feeding areas for fish.

22 A 2011 Ministry of Water and Environment assessment for an improved integrated water management project for River Mpanga noted that residents of all fishing villages on Lake George stated that the level of the lake had gone down. The decline may be attributed to increased sedimentation from poor agricultural and other practices, as well as to increased length and occurrences of dry spells triggered by climate change.

CLIMATE STRESSORS	CLIMATE RISKS	DIRECT IMPACTS TO BIODIVERSITY	INDIRECT IMPACTS TO LIVELIHOODS FROM BIODIVERSITY IMPACTS	INDIRECT IMPACTS TO BIODIVERSITY FROM LIVELIHOOD IMPACTS	POTENTIAL ADAPTIVE RESPONSES
		thresholds may be affected.	Cultural and medicinal wetland-based resources could be adversely affected. Plant resources, such as ambatch, that grow on shorelines of lakes and artisanal salt mining on Lake Katwe are at risk with decreased flow of water in wetlands, rivers and lakes. • Increased HWC. With decreased water flow in wetlands and lakes, crocodile and hippo attacks may increase as they move in search of areas with water. Species moving closer to human settlements, where they are killed or chased, result in conflict between PAs and the communities and calls to remove the areas' protected status.		surrounding the PAs. • Support domestication/on-farm production of resources used by communities. • Update sustainable use agreements between the PA and communities that take into account effects of reduced water in wetlands, rivers and lakes. • Scale up best measures to control wildlife movement outside the PA, such as fencing water points where communities fetch water.

2.5.9 CLIMATE CHANGE RISK SIGNIFICANCE RATING

LANDSCAPE 5 – Queen Elizabeth and Murchison Falls Protected Areas (QEPA and MFPA) and Surrounding Communities

	CRITERIA	RATING*	NOTES
1	Importance of biodiversity	**3**	Ecosystems of mountains, lakes and grassland form a varied and unique assemblage. Rich in birdlife and mammals, including elephant and hippo, rare and endemic species; regional and global importance. QEPA supports more biodiversity than any other PA in Uganda.
2	Significance of climate change impacts on biodiversity	**2**	Rising temperatures will mean increased evaporation and loss of water exacerbated by projected inconsistent rains. Changing conditions will favor invasive species over those species adapted to the area. Lower availability of water will directly affect wetlands and lakes, which can also induce more HWC, including of fishermen with crocodile.
3	Importance of natural resources to livelihoods	**3**	Over 3 million people live in and around the sub-landscape and depend on the PAs for livelihoods (fishing, livestock, tourism, agriculture, crafts and medicinal plants). Important for hydropower production, it is also one of the main sources of the River Nile, important in Uganda and beyond.
4	Significance of climate change impacts on livelihoods	**2**	Decreased tourism from declining conditions for wildlife and recreation will directly affect incomes. Fishing is a significant livelihood and has already shown signs of decreasing. Lower-quality PAs affect extraction of resources such as plants. Direct HWC will increase (crop raiding, crocodile attacks, etc.) and wildlife interactions will increase disease transmission to domestic animals.
5	Relative impact of climate stressors compared to non-climate stressors	**1**	Non-climate stressors are more significant in this sub-landscape than climate stressors. As elsewhere in the Albertine Rift, high population density and growth, low levels of development and unsustainable practices persist. Unique to this area is oil exploration.
6	Imminence of climate impacts	**2**	Impacts are already being felt, including reductions in lake water levels and a shift to savanna climate.
7	Potential value in piloting adaptation response	**2**	As this area's habitats are similar to many other places in Uganda, solutions to problems experienced would be a good model. QEPA has the highest profile of PAs in Uganda.
Overall Significance**		**Medium** (15)	**Climate change risk is not as immediately significant as non-climate stressors, but landscape provides potential for implementing successful adaptive responses that could be replicated elsewhere.**

*Ratings: **High (3),** **Medium (2),** **Low (1)**
**Overall Significance: Sum of criteria scores; 7–10=low; 11–15=medium; 16–21=high.

