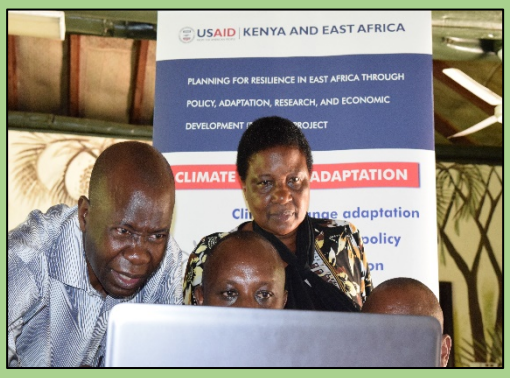
VULNERABILITY, IMPACTS AND ADAPTATION ASSESSMENT IN THE EAST AFRICA REGION



CHAPTER 4: TERRESTRIAL ECOSYSTEMS, INCLUDING FORESTRY, WILDLIFE, AND TOURISM BASELINE FOR EAST AFRICA

OCTOBER 2017

This report was produced for review by the United States Agency for International Development. It was prepared by Camco Advisory Services (K) Ltd. under subcontract to Tetra Tech ARD.

This report was produced for review by Camco Advisory Services (K) Ltd. under subcontract to Tetra Tech ARD, through USAID/Kenya and East Africa Contract No. AID-623-C-13-00003.

Tetra Tech ARD
159 Bank Street, Suite 300
Burlington, Vermont 05401 USA

Tetra Tech ARD Contacts:

Anna Farmer
Project Manager
Tetra Tech
Burlington, Vermont
Tel.: (802) 495-0282
Anna.Farmer@tetratech.com

Korinne Nevins
Assistant Project Manager
Tetra Tech
Burlington, Vermont
Tel.: (802) 495-0282
Korinne.Nevins@tetratech.com

VULNERABILITY, IMPACTS AND ADAPTATION ASSESSMENT IN THE EAST AFRICA REGION

CHAPTER 4
TERRESTRIAL ECOSYSTEMS, INCLUDING FORESTRY, WILDLIFE, AND TOURISM BASELINE FOR EAST AFRICA

October 2017

DISCLAIMER
This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The views expressed are those of the authors and do not necessarily reflect the views of USAID or the United States Government.

CONTENTS

ACRONYMS

AMCEN	African Ministerial Conference on Environment
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
EIA	Environment impact assessment
GDP	Gross domestic product
GIS	Geographic information system
ICPAC	IGAD Climate Prediction and Applications Centre
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LPI	Living Planet Index
LULC	Land use-land cover
LVB	Lake Victoria Basin
LVBC	Lake Victoria Basin Commission
MMNR	Masai Mara National Reserve
NAPA	National Adaptation Programme of Action
NBI	Nile Basin Initiative
NCA	Ngorongoro Conservation Area
NCCAP	National Climate Change Action Plan
NCCR	National Climate Change Response Strategy
NDVI	Normalized Difference Vegetation Index
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NRT	Northern Rangeland Trust
PREPARED	Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development
RCMRD	Regional Centre for Mapping of Resources for Development
REDD	Reducing Emissions from Deforestation and Degradation
REMA	Rwanda Environment Management Authority
SADC	Southern Africa Development Community
SENAPA	Serengeti National Park
SME	Serengeti-Mara Ecosystem
TAWIRI	Tanzania Wildlife Research Institute
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	United Nations World Tourism Organisation
USAID	United States Agency for International Development
VIA	Vulnerability, Impacts and Adaptation Assessment
WMA	Wildlife Management Area

EXECUTIVE SUMMARY

Essential ecological processes are governed, maintained, and moderated by terrestrial ecosystems that are essential to food production, health, and other aspects of survival and sustainable development. For this reason, terrestrial ecosystems, including forests, wildlife, and tourism are a high priority for the East African Community (EAC) Partner States and the Lake Victoria Basin (LVB). Terrestrial ecosystems, like all other ecosystems, is severely affected by climate change, the impacts of which are depleting vegetation, forests, and wildlife populations with irreversible consequences for biodiversity, wildlife-based tourism, and other resources.

As the IPCC defines it, vulnerability is "a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." This study used a Vulnerability, Impacts and Adaptation Assessment (VIA) framework, based upon Intergovernmental Panel on Climate Change (IPCC) guidelines (USAID 2014a). Using this framework, four key components have been recognized as determinants of whether, and to what extent, terrestrial ecosystems are susceptible to climate change. These four components are exposure, sensitivity, potential impact, and adaptive capacity.

Climate change vulnerability assessment based on the four components identifies the Serengeti-Mara Ecosystem (Kenya-Tanzania) and Nyungwe-Kibira Ecosystem (Rwanda-Burundi) as hotspots for the terrestrial sector in the LVB. These hotspots have been recognized by other studies and are cross-border; of global importance; and have critical biodiversity, economic, and social value. One other hotspot identified in the EAC Partner States—also cross-boundary in nature—was the Elgon ecosystem of Kenya and Uganda.

Increased rainfall variability affects vegetation growth and consequently affects habitat for wild animals and pasture for livestock. Analysis of rainfall trends between 1984 and 2014 shows that rainfall on the southeastern side of the LVB, which includes the Serengeti-Mara Ecosystem, is more variable compared to other parts of the basin. This could have negative impacts on the terrestrial sector because rainfall is crucial to the growing cycle and to changes in vegetation cover that affect wildlife habitat and livestock pasture, leading to increased competition between species (Ogutu et al. 2016).

Increased warming is projected to bring shifts in ecosystems, fundamentally altering species compositions and even leading to the extinction of some species. Climate change is projected to affect individual organisms, populations, species distributions, and ecosystem composition and function both directly and indirectly.

Land use is a major threat to terrestrial ecosystems. This change is driven by socioeconomic processes, such as human population growth, which has resulted in increased demand for land for settlement and farming, economic development, blockage of migratory corridors, deforestation, and trade. Climate change will add impacts to already stressed, threatened, and over-exploited ecosystems due to land use changes and population pressure.

Most wildlife in East Africa is in reserved areas, which makes them vulnerable to the effects of climate change. Most reserved areas are surrounded by human settlements and disconnected from similar ecological areas. When vegetation is unable to respond quickly to new climatic conditions, the wildlife will be unable to resort to their natural adaptation, which would be to move to another area with more suitable conditions. This would increase conflicts between wildlife and livestock and wildlife and humans and result in lower populations of wildlife. A 30-year trend of wildlife in Kenya already indicates a decline of 67 percent between 1977 and 2013.

This study offers six policy and institutional mitigation and adaptation options to fill identified capacity gaps.

1. **Climate-smart policies are essential for terrestrial ecosystems, wildlife, and the tourism sector**. While many legal and policy guidelines related to environmental and natural resources protection are in place, they remain short of climate change focus. There is need to continue integrating climate change in existing provisions. It is important to note that more recently some of the EAC Partner States have developed climate change policies, strategies, and action plans.
2. **Inadequate policy harmonization enforcement, and poor institutional coordination**. A strong linkage is needed between existing policies and strategies related to terrestrial ecosystems and climate change. Furthermore, the protection of terrestrial ecosystems requires an integrated approach.
3. **Inequitable gender representation at both policy and institutional levels.** Gender needs to be integrated in all aspects of climate change policies and programs related to the sector.
4. **Access to climate finance.** Finance is critical in factoring complex, cross-cutting environment and climate change issues into strategic planning and implementation. To effectively secure resources from existing global funding mechanisms, relevant government ministries in all five Partner States need to develop their capacity for resource mobilization (Gachanja 2014, REMA 2014).
5. **Research and development.** Research that assesses and quantifies the impact of climate change on terrestrial ecosystems—and the socioeconomic consequences of the loss of ecosystems, of economic activities, as well as of certain mitigation and adaptation choices—is limited. The EAC Secretariat should explore funding mechanisms to support research. A mechanism or a platform needs to be established to package information and knowledge to guide adaptation strategy.

Incentives to promote conservation. Incentives to manage fragile and endangered ecosystems need to be promoted. These incentives should include payment for ecosystem services, easements, and other financial instruments. The private sector should be involved in supporting these initiatives to ensure their long-term sustainability.

1. INTRODUCTION: TERRESTRIAL ECOSYSTEMS

An ecosystem is a collection of interrelated communities of living and non-living things. Terrestrial ecosystems are found only on land. The biotic, or living things found in an ecosystem include various life forms, such as plants and animals. The terrestrial biosphere interacts strongly with the climate, providing both positive and negative feedback due to bio-geophysical and bio-geochemical processes. For instance, the biosphere moderates the moisture distribution in the hydrological cycle, contributing to rainfall variability and climate in a region.

The terrestrial sector includes vegetation (forests, woodlands, grassland and savannas, and mountains), wildlife, and associated tourism and is crucial to the sustainable development of the East Africa Community (EAC). Vegetation in East Africa is highly diverse, ranging from mangrove forests on the coast of Kenya and Tanzania to savanna grassland and woodlands to evergreen forests on mountain slopes. The distribution of natural vegetation is influenced by rainfall, temperature, topography, soil, human activities, and various regional and individual government policies in the region.

Large areas of the Lake Victoria Basin (LVB) are covered by wetland, savanna, forests, and grasslands (Figure 1), all hosting species of high significance, including endemic and vulnerable species. Human population growth ranks highest among the dominant threats to the LVB's biodiversity and seriously imperils many known (and unknown) globally threatened species.

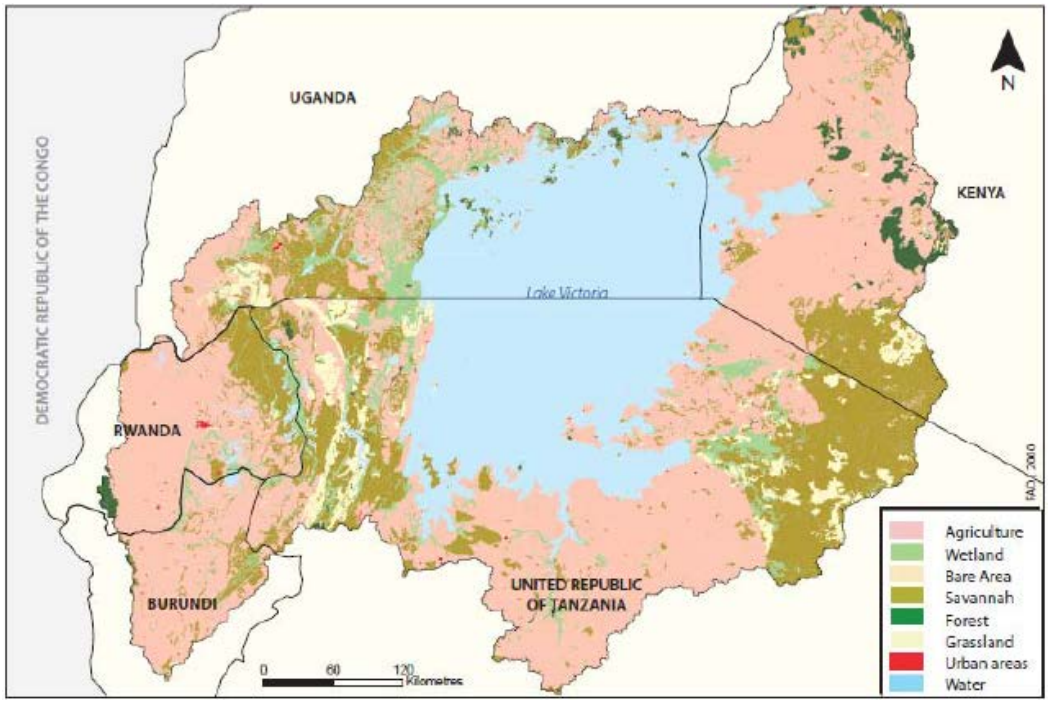


Figure 1: Ecosystems of the Lake Victoria Basin (based on global cover data from 2009)

East Africa is endowed with spectacular scenery and diverse wildlife protected in national parks and reserves, some of which are in forests, woodlands, and rangelands (grassland and savannas and mountains). The region has established protected areas to safeguard its natural heritage, support nature-based tourism, and achieve biodiversity, watershed protection, and other environmental objectives. The area devoted to wildlife protection covers 19 percent of Tanzania, 10 percent of Uganda, and 8 percent of Kenya.

2. IMPORTANCE OF THE TERRESTRIAL SECTOR

2.1 SECTOR PRIORITY IN THE FIVE EAC COUNTRIES

Because of their role in provision of environmental goods and services, terrestrial ecosystems are a high priority for East Africa. Forests and woodlands are sources of food, timber, fuel for energy, and non-timber forest products. They contribute significantly to household and community wealth and health, especially among the poor and support national, regional, and global well-being through the ecological services they provide. They also provide essential services that are critical to combating land degradation and climate change and thus are critical for agriculture and food production (Groner 2003).

Management of protected areas, forests, wildlife, and tourism are identified as priorities in each EAC Partner State's National Adaptation Programme of Action (NAPA) and National Vision Statement, as highlighted in Box 1. Their value and contribution to the national economies is summarized in Box 2.

Box 1: Terrestrial Ecosystems as a Priority in the Five EAC Partner States

- Management of protected areas is priority 3 out of 14 priorities in **Burundi** (Republic of Burundi 2007).
- Integrated water resource management is priority 1 out of 6 in **Rwanda** (Republic of Rwanda 2006).
- **Kenya and Tanzania:** Wildlife and associated tourism is one of 6 priority areas in Kenya's Vision 2030 (Government of Kenya 2007) and in Tanzania NAPA (United Republic of Tanzania 2007)
- Forestry, wildlife, and tourism are identified as priorities 4, 6/7, 6/7 out of 13 priorities in **Tanzania** (United Republic of Tanzania 2007).
- Land and land use and farm forestry are identified as priorities 1 and 2 out of 8 priorities in **Uganda** (Republic of Uganda 2007), and forestry is a primary growth sector in Uganda's economy (Republic of Uganda 2010).
- Deforestation, prolonged drought, changing rainfall, floods, and temperature rise are priorities in the 4 NAPAs (**Burundi, Rwanda, Tanzania,** and **Uganda**) and in **Kenya's** National Climate Change Response Strategy (NCCRS) and National Climate Change Action Plan (NCCAP) (Government of Kenya 2010 and 2013).

Box 2: Contribution of Forestry in EAC Partner States

- In Burundi, wood-based energy demand is estimated at **97 percent,** mostly for firewood (USAID 2010).
- In Kenya, the forestry sector contributes **3.6 percent** to gross domestic product (GDP) (UNEP 2012).
- According to Rwanda's Vision 2020, wood is an energy source for **99 percent** of the population.
- In Tanzania, the forestry sector contributes **92 percent** of fuel energy, 2–3.5 percent per year to GDP, and 10 percent to external trade (United Republic of Tanzania 2007). In Uganda, forestry contributes **6 percent** (1.9 percent formal sector, 2.75 percent informal sector, and 1.45 percent non-marketable outputs) to GDP (NFA 2009) and **90 percent** of the population is dependent on wood energy (800,000 cubic meters of charcoal and 25–30 million cubic meters of firewood) per year.

2.2 BIODIVERSITY

Biodiversity hotspots are regions known to hold especially high numbers of species found nowhere else. According to the criteria developed by Myers et al. (2000), a hotspot must meet two thresholds to qualify: "it must have at least 1,500 endemic, native vascular plant species; and it must have already lost at least 70 percent of its primary, native vegetation." About two billion people live in hotspots and 300 million live within less than 10 kilometers of protected areas (Biodiversity Hotspots Revisited, Conservation International 2004).

Among the 34 world biodiversity hotspots, 8 are in Africa and 2 are in East Africa. These hotspots include the coastal forests of eastern Africa and the eastern Afromontane (Conservation International: Biodiversity hotspot; IUCN 2009). Figure 2 shows the distribution of mammals, birds, and reptiles and illustrates the species richness in East Africa.

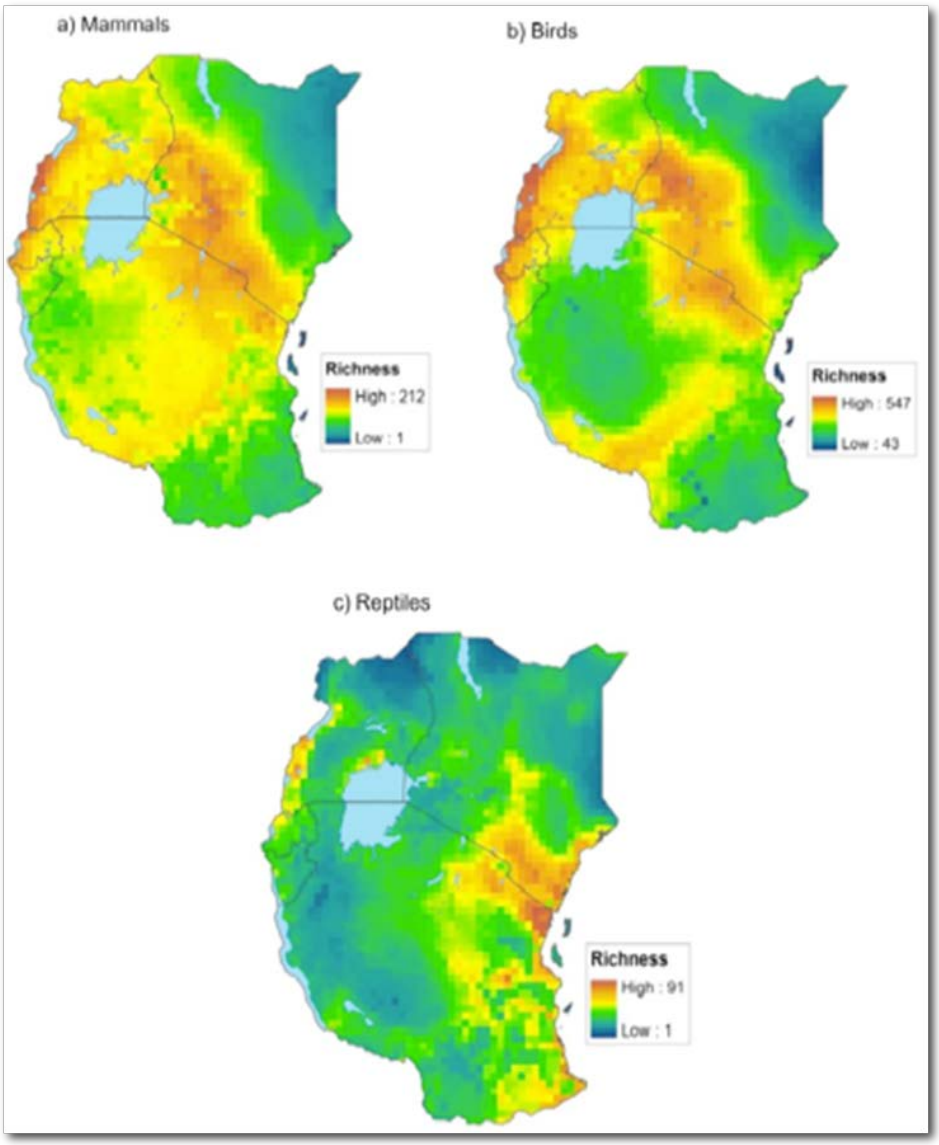


Figure 2: Species richness of mammals, birds, and reptiles in Eastern Africa; Note: Yellow toward red indicates areas of high concentrations (source: African Conservation Centre)

Following is a summary of the biodiversity hotspots in EAC Partner States.

- *The Coastal Forest of Eastern Africa.* Although there are more than 40,000 varieties of African violets, all were developed from a few species native to the coastal Tanzanian and Kenyan forests. The same hotspot supports primate species, including three endemic and highly threatened monkey species and two endemic species of bush babies. Central Kenya's Tana River features the Tana River red colobus and the Tana River mangabey, both of which are endemic and threatened. Agriculture, both subsistence farming and commercial farming, is the major threat to the habitats of these species.

- *The eastern Afromontane.* This hotspot encompasses several widely scattered but biogeographically similar mountain ranges in East Africa. The main part of the hotspot's more than one million square kilometers is made up of three ancient massifs: the Eastern Arc Mountains and Southern Rift, stretch from southeastern Kenya to southern Tanzania; the Albertine Rift includes portions of Rwanda, Burundi, Uganda, and Tanzania. Mounts Kilimanjaro, Meru, Kenya, and Elgon, the Aberdares Range, and other peaks, all of which have very similar flora, are also part of this hotspot. The Albertine Rift has more endemic mammals, birds, and amphibians than any other region in Africa.

- *The Lake Victoria Basin.* A vast amount of freshwater fish diversity can be found in the lakes of the LVB, which is home to 617 endemic fish species.

2.3 WILDLIFE

East Africa is endowed with spectacular scenery and diverse wildlife protected in national parks and reserves, some of which is found in forests, woodlands, rangelands (grassland and savannas), and mountains. The region has established protected areas to safeguard its natural heritage, support nature-based tourism, and achieve biodiversity, watershed protection, and other environmental objectives. The area devoted to wildlife protection covers 19 percent of Tanzania, 10 percent of Uganda, and 8 percent of Kenya.

East Africa has some of the largest migrations of large animals and has large wetlands that are important for the breeding and migrations of birds. The annual wildebeest migration from the Serengeti in Tanzania to Masai Mara in Kenya is one of the greatest natural spectacles in the world. The annual movement of massive herds of wildebeest—recently proclaimed the seventh worldwide wonder—continues year-round in Tanzania's Serengeti National Park and Kenya's Masai Mara National Reserve. With regard to large animals, the savannahs of Ruvubu National Park in Burundi are the last place in the LVB with populations of buffalo (*Syncerus caffer*), Cobe waterbuck (*Kobus ellipsyprimnus defassa*), roan antelope (*Hippotragus equinus*), Cobe redunca (*Redunca redunca*), and red colobus (*Piliocolobus pennantii*). The wildlife of East Africa is important for:

- Its use value, both consumptive (trophy and subsistence hunting, fishing, game farming) and non-consumptive (viewing, photography)
- Its ecosystem value (use value), biological, scientific, and ecosystem health
- Its existence value (non-use), intrinsic and culture.

2.4 TOURISM

Tourism has become an important sector for international commerce and represents a major source of income for many developing countries. It contributes 9 percent to the global GDP, 1 out of 11 jobs, US$1.5 trillion in exports, 6 percent of the world's exports, and 30 percent of service exports (UNWTO

2015). Tourism is a key vehicle for sustainable growth, job creation, and poverty alleviation across Africa. In 2014, United Nations World Tourism Organisation (UNWTO) Secretary-General Taleb Rifai noted that "Without the draw of its spectacular wildlife, future tourism development and millions of people depending on it will suffer." Tourism contributed 13.7 percent to GDP in Kenya and 13.3 percent in Tanzania in 2011. Tourism contributes to poverty reduction by creating development and employment opportunities in the region. In Burundi, tourism contributes about 3.8 percent to GDP. It contributes to poverty reduction and peace-building by creating development and employment opportunities in the country. The tourism sector is the second most important source of foreign currency in Rwanda. The country has many tourist attractions, the main one being Volcanoes National Park and the famous mountain gorillas. Uganda's tourism sector has significantly improved over the years. It currently contributes 8.2 percent to GDP (World Travel and Tourism Council Data 2011) and is the major foreign exchange earner for the country.