REFERENCES

Baastel Consortium, (2015), *Economic assessment of the impacts of climate change in Uganda: Key results.* Climate and Development Knowledge Network. Retrieved from http://cdkn.org/wp-content/uploads/2015/11/UGANDA_Economic-assessment-of-climate-change_WEB.pdf

Barihaihi, M., (2010), *Country Level Literature Review*, Africa Climate Change Resilience Alliance (ACCRA), Kampala, Uganda.

Carr, J. et.al. (2013), *Vital but vulnerable: Climate change vulnerability and human use of wildlife in Africa's Albertine rift*, IUCN, Gland.

Directorate of Water Resources Management (DWRM), (2011), *Involving local communities in preparing a long-term CC and IWRM action plan to enhance their adaptive capacity to climate change, and integrate improved water management in the Mpanga Catchment of the Nile Basin in Uganda*, Uganda PROTOS and Ministry of Water and Environment, Kampala, Uganda.

DWRM, (2013), *National Water Resources Assessment*, Ministry of Water and Environment, Kampala, Uganda.

Eilu, G. and Galabuzi, C., (2015), *Changes in Vegetation types in response to climate change in Rwenzori Mountain National Park, Research Gate*. Retrieved at: https://www.researchgate.net/publication/277571576

FEWS NET, (2012), *A Climate Trend Analysis of Uganda*, USGS and USAID. Retrieved from http://www.fews.net/east-africa/uganda/climate-change/june-2012

Kaggwa, R., et. al. (2009), *Enhancing the Contribution of Weather, Climate and Climate Change to Growth, Employment and Prosperity*, UNDP/NEMA/UNEP Poverty Environment Initiative, Uganda.

Mafabi, P. (1997), *Case Study 5: Uganda; Lake George,* in Wetlands, Biodiversity and the Ramsar Convention: The Role of the Convention on Wetlands in the Conservation and Wise Use of Biodiversity. Ed. A.J. Halls. Retrieved at http://www.ramsar.org/sites/default/files/documents/library/wetlands_biodiversity_and_the_ramsar_convention.pdf

McGahey, D., et al., (2013), *Investigating climate change vulnerability and planning for adaptation: Learning from a study of climate change impacts on the Mountain Gorilla in the Albertine Rift,* Vol.5, No.5A, 10–17, *Natural Science*. Retrieved at: https://dx.doi.org/10.4236/ns.2013.55A002

Mubiru, D, N. (2010), *Climate Change and Adaptation Options in Karamoja*, European Commission and Food and Agriculture Organisation, Kampala, Uganda.

Muhweezi, A. (2014), *An Overview of Climate Change and Biodiversity in Uganda*, U.S. Agency for International Development (USAID), ARCC.

Nature Uganda, (2009), *Ecological Baseline Surveys of Lake Bisina, Lake Opeta, Lake Mburo and Nakivali Wetlands Systems*, The East African Natural History Society, Kampala, Uganda.

Seimon, A., and Phillipps, G., (2009), *Climatological Assessment of the Albertine Rift for Conservation Applications*, Wildlife Conservation Society.

Seimon, A., and Phillipps, G., (2011), *Regional Climatology of the Albertine Rift*, Nova Science Publishers, Inc. ISBN: 978-1-61122-780-2, New York.

Seimon, A. et.al, (2012), *Building Consensus on Albertine Rift Climate Change Adaptation for Conservation: A Report on 2011–12 Workshops in Rwanda and Uganda*, WCS Workshop report, World Conservation Society, New York.

Uganda Bureau of Statistics, (2014), *National Population and Housing Census 2014, Summary Provisional Results*, UBOS, Kampala, Uganda.

Uganda Ministry of Agriculture, Animal Industry and Fisheries; Uganda Bureau of Statistics; Food and Agriculture Organization of the United Nations; International Livestock Research Institute; and World Resources Institute, (2010), *Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda*. World Resources Institute, Washington, DC, and Kampala, Uganda.