Nature-based tourism is a major attraction for many African countries, including East Africa and the LVB (Figure 3). Climate change impacts the sector by affecting the migration patterns of animals in search of available pasture and water. Non-climatic influences on the sector include construction, and other human activities that result in human-wildlife conflicts.

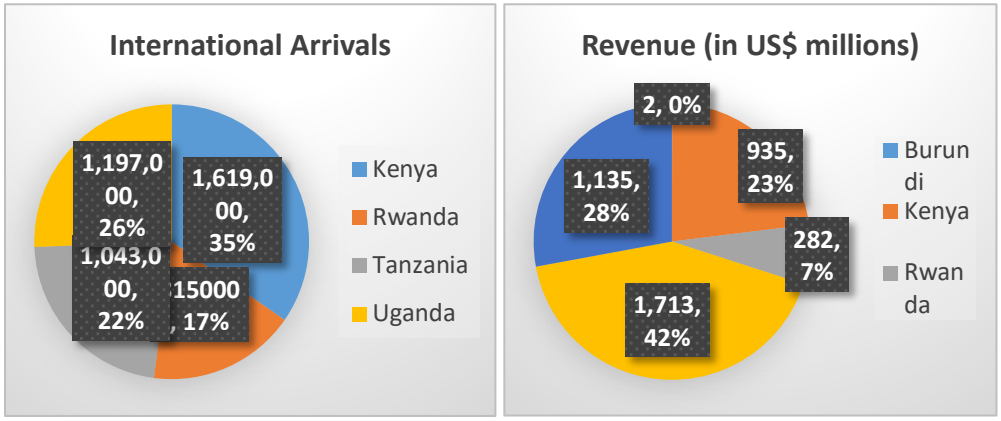


Figure 3: Magnitude of Tourism in East Africa (source: UNWTO Highlights 2014)

2.5 Climate Change Vulnerability Assessment Framework

In recent years, vulnerability assessments have increasingly been used to identify climate change impact and to provide input for adaptation and development planning at local, national, and regional levels. Effective and strategic adaptation planning targets those systems that will be most affected by adverse climate change impacts. In planning climate change adaptation, the concept of "vulnerability" can aid in understanding what lies behind adverse climate change impacts. The recent framework developed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) helps to conceptualize the approach. The GIZ approach to vulnerability is based on the most widely used definition provided by the Fourth Assessment Report of the IPCC (AR4). It refers to vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes." According to Parry et al. (IPCC 2007) vulnerability is "a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

Based on this definition, four key components have been recognized as determinants of whether, and to what extent, a system is susceptible to climate change (Fritzsche et al. 2014). These four components are exposure, sensitivity, potential impact, and adaptive capacity. Exposure to climate variables, and a system's

sensitivity to that exposure, determines the potential impact. However, vulnerability to that impact also depends on the system's adaptive capacity (Figure 4).

The four key components, as set out in Fritzsche et al. (2014) are as follows:

- **Exposure** is directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Typical exposure variables include temperature, precipitation, evapotranspiration, and climatic water balance, as well as extreme events such as heavy rain, floods, and droughts. Changes in these parameters exert major additional stress on systems.

- **Sensitivity** determines the degree to which a system is adversely or beneficially affected by a given climate change exposure. Sensitivity is typically shaped by natural and/or physical attributes of the system. It also refers to human activities, which affect the physical constitution of a system, such as water management and population pressure.

- **Potential impact:** Exposure and sensitivity in combination determine the potential impact of climate change.

- **Adaptive capacity:** The IPCC's AR4 describes adaptive capacity as "the ability of a system to adjust to climate change (including climate variability and extremes)."

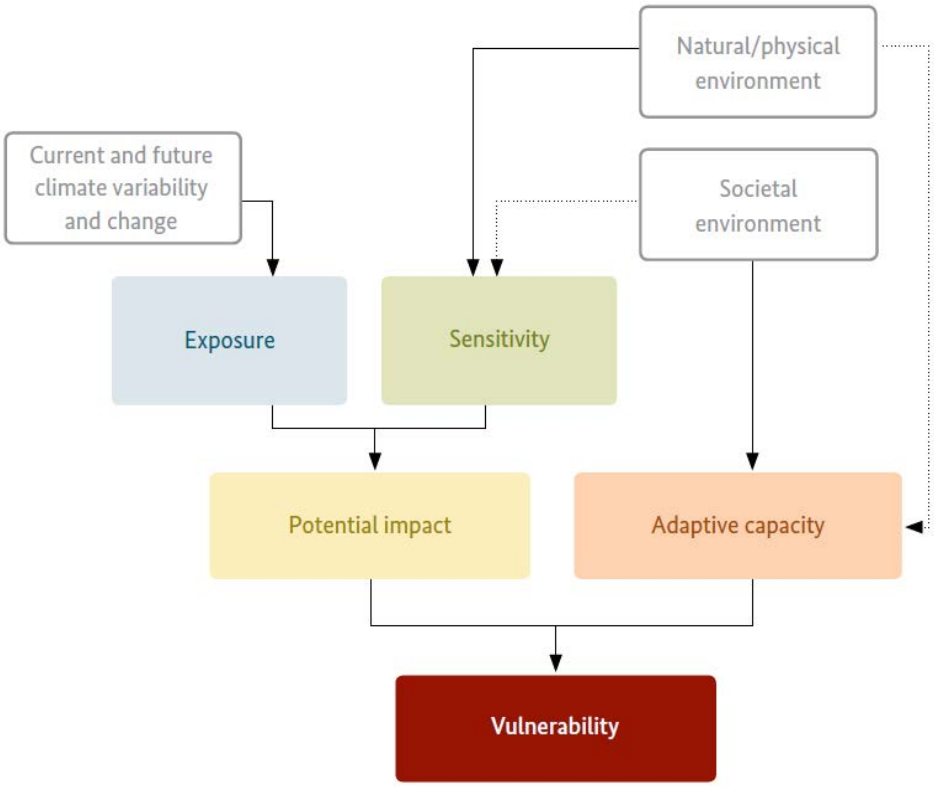


Figure 4: The vulnerability framework (source: Fritzsche et al. 2014)

To better understand the impacts of climate change on this sector, an impact chain was developed using the GIZ methodology. This was done for the terrestrial ecosystems, including forests and wildlife (Figure 5), and then for the tourism sector (Figure 6).

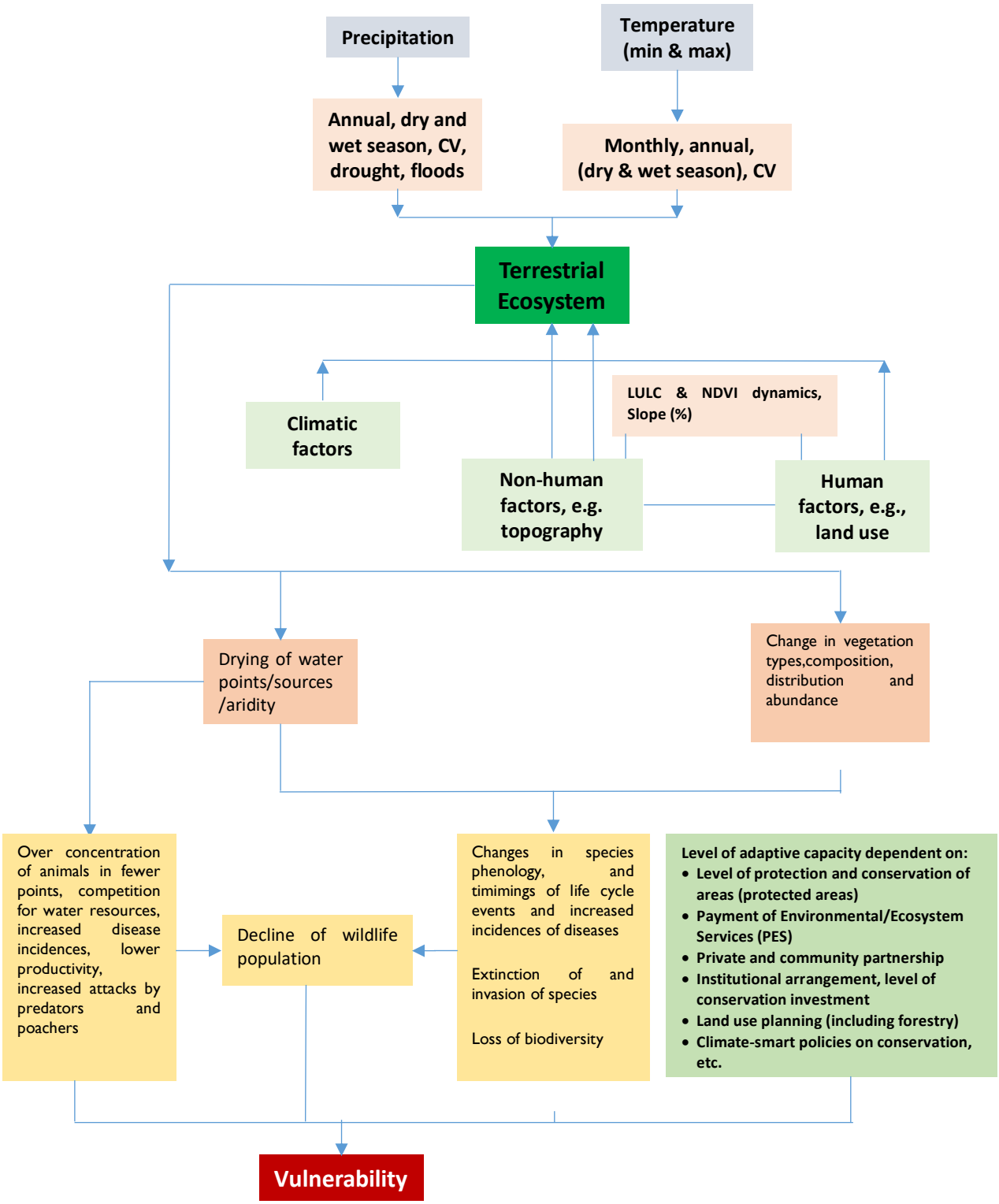


Figure 5: The Impact Chain Framework for Terrestrial Ecosystems, Including Forests and Wildlife in East Africa

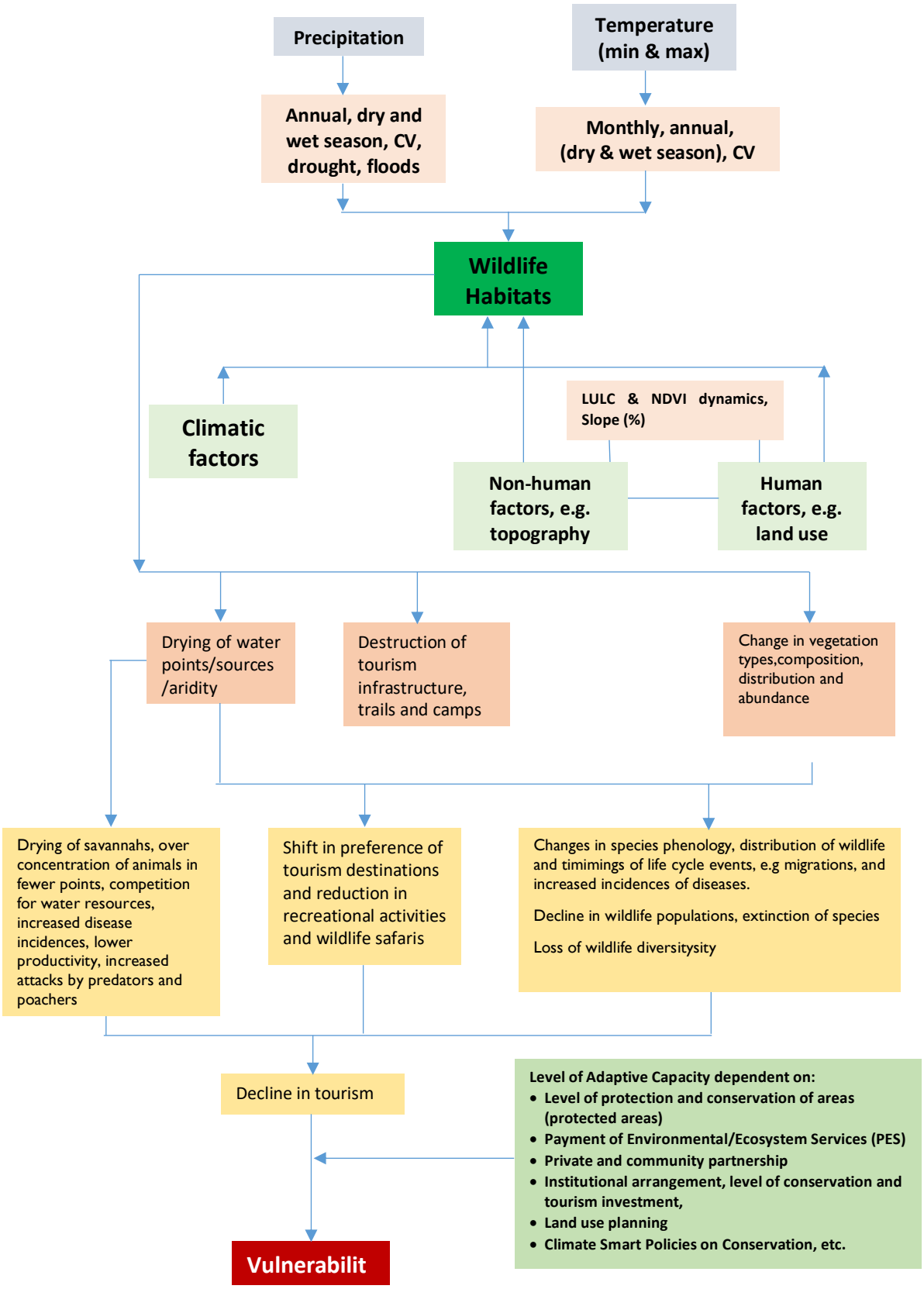


Figure 6: The Impact Chain Framework for Tourism in East Africa

3. VEGETATION

3.1 LAND COVER DYNAMICS AND LAND COVER CHANGES

Land cover plays an important role in various biophysical processes related to global climate. At the global level, human activities over the past three centuries have significantly transformed the Earth's environment, through the conversion of natural ecosystems to agriculture, settlement, and infrastructure development. Human activities, such as deforestation and overgrazing, in combination with such natural factors as wildfires, have had many negative effects on the environment. Seventy percent of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their habitats. Deforestation has an impact on climate variability and change. Human-induced drivers, including population increase, are leading to the modification and rapid disappearance of natural vegetation both globally and in the EAC Partner States (Figure 7a and 7b).

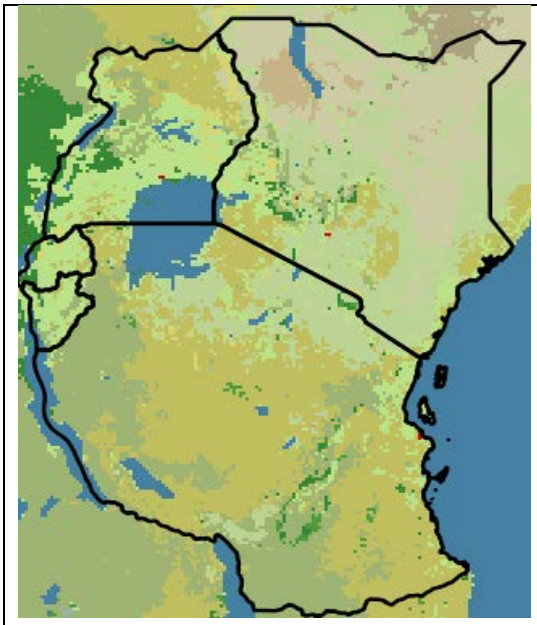


Figure 7a: Land cover 2001

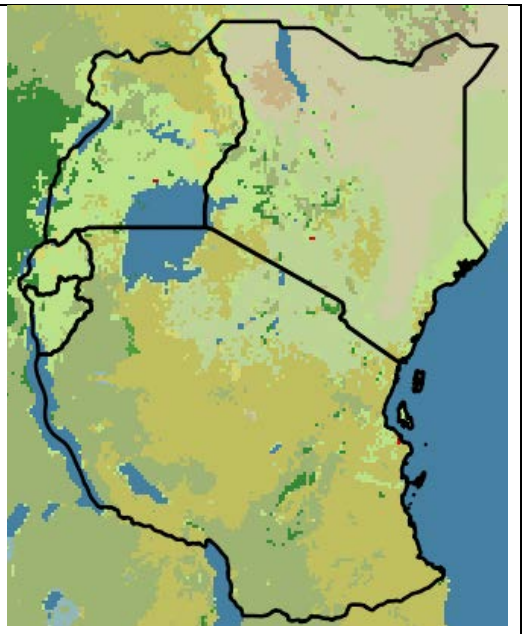


Figure 7b: Land cover 2010

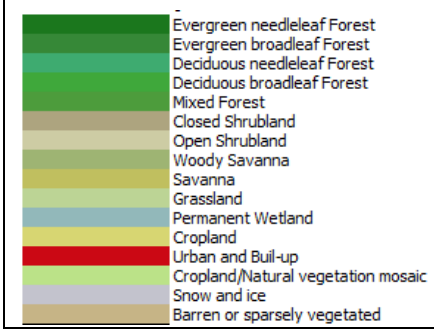


Figure 7a and b: Spatial and temporal distribution of natural vegetation in the EAC based on 10 years (2001–2010) of MODIS data. (source: The United States Geographic Service Land Cover Institute [LCI])

Satellite images are very useful in mapping and monitoring changes in land use over time, including both seasonal and longer-term changes (Huete et al. 2002). The Normalized Difference Vegetation Index (NDVI), a satellite-based time series vegetation index, is the most widely used indicator of vegetation health. The analysis based on NDVI in the LVB between 2001 and 2010 based on MODIS images (Figure 7) shows that the area under woody savanna has increased while there has been a decrease in natural vegetation, especially land under forests, shrubland, and grassland in the Nile Basin areas of the five East

African countries (UNEP 2013a). This change has a significant impact on the terrestrial ecosystems in the region, especially in the LVB, which is part of the larger Nile Basin.

Country Profiles—Decadal Change in Seasonal Vegetation Dynamics in LVB

Burundi

Vegetation in the basin in 2009 was dominated by woody savanna (28.4 percent) and cropland or vegetation (23 percent). Savannas covered 11 percent, built-up or barren lands 11 percent, crops 10 percent, wetlands 8 percent, grasslands 7 percent, and forest and shrublands 1 percent each (Figures 8a and b; UNEP 2013a). Between 2001 and 2009 the area under woody savanna increased, while there was a large decrease in the cropland and natural vegetation mosaic and in land under forests (UNEP 2013a). There was a 5.5 percent decrease in forest cover on both the western and eastern sides of the basin area with only 0.8 percent forest cover remaining in 2009. The land has been replaced with woody savanna or cropland and natural vegetation.

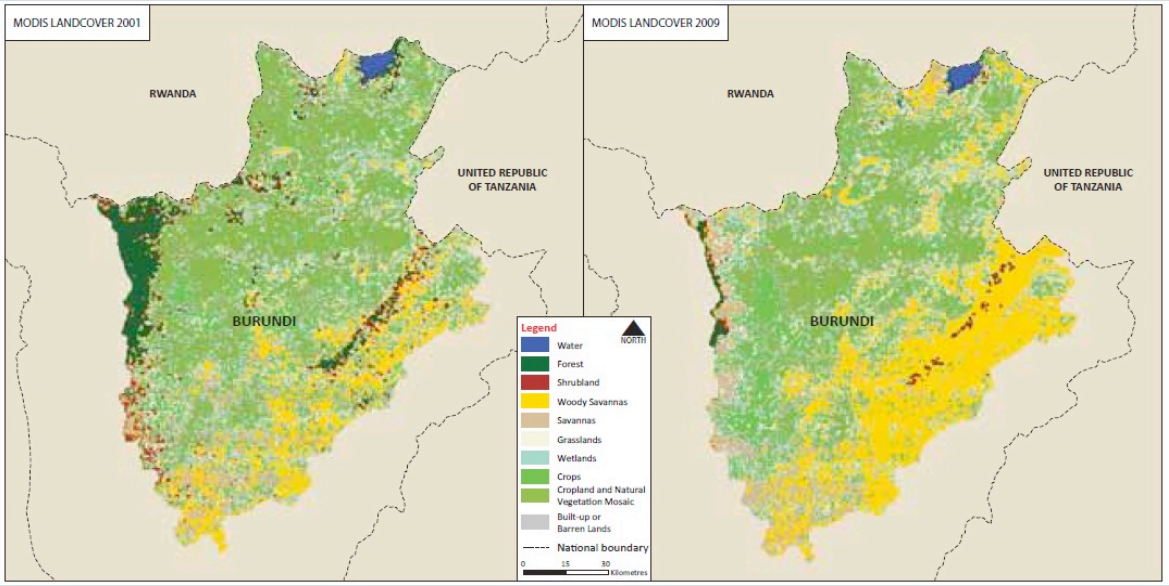


Figure 8a: Land cover change from MODIS between 2001 (left) and 2009 (right) for Burundi (source: UNEP 2013a)

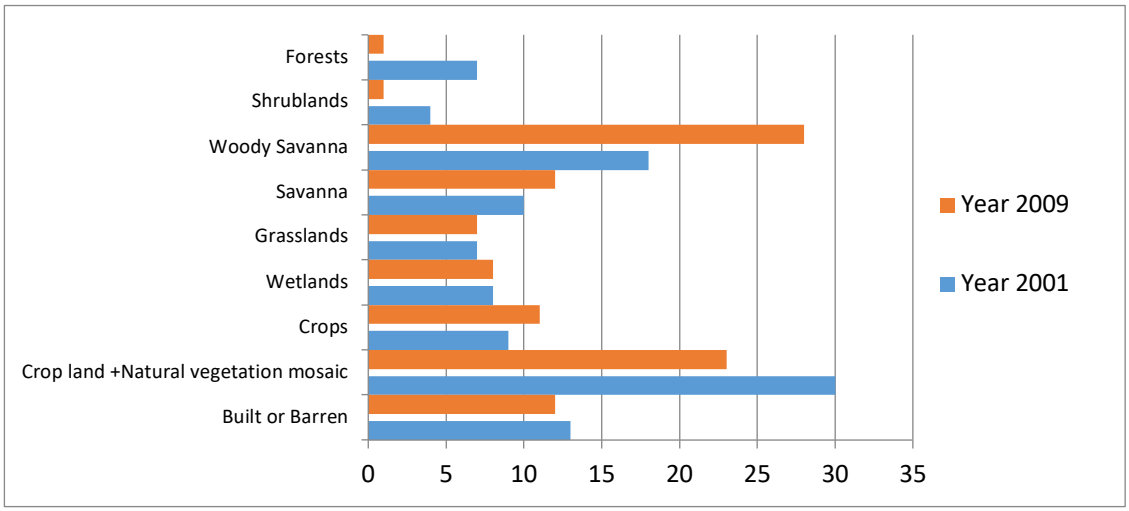


Figure 8b: Relative extent of land cover types in Burundi in 2001 and 2009 (source: UNEP 2013a)

Kenya

Cropland and natural vegetation dominate the land cover in this area, which remained stable at 29 percent between 2001 and 2009 (Figures 9a and b). Savannas and woody savannas also covered a considerable part of the terrain at 18.6 percent and 13.8 percent, respectively, in 2009. These percentages reflect an increase from 2001 of 4.6 percent for savannas and 2.8 percent for woody savannas. The remaining land cover types decreased from 2001 to 2009: shrublands (-0.5 percent), forest (-1.9 percent), grasslands (-2.5 percent), wetlands (-0.9 percent), crops (-0.6 percent), and built-up or barren lands (-0.9 percent). Despite a decline in forest cover, forests in protected areas, such as the Kakamega-Nandi, Tinderet Reserve, Southwestern Mau, and Eastern Mau Reserves, appear to have been kept mostly intact.