Uganda Ministry of Water and Environment, (2014), *Uganda's Second National Communication to the UNFCCC*; Global Environmental Facility and United Nations Environment Program.

Uganda Wildlife Authority (UWA), (2003), *Lake Mburo Conservation Area General Management Plan 2003–2013*, Kampala, Uganda.

UWA, (2008), *Bwindi-Mgahinga Conservation Area Management Plan 2001–2011*, Revised edition 2008, Kampala, Uganda.

UWA, (2012), *Kidepo Valley National Park General Management Plan 2012–2022*, Ministry of Tourism, Wildlife and Antiquities, Kampala, Uganda.

UWA, (2013), *Murchison Falls Protected Area General Management Plan 2012–2022*, Kampala, Uganda.

UWA, (2015a), *Queen Elizabeth Protected Area General Management Plan 2011–2021*, Kampala, Uganda.

UWA, (2015b), *State of Uganda's Wildlife Resources*, Ecological Monitoring and Research Unit; Conservation Department, Kampala, Uganda.

UWA, (2016), *Rwenzori Mountains National Park General Management Plan 2016–2025*, Kampala, Uganda.

United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP), (2004), *Policy Brief: Climate Change, the Environment and Human welfare; Lessons Learnt from the Lake Kyoga Catchment Area*, Nairobi, Kenya.

United States Agency for International Development (USAID), (2011), *Climate Change and Conflict in Uganda: The Cattle Corridor and Karamoja*, CMM Discussion Paper No. 3, USAID.

USAID, (2014), *Uganda Climate Change Vulnerability Assessment Report*, USAID.

USAID, (2015), *Uganda Environment Threats and Opportunities Assessment*, USAID
.
World Bank, (2016), Databank: Uganda. Retrieved at http://data.worldbank.org/country/uganda

World Wide Fund (WWF), (2015), *Climate Change Vulnerability Assessment: Improving the Ability Of The Ecosystems And Communities In The Albertine Graben To Respond Adequately To Threats Of Climate Change*, Uganda Country Office, Kampala, Uganda.

ANNEX A: LIST OF CONTACTS

NAME	ORGANIZATION	POSITION
Margaret A. Mwebaze	FSSD/Ministry of Water and Environment	Assistant Commissioner/REDD+ Focal Point
Sheila Kiconco	UN-REDD+	National Technical Advisor
Olive Kyampaire	FSSD/REDD+ Secretarial	Communications Specialist
Abiaz Rwamiri	USAID-AW Biodiversity Project	Communications Officer
Sam Mwandha	USAID-AW Biodiversity Project	Chief of Party
George Okwaro	USAID-AW Biodiversity Project	Conservation Planner
Dr. Isiah Owiunji	WWF Uganda	Coordinator Energy and Climate Programme
Ibrahim Mutebi	WWF Uganda	Energy Manager
Martin Asiimwe	WWF Uganda	Project Manager
Polycarp Mwima	IUCN	Programme Manager
Edgar Buhanga	Uganda Wildlife Authority	Deputy Director Planning
Richard Kapere	Uganda Wildlife Authority	Ag. Planning Coordinator
Nelson Guma	Uganda Wildlife Authority	Conservation Area Manager-Kibale Conservation Area
Aventino Bekunda	Fisheries Department-Ministry of Agriculture Animal Industry and Fisheries	Principal Fisheries Officer
Geoffrey Dheyongera	Fisheries Department-Ministry of Agriculture Animal Industry and Fisheries	Senior Fisheries Inspector
Patrick Byamukama	Fisheries Department-Ministry of Agriculture Animal Industry and Fisheries	Senior Fisheries Officer
Francis Ogwal	National Environment Management Authority	
Levi Etwodu	National Forestry Authority	Director of Natural Forests
Noel Abaho	Lake Mburo National Park	Ag. Warden Community Conservation
Robert Mbagaya	Lake Mburo National Park	Ag. Warden Law Enforcement
Shillah Ampeire	Lake Mburo National Park	In Charge Intelligence unit
Micheal Murinda	Lake Mburo National Park	EN&R Lake Mburo Conservation Area
Moses Matsiko	Lake Mburo National Park	Head Guide
Abdu Kamoga	Isingiro District Local Government	Assistant Environment Officer
Emmanuel Bwenge	Isingiro District Local Government	District Natural Resources/District Forest Officer
Celestine Makaaka	Lake Kalulimbi/Nakivale Restoration and Monitoring Committee	Committee Chairperson
Musingwire Jeconious	Mbarara District Local Government	District Natural Resources Officer/Secretary River Rwizi Catchment Management Committee/Focal