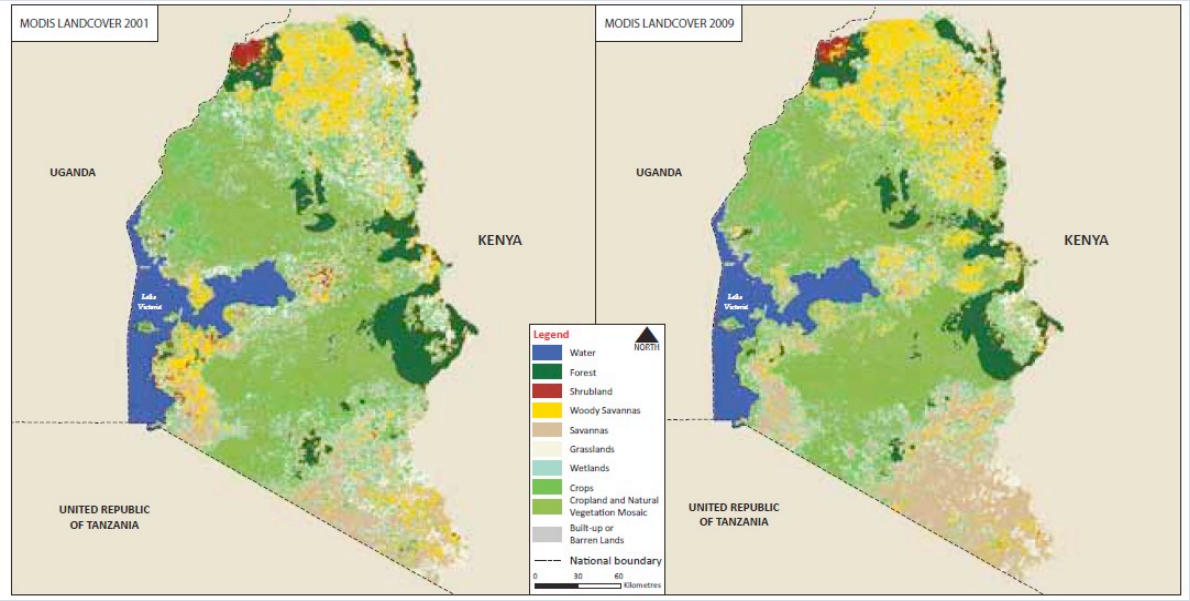


Figure 9a: Land cover change from MODIS between 2001 (left) and 2009 (right) for Kenya (source: UNEP 2013a)

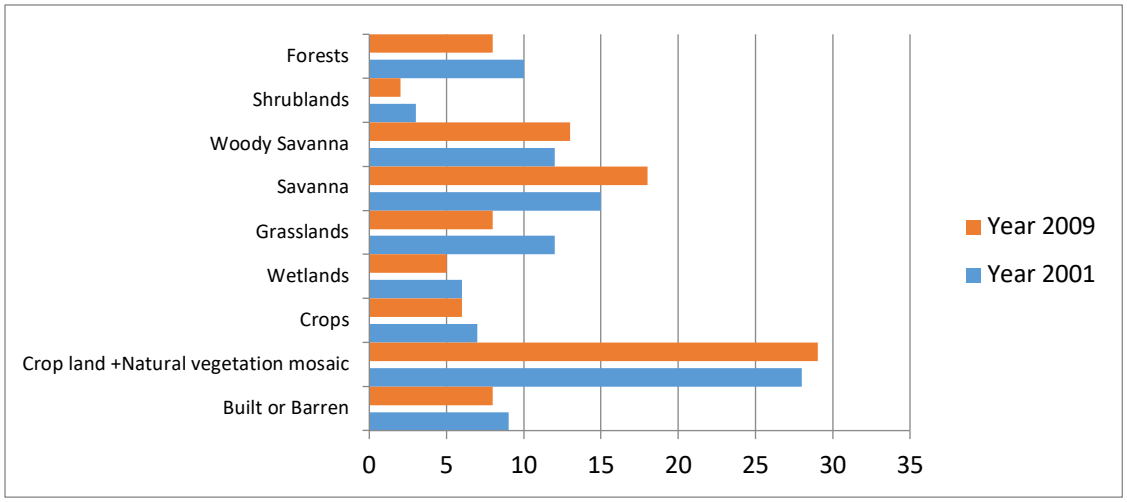


Figure 9b: Relative extent of land cover types in Kenya in 2001 and 2009 (source: UNEP 2013a)

Rwanda

There was a 14.6 percent decline in forest cover in Rwanda between 2001 and 2009 (Figures 10a and b). The Rwandan forest department notes that between 1960 and 2007, Rwanda lost about 64 percent of its forests (REMA 2009). However, agroforestry has been introduced to the country as part of efforts to offset the growing demand for fuelwood (Ndayambaye and Mohren 2011). As a result, forest cover can appear to fluctuate, reflecting firewood harvest. Cropland and natural vegetation experienced a 5 percent decline, but crops increased by 8.3 percent from 10.2 percent in 2001 to 18.5 percent in 2009, shrublands also declined by 1.8 percent. There were increases in built-up or barren lands (4.5 percent), woody savannas (4.8 percent), savannas (3.5 percent), and wetlands (1.2 percent), and grasslands marginally decreased by 0.1 percent.

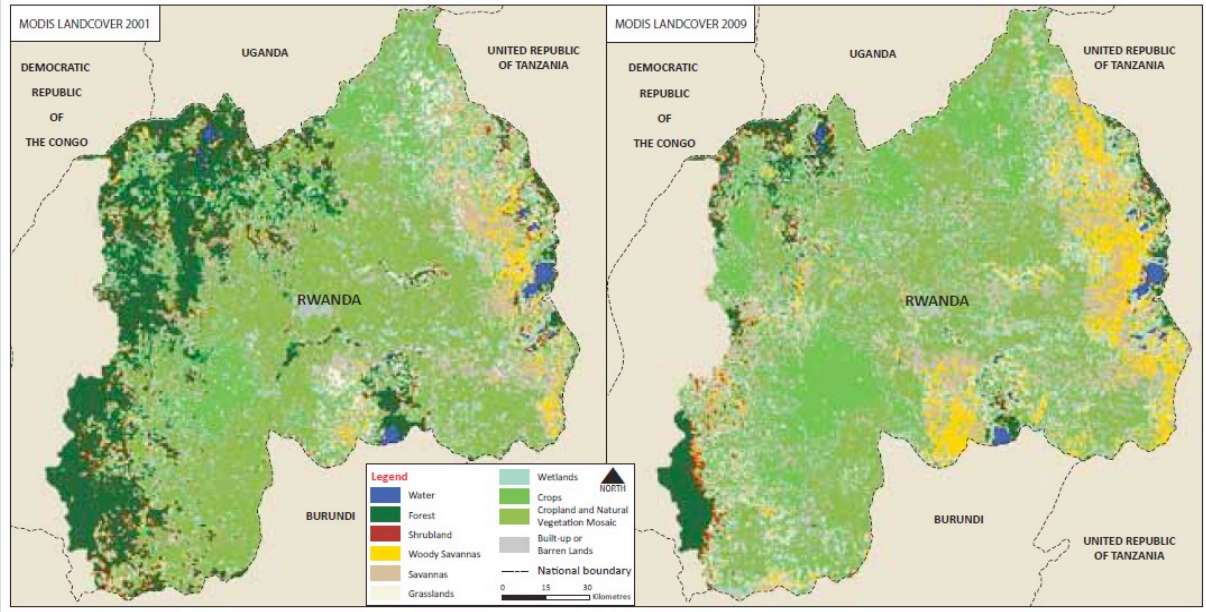


Figure 10a: Land cover change from MODIS between 2001 (left) and 2009 (right) for Rwanda (source: UNEP 2013a)

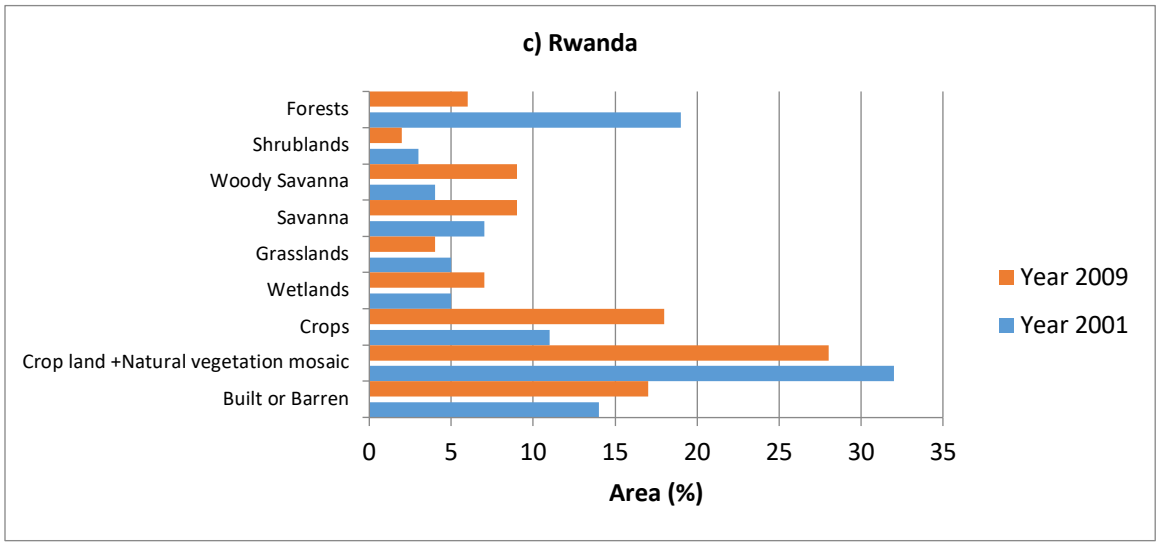


Figure 10b: Relative extent of land cover types in Rwanda in 2001 and 2009 (source: UNEP 2013a)

Tanzania

Noticeable changes in land cover from 2001 to 2009 include a 15.7 percent increase in savannas from 34.5 percent to 50.2 percent, and an 8.8 percent reduction in grasslands from 22.4 percent to 13.6 percent (Figures 11a and b). The remaining land cover types only changed slightly, with most in decline: cropland and natural vegetation (-2.2 percent), built-up or barren lands (-1.6 percent), shrublands (-1.1 percent), wetlands (-1.1 percent), crops (-1 percent), forest (-0.6 percent), and woody savanna there was observed increase (0.7 percent).

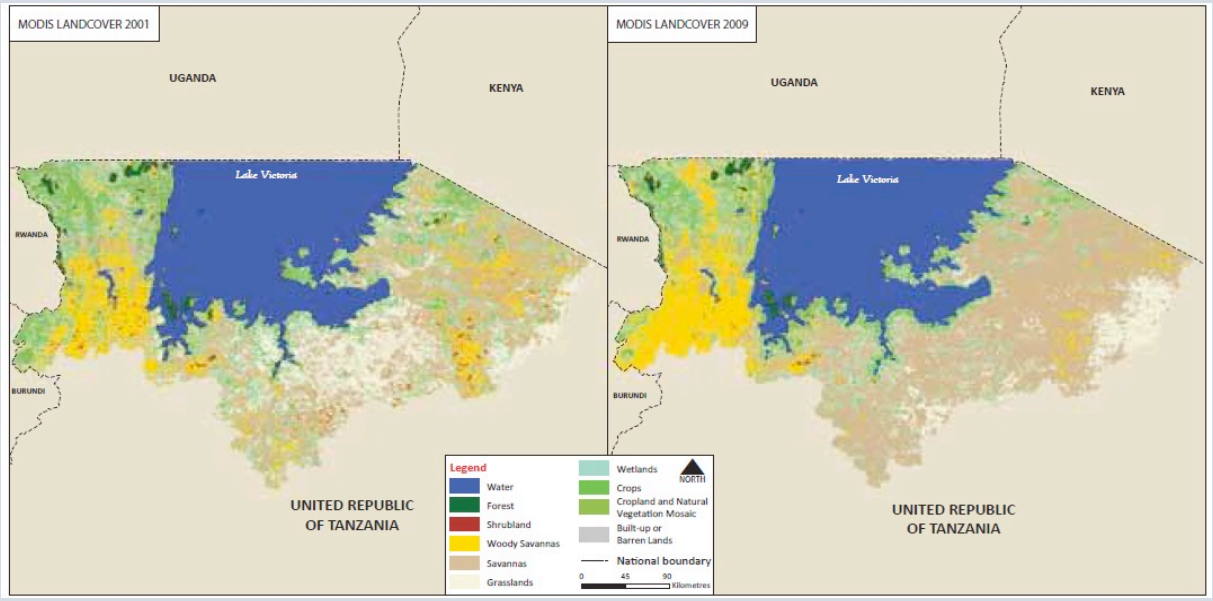


Figure 11a: Land cover change from MODIS between 2001 (left) and 2009 (right) for Tanzania (source: UNEP 2013a)

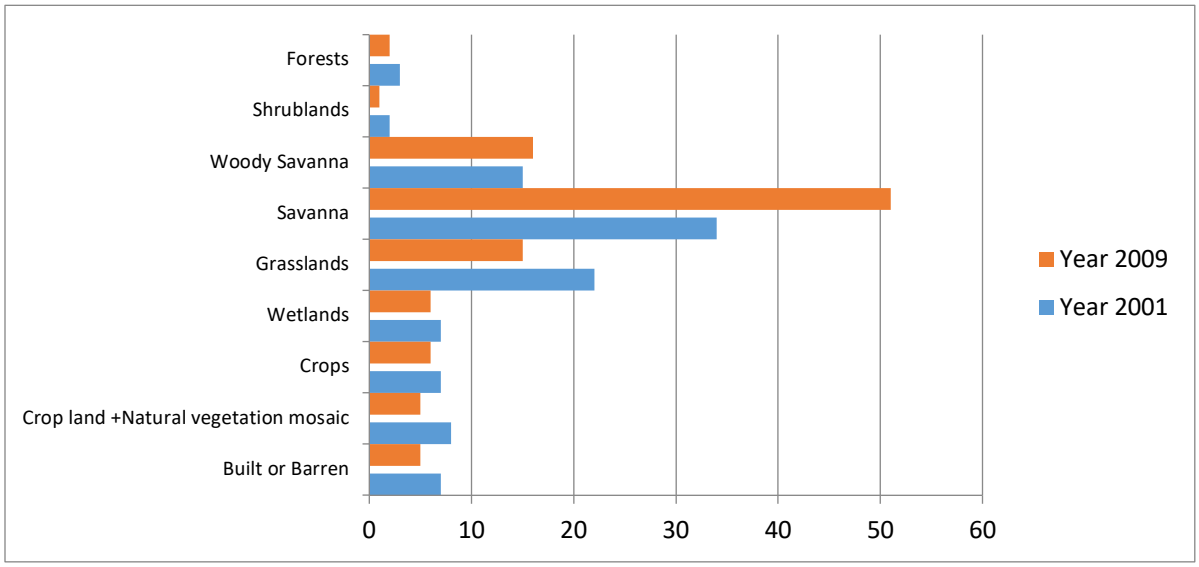


Figure 11b: Relative extents of land cover types in Tanzania in 2001 and 2009 (source: UNEP 2013a)

Uganda

Uganda hosts the major lakes in the basin and 45 percent of the surface area of Lake Victoria. There is a natural fringe of woody savannas along the northern edges of these water bodies, while crops and cropland/natural vegetation mosaic form a border along the southern edges of the lakes (Figures 12a and b). Woody savannas increased by 5.3 percent between 2001 and 2009. Crops and cropland/natural vegetation both increased slightly over the same period. Crops increased by 0.9 percent to 10.1 percent while cropland and natural vegetation increased by 1.4 percent. Savannas decreased slightly from 11.4 percent in 2001 to 11 percent in 2009. In 2009, grasslands and wetlands each made up about 5 percent of the land cover, a 1 percent decrease from 2001. Forests covered 6 percent of the land in 2009, down 2 percent from 2001 despite protected forest reserves such as Budongo, Mabira, Mount Elgon, Queen Elizabeth National Park, Bwindi, Ruwenzori Mountains, Kibale, and Toro-Semliki reserves.

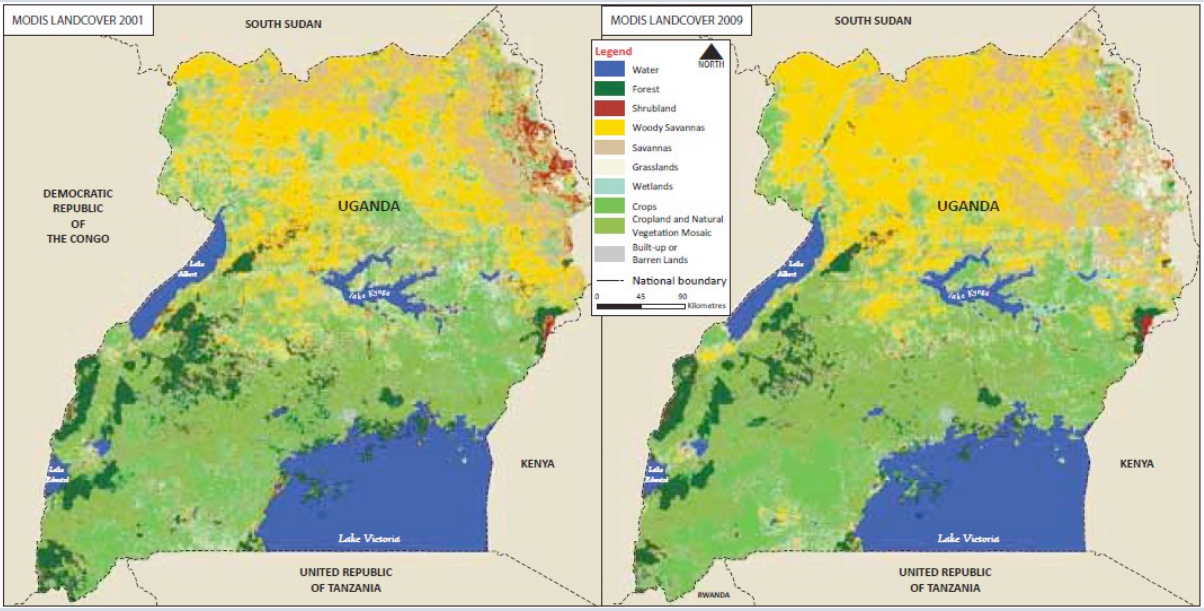


Figure 12a: Land cover change from MODIS between 2001 (left) and 2009 (right) for Uganda (source: UNEP 2013a)

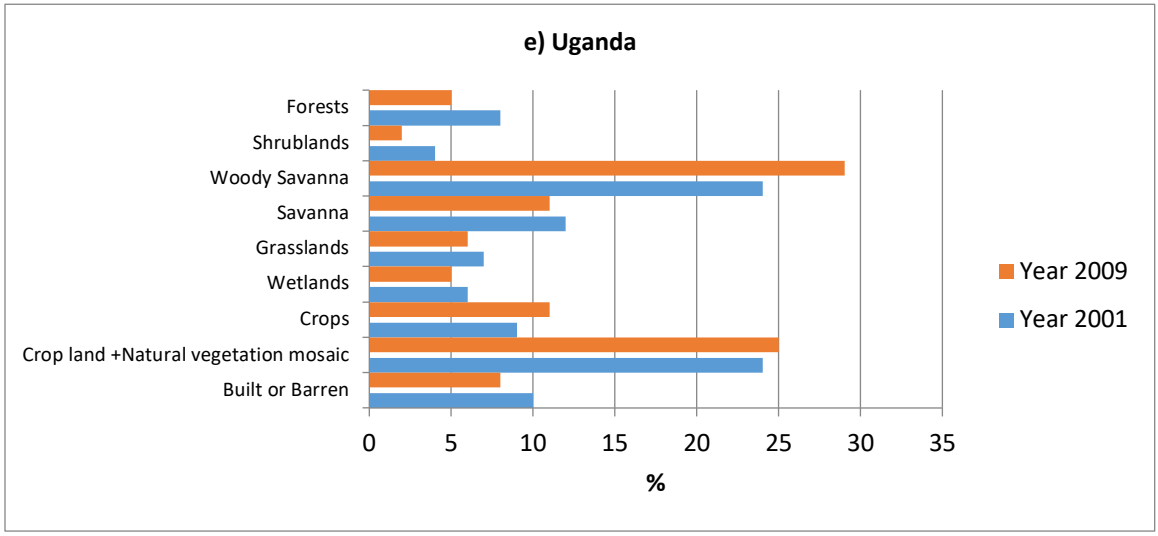


Figure 12b: Relative extents of land cover types in Uganda in 2001 and 2009 (source: UNEP 2013a)

The most critical threat to terrestrial ecosystems in the LVB, including forests, is the pressure caused by growing population density. This leads to growing demand for natural resources both for communities and for urban and industrial use, as well as increased demand for agricultural land and wood.

> *"We are using nature's gift as though we have more than one planet at our disposal. By taking more from our ecosystems and natural processes than can be replenished, we are jeopardizing our very future."*
> *Marco Lambatini, Director General, WWF International.*

3.2 Forest Cover Change and Dynamics in the EAC

Many studies have shown that East Africa is losing its forest cover because of the expansion of agricultural land and settlements, forest fires, mining activities, overgrazing, and illegal harvesting, among other factors. The trends in forest cover loss are shown in Table 1.

Table 1: Trends in the Extent of Forest Cover Between 1990 and 2010 in the EAC

Country	Forest area (1,000 ha)				Annual change rate					
	1990	2000	2005	2010	1990–2000		2000–2005		2005–2010	
					1000ha/yr	Percent	1000ha/yr	Percent	1000ha/yr	Percent
Kenya	3,708	3,582	3,522	3,467	-13	-0.35	-12	-0.34	-11	-0.31
Uganda	4,751	3,869	3,429	2,988	-88	-2.03	-88	-2.39	-88	-2.72
Tanzania	41,495	37,462	35,445	33,428	-403	-1.02	-403	-1.10	-403	-1.16
Burundi	289	198	181	172	-9	3.71	-3	1.78	-2	-1.01
Rwanda	318	344	385	435	3	0.79	8	2.28	10	2.47

Source: FAO 2011.