		Person National Environmental Management Authority, South western region
Michael Opige	Nature Uganda	
Steven Muwaya	MAAIF	SLM/UNCCH Focal Point
Vicent Barugahare	Wetlands Department-Ministry of Water and Environment	Principal Wetlands Officer
Community Groups and Resource Users		
Rwamuku Community Conservation Association-Lake Mburo National Park		
Cattle keepers and members of Nshara Wildlife and Sport Hunting Association		
Rubare Fishing Community at Rubare gazetted fish landing site inside Lake Mburo National Park		

ANNEX B: DETAILED STUDY DESIGN

STUDY PURPOSE

The study's purpose was to explore direct and indirect effects of climate change on biodiversity and livelihoods in Uganda and to make recommendations regarding USAID/Uganda conservation and climate adaptation programming.

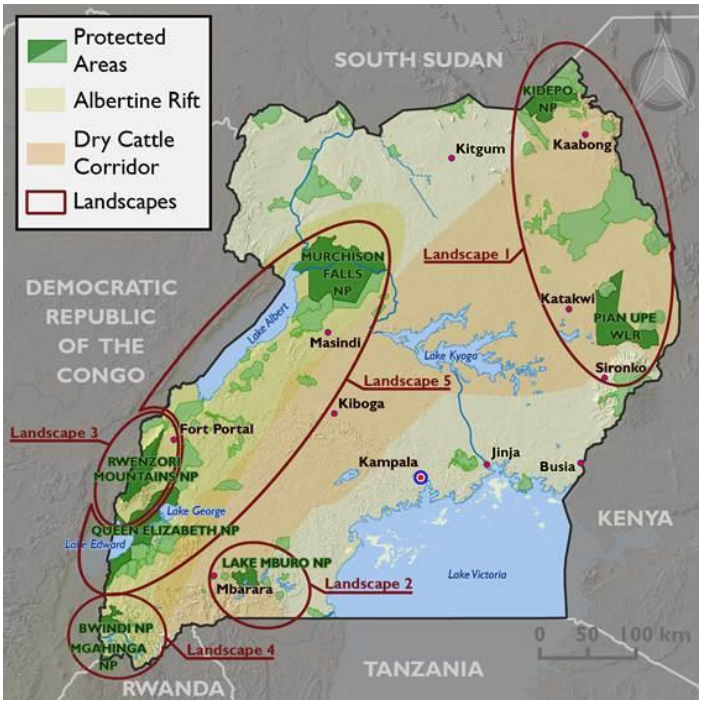
Because its purpose was to examine the impacts of climate change on biodiversity with specific attention to the role that climate risks play in biodiversity and livelihoods, this study focuses on a limited number of highly biodiverse areas in and around protected areas (PAs) and their surrounding human communities. These areas encompass a variety of climates and socioeconomic profiles. This assessment's target geographies fall within two distinct regions in Uganda: the Dry Cattle Corridor and the Albertine Rift.