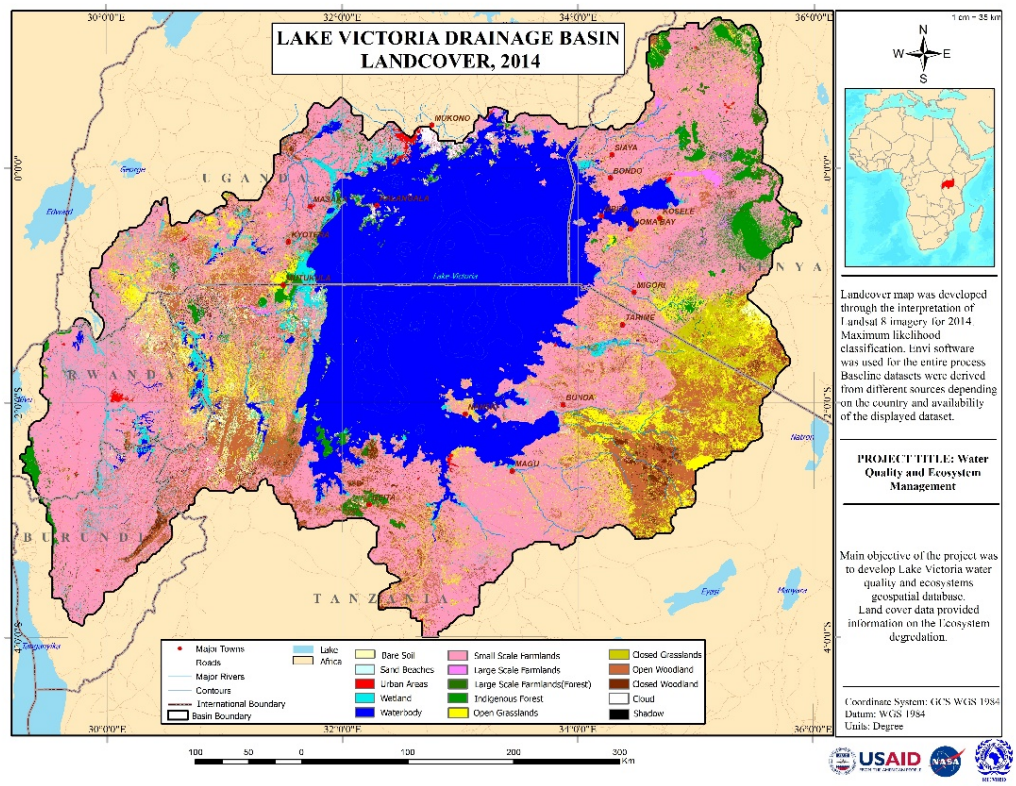


Figure 13: Land Cover for LVB for 2014 (source: Regional Centre for Mapping of Resources for Development [RCMRD])

Although Rwanda now has a positive trend, the country lost about 64 percent of its forests between 1960 and 2007 (REMA 2009). In Burundi, forest cover has decreased from 30–50 percent cover to 4.6 percent—7.4 percent (USAID 2010). During the 1990s, it was suggested that Burundi was experiencing the highest deforestation rate in the world, at 9 percent (Athman et al. 2006). According to the Kenya Forest Service (KFS 2010), Kenya is losing about 12,000 hectares of its forests annually. Decreasing forest cover has also been observed in Tanzania and Uganda. A recent study by the National Forest Resources Monitoring and Assessment Project (NARFOMA) showed that Tanzania is losing forest cover at the rate of 400,000 hectares annually, about a 1 percent annual decline. For Uganda, according to the National Forest Authority (NFA 2009), forest cover has declined from 4.9 million hectares in 1990 to 3.6 million hectares in 2005, about a 1.8 percent annual reduction.

Similar forest loss has been observed in the LVB. A study by Mugagga et al. (2012) examined the spatial and temporal trends in land cover on the slopes of Mountain Elgon in Uganda for the period 1960–2006. The results (Figures 14a and b) confirm a drastic decline of forest and woodland on the slopes of Mount Elgon due to agricultural encroachment, particularly into the national park. Similar trends have been observed in Mount Kilimanjaro, where bushland is progressively being replaced by agriculture.

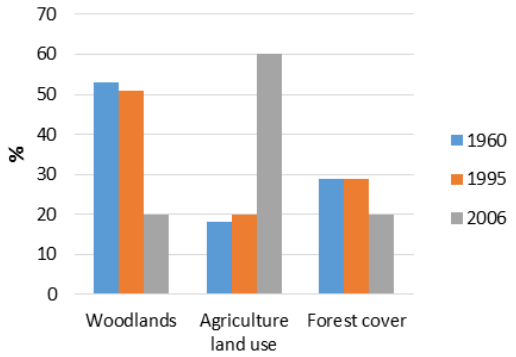


Figure 14a: Land cover change between 1960 and 2006 on the slopes of Mount Elgon (Mugagga et al. 2012)

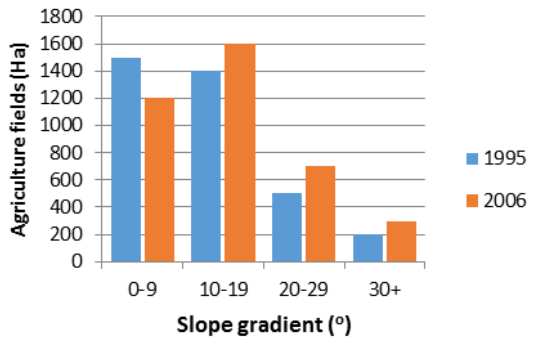


Figure 14b: Expansion of agricultural fields onto critically steep slopes of Mount Elgon (Mugagga et al. 2012)

Similar pressure of human activities and deforestation is experienced in the Kibira National Park area in Burundi. Since the mid-1990s, the forests have faced destruction through bush fires, illegal cutting of wood products, farming, logging, gold panning, grazing, and charcoal production.

3.3 Impacts of Climate Change on Terrestrial Ecosystems

Terrestrial ecosystems in Africa contribute significantly to biodiversity and human well-being. Between 25 and 40 percent of mammal species in national parks in Sub-Saharan Africa will become endangered (IPCC 2007, AMCEN report) and there is evidence that climate is modifying natural mountain ecosystems via complex interactions and feedbacks. A few examples are highlighted below:

- **Ecosystems in East Africa are undergoing changes due to climatic and anthropogenic factors.** Plant phenology, an important ecosystem property, is among the first signs of a response to climate change. Time series remotely sensed imagery have revealed a great variability in phenological patterns over East Africa. Phenological patterns were highly correlated with precipitation patterns and land cover types. The start of the growing season has been delayed in large parts of Tanzania while it has been earlier in parts of Uganda (Figure 15). The results suggested climatic and anthropogenic factors are important contributors to phenological changes but their degrees of influence differ from place to place.

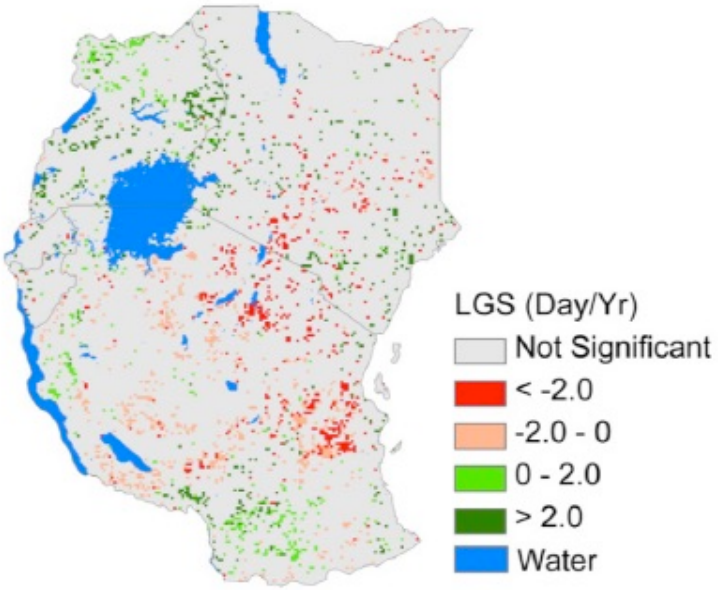


Figure 15: Changes in the Length of Growing Season (source: Qin et al. 2011)

- **Impacts on mountain ecosystems will be greatly influenced by the increased melting (and shrinking) of glaciers.** The ice fields on Mounts Kilimanjaro and Rwenzori have been melting, affecting not only the tourism industry but also the water supply for drinking, sanitation, agriculture, and hydroelectric power production. These impacts may be exacerbated by ecosystem degradation, pressures, such as land use changes, overgrazing, trampling, pollution, vegetation destabilization, and soil losses (Gitay et al. 2001 in IPCC 2007). Mount Kilimanjaro in Tanzania is reported to have already lost more than a third of its ice fields during the last two to three decades (Figure 16). Studies show that Mount Kilimanjaro decreased by 50–80 percent between 1993 and 2000. It is estimated that 80 percent of snow on Mt. Kilimanjaro has disappeared leading to reduced water flows at the foot of the mountain where communities live (EAC 2011b).

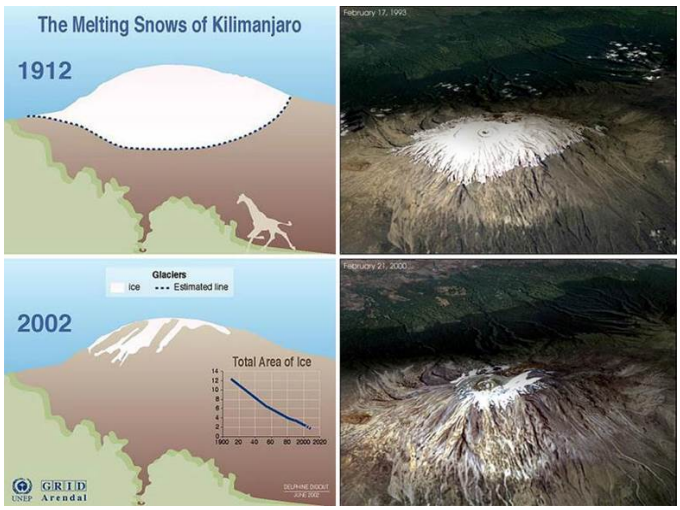


Figure 16: Changes in the snow cap of Mount Kilimanjaro

- **Intensification and expansion of wildfires is likely to increase globally, as temperatures increase and dry spells become more frequent and more persistent.** Among the areas negatively affected by chronic bush fires are Mount Uluguru and Kilimanjaro in Tanzania. On Mount Kilimanjaro, vegetation cover has not only changed but has also been diminishing year after year due to frequent fires.

Climate change will affect individual organisms, populations, species distributions, and the composition and function of ecosystems through higher temperatures and changes in precipitation, as well as through changes in the intensity and frequency of disturbances (IPCC 2002). Many of these systems will be constrained by temperature, aridity, resource availability, habitat requirements, enemies, soil characteristics, competitors, and pollinators (Parmesan Yohe 2003). Figure 17 shows impacts on species range and shows the projected changes in *Acacia abysinnica*, a montane species. It shows a substantial contraction of its range and suggests that it could face extinction due to climate change (MEWNR 2015).