Landscape 1: (*Dry Cattle Corridor)* Kidepo Valley National Park (KVNP), Pian Upe Wildlife Reserve (WR), Lake Bisina and Lake Opeta wetlands systems and surrounding communities

Landscape 2: (*Dry Cattle Corridor)* Lake Mburo Conservation Area (LMCA) and surrounding communities

Landscape 3: (*Albertine Rift)* Rwenzori Mountains National Park (RMNP) and surrounding communities

Landscape 4: (*Albertine Rift)* Bwindi-Mgahinga Conservation Area (BMCA) and Echuya Central Forest Reserve (ECFR) and surrounding communities



Landscape 5: *(Albertine Rift)* Queen Elizabeth and Murchison Falls Protected Areas (QEPA and MFPA), Lake George and Albert Nile Delta wetlands systems and surrounding communities

GENERAL METHODOLOGY

PHASE 1 – Desk Study

1. Review literature

The overall goal of the literature review is to identify expected climate change at target locations and key climate stressors, related to climate variability and change, on biodiversity and ecosystem services in the study area. Specific actions will be to:

- Identify the baseline situation of climate change knowledge and impacts on target locations, gaps and predictions.
- Review and analyze existing studies to identify the expected/predicted/ potential) climate change at target locations.
- Review the Environmental Threats and Opportunities Assessment (ETOA), the ARCC (African and Latin American Resilience to Climate Change project) assessment, Climate Change and Biodiversity in Uganda, etc. (see references–-Wildlife Conservation Society documents) to establish the baseline information/how climate change is expected to affect the target locations.

2. Identify and analyze the direct and indirect impacts of climate change on biodiversity

The analysis will take into consideration that impacts occur over time and space; some impacts are immediate while others are delayed. Some impacts occur as a direct result of an activity; others occur as secondary or higher-order impacts resulting from changes in other environmental components. When available, quantitative data will be used, but data will be analyzed for gaps, shortcomings and methodology in developing the data.

Analysis of Direct Impacts

Using the ARCC Climate Change-Biodiversity (CC-BD) Study as a starting point, the CC-BD Specialist will analyze (based on existing literature) direct impacts of climate change on biodiversity in the target regions and describe the impact pathways (how and where climate change affects target locations and their biodiversity resources). This analysis will be specific to each target location.

Direct impacts of climate change on biodiversity and ecosystem services will include but not be limited to:

- changes in the composition of vegetation, including increased spread or prevalence of invasive plants and possibly other genera
- changes in rainfall and temperature that would (more directly) impact plants and animals (e.g., lack of food, diseases)

These analyses will take into consideration:

- assemblages of biodiversity as found inside and outside protected areas (PAs), irrespective of their demonstrable economic value
- species of economic importance:
  - such as gorillas/chimps (chimps' use of riparian corridors)
  - fish and other aquatic biodiversity likely to be impacted by changes in quantity, quality and availability of water and health of wetlands
- high-value timber such as mahogany

- sensitive species that might be forced to migrate (due to temperature regime, precipitation, water availability, availability of food, etc.)
- ecosystem services such as water provision, watershed protection, erosion control and provision of fuel wood

Analysis of Indirect Impacts

The CC-BD Specialist will use the direct impact analysis to identify the indirect impacts of climate change on biodiversity. As above, the CC-BD Specialist will use existing assessments to review, analyze and discuss each indirect effect. Together the Team will discuss and based on the literature make assumptions of likely indirect impacts at each target landscape.

Indirect impacts of climate change on biodiversity and ecosystem services (from direct effects) will include clarifying specific pathways for impact:

- agricultural expansion that is leading to pressures on protected areas
  - which could include farming communities or individual farmers
  - as well as coffee (the biggest cash crop) in Mt. Elgon and Mt. Rwenzori
- fields (not just coffee) moving up the mountains (for both expanded land and to seek cooler climates)
- other resource extraction from PAs including forest reserves (over 500 in Uganda with a variety of governance structures and resources and in a range of conditions)
- conversion of critical habitat, both forest and open systems, to bush-dominated habitats, likely exacerbated by the spread of invasive species, resulting in increased human-wildlife conflict.

3. Analyze how the climate change impacts on biodiversity will affect people and their livelihoods

This step will analyze how the direct and indirect impacts on biodiversity will affect people, including livelihoods and human vulnerability aspects. The BD-CC will review the ARCC Uganda Vulnerability Assessment (January 2013), the ETOA, and other existing assessments.

Examples include:

- lack of water/pasture leading pastoralists to bring cattle into highly biodiverse and sensitive ecosystems (e.g., PAs, IBAs, Ramsar Sites) leading to increased conflict
- nature tourism
- agriculture, etc. — this is where the climate change vulnerability assessment would help– Mission's vulnerabilities based on its chosen sectors
- disaster management: extreme weather events or weather variability that triggers landslides and flooding, which can impact biodiversity and functioning of ecosystem services
- water availability issues directly affecting biodiversity
  - dependence on glacial melt loss (already estimated at as much as 90 percent) directly affects dependent farming
  - other water resources – lakes, rivers, streams, wetlands, etc.

4. Validate information and develop scenarios

Together the Team will review, discuss, revise and finalize the Analysis Framework (direct and indirect impacts of climate change on biodiversity and the expected effects on people) and come to agreement on the findings. The Team will then develop location-specific scenarios that describe, in detail and as specifically as possible, direct and indirect impacts of climate change on biodiversity and the resulting effects on people (including the ecosystem services that affect livelihoods and vulnerabilities) and will include non-climate stressors (see below). Non-climate stressors on biodiversity that could affect vulnerabilities and livelihoods will be described, including:

- interaction with population growth
- interaction with oil/mining exploration
- interaction with unclear land tenure
- interaction with food security, water scarcity, conflict
- interaction with natural resource governance
- interaction with expansion of agriculture into PAs

The scenarios will be developed by compiling and analyzing existing studies and through Team discussions. They will be validated during step 5, below. They will be developed in a way that will allow USAID to clearly envision the situation at each target landscape; to understand the options for addressing impacts (adaptation measures); and to compare the situation between target landscapes.

5. Rank significance of impacts based on multiple scales

The Team will develop criteria comprising:

- biodiversity/ecosystem services importance (low, medium, high)
- livelihood importance (low, medium, high)
- scale of effects (slight, moderate, grave)
- timeframe (imminence) of threat (short, medium, long)
- other (previous or existing USAID programming?)

PHASE 2 – Field Work and Analysis

6. Visit the field

Prior to leaving, the Team will:

- Determine appropriate methods to validate and confirm the scenarios--whether consultations in Kampala, site visits or focus groups.
- Together and in consultation with USAID, identify stakeholders to interview and sites to visit. Local specialist will identify stakeholders based on the information in the table and will arrange meetings, including a focus group. The Team will then develop an itinerary, which will include an in-brief and an exit brief for USAID staff, sites to visit and purpose for each site visit.
- Use study questions to develop an interview guide for consultations (key informant questions, focus group discussions) including questions for different stakeholders and for focus groups.

Upon arrival of the full Team in-country, they will carry out consultations and site visits. The focus group (which would include USAID as observers) will meet after the bulk of consultations and the site visits have been completed, and will be used to validate the analyses, findings and conclusions.

7. Incorporate findings from the field and propose actions/ recommendations

The BD-CC Specialist will incorporate findings from field consultations into the scenarios, revising as needed. The full Team will review the Country Development Cooperation Strategy (CDCS); Executive Order on climate change; USAID climate change guidance; Biodiversity Handbook; and other USAID guidance. Based on the scenarios of direct and indirect impacts, the impacts to livelihoods and significance rankings, the Team will identify:

- the main concerns that need to be addressed
- measures to better manage ecosystem services and biodiversity to help reduce human vulnerability to climate change and
- specific recommendations for use of USAID/Uganda global climate change and biodiversity funds (as opposed to using other funds or building interventions into other activities)

8. Make recommendations

The Team will analyze the landscape analyses and make recommendations for Mission programming promoting climate change adaptation generally, and using climate change adaptation funding specifically. Recommendations will include quick wins or low-hanging fruit, actions not requiring collaboration, catalytic and transformational work, etc. at various levels including local, regional and national.