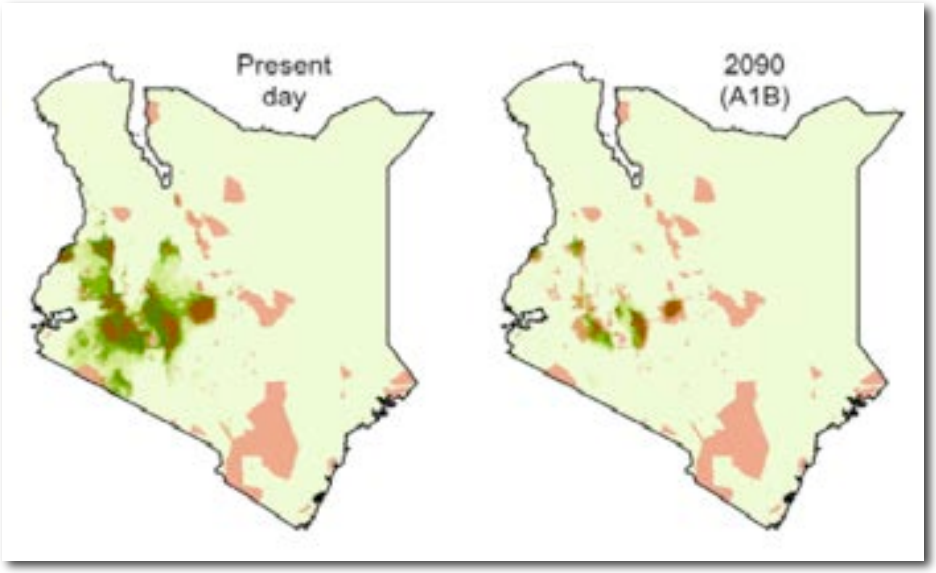


Figure 17: Projected changes in *Acacia abysinnica,* present day to 2090 (source: MEWNR 2015)

- **The ability of savannas and grasslands to sequester carbon will likely be reduced by warming soils, increased wildfires, and more variable rainfall. However, "regional gains in woody cover through direct CO_2-fertilization, and increased plant carbon stocks, cannot be excluded"** (IPCC 2007). Shrub and grassland vegetation types generally have shallow, dense root systems; these plants draw their moisture from water in upper soil layers and their growth is highly dependent upon the timing, intensity, and duration of rainfall. Climate projections suggest that during already dry months, less precipitation will occur, likely reducing the resilience of these plants (Vanacker et al. 2005). Few climate change impact studies have been done for savanna and grassland fauna. The proportion of threatened mammal species may increase to between 10 and 40 percent between 2050 and 2080 (Thuiller et al. 2006a). Ungulates and their preditors are particularly threatened by changing migration routes (Thirgood et al. 2004). In addition, Ogutu and Owen-Smith (2003) found that reduced summer rainfall could result in the extirpation of some African savanna ungulates.

- **Aridity is projected to spread due to changes in temperature and precipitation, most notably in southern Africa.** In a 4°C world, total hyper-arid and arid areas are projected to expand by 10 percent compared to the 1986–2005 base period (World Bank 2013). The 4°C increase will have devastating impacts of the LVB as it will be drier (Figure 18). At 3°C of global

warming the savanna is projected to decrease to approximately a seventh of the total current land area (World Bank 2013).

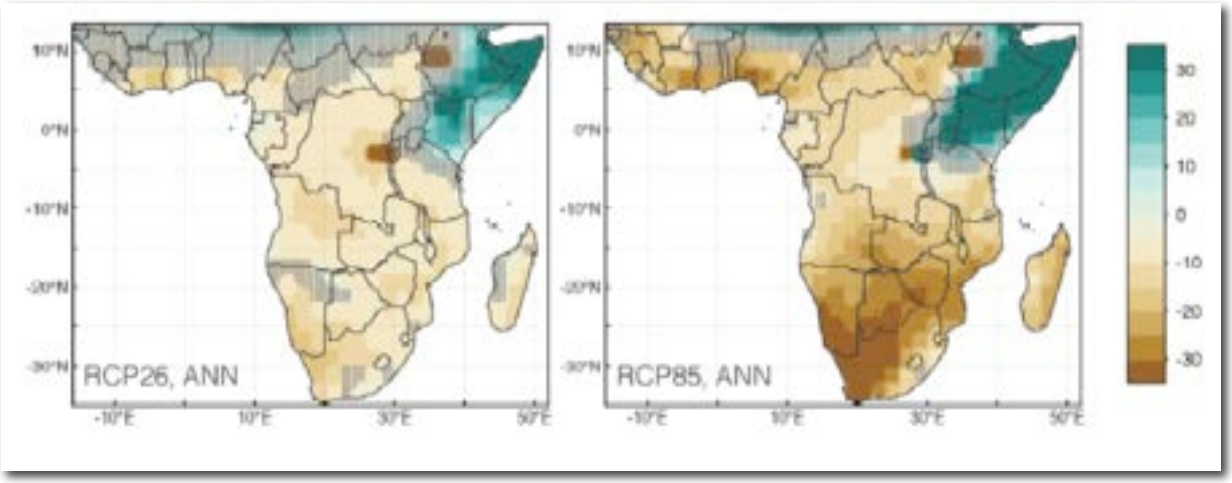


Figure 18: Multi-model Mean of the Percentage Change in the Annual Aridity Index in a 2°C world (left) and a 4°C world (right) for Sub-Saharan Africa by 2071–2099 relative to 1951–1980. Negative change corresponds to a shift to more arid conditions. (source: World Bank 2013)

- **Increased warming is projected to bring shifts in ecosystems, fundamentally altering species compositions and even leading to the extinction of some species (World Bank 2013).** By the 2030s (with 1.2–1.3°C warming), some ecosystems in Africa are projected to experience maximum extreme temperatures well beyond their present range. The distribution of species within savanna ecosystems are projected to shift from grasses to woody plants, as CO_2 fertilization favors the latter, although high temperatures and precipitation deficits might counter this effect. This shift will reduce available forage for both livestock and wildlife that dominated some of these landscapes.

- **Increases in atmospheric CO_2, longer growing seasons, nitrogen deposition, and management changes have resulted in an increase in annual forest CO_2 storage capacity in the past few decades.** This has led to a more significant net carbon uptake and a global net primary production increase of 6 percent from 1982 to 1999 with large increases in tropical ecosystems (Nemani et al. 2003). Cramer et al. (2001) projected a reversal of carbon sequestration gains during the 21st century. This is due to effects on respiration and transpiration that could result in net carbon losses in the global ecosystem.

- **Forests are vulnerable to climate change because trees have long lifetimes and low adaptive capacity to changing ecological conditions through migration.** Climate change will add impacts to already stressed, threatened, and over-exploited ecosystems for number of reasons including agricultural expansion, destruction of habitat, pollution, high rates of land use change, and population growth. Climate change will add to these issues and have major effects on both managed and natural ecosystems and associated services (USAID 2013). According to the Tanzania NAPA (2007), the expected change of vegetation types in the forest zones due to increase in temperature are summarized in Table 2.

Table 2: Predicated Changes in Forests

Type of vegetation	Expected change
Subtropical dry forest and subtropical moist forest life zone	Change to tropical; very dry forest, tropical dry forest and tropical moist forest
Subtropical thorn woodland	Completely be replaced/disappear
Subtropical dry forest	Decline by 61.4%
Subtropical moist forest	Decline by 64.3%

- **Projections of future climate change indicate that unless greenhouse gas emissions are substantially reduced, increased temperatures and other changes in climate could exceed the resilience of many ecosystems** (IPCC 2007b). Climate change could convert extensive land areas from one biome to another, increase wildfire, and isolate or drive to extinction numerous plant and animal species. Approximately 20–30 percent of species assessed so far are at high risk of extinction if global mean temperatures increase 2–3°C above pre-industrial levels (Thomas et al. 2004, IPCC 2007b).

- **Historical and RCP8.5 simulation for the Nyungwe area (Rwanda) (Figure 19) depicts a widespread conversion of tropical forest to agriculture,** a fivefold increase over 70 years. Beyond 2005 the simulation shows stabilization of agricultural area while forests continue to decrease at a lower rate. The forest loss is balanced by an increase of grassland. The forest loss beyond 2005 could be attributed to drivers such as deforestation due to logging, charcoal manufacture, livestock keeping, and bush fires.

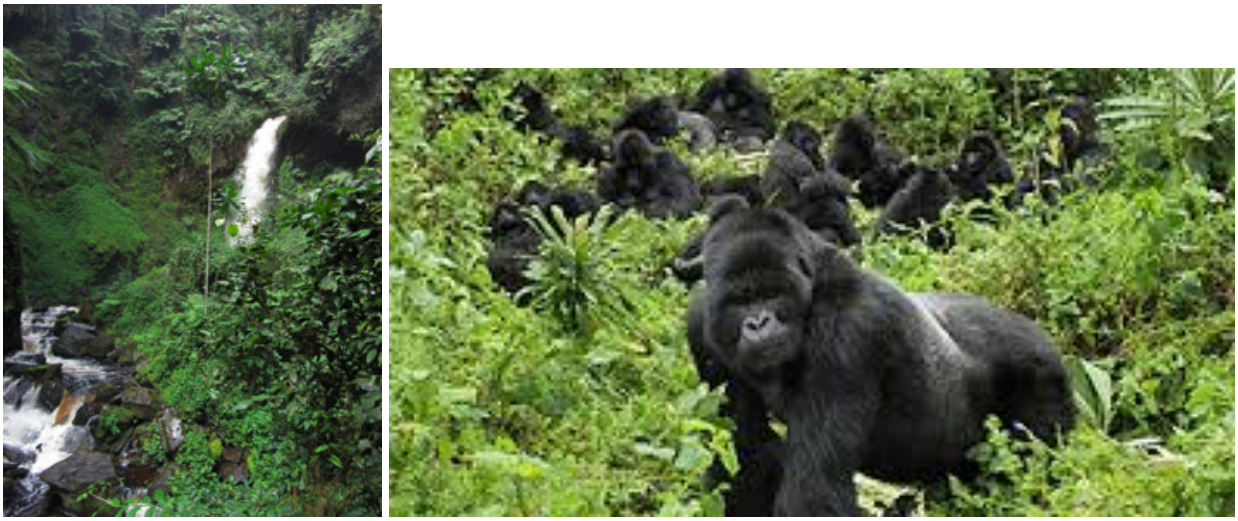


Figure 19: The Nyungwe Forest National Park covers 1,020 square kilometres and includes the largest remaining montane forest in East and Central Africa. It is home to about 310 bird species, hundreds of butterfly and orchid species, and more than 75 mammal species, including 13 primates (about a quarter of all the continent's primates).

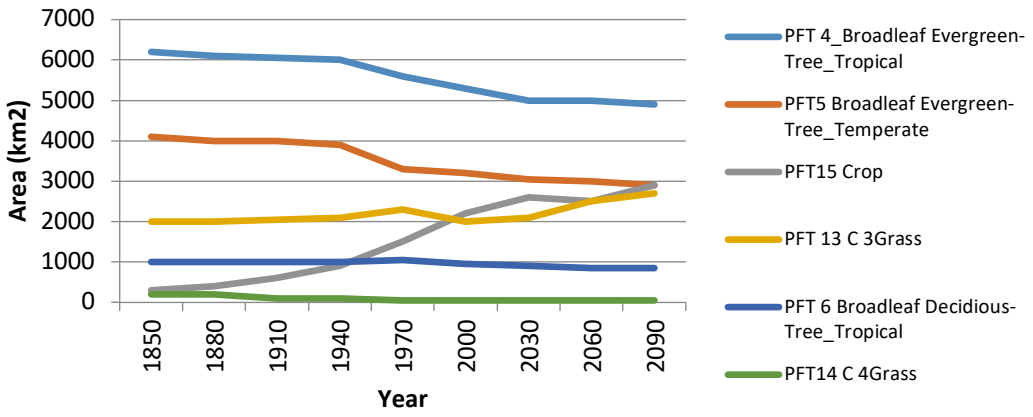


Figure 20: Merged Historical and PCP8.5 Trends in Plant Functional Types (1850-2100) for the Nyungwe Forest National Park (source: Anton Seimon 2012)

4. GLOBAL BIODIVERSITY TRENDS

4.1 BACKGROUND

The world has lost 52 percent of its biodiversity since 1970 (WWF 2014). The number of mammals, birds, reptiles, amphibians, and fish across the globe is, on average, about half what it was 40 years ago (WWF Living Planet Report 2014). This is a much bigger decrease than has been reported previously. Scientists studied trends in more than 10,000 populations of 3,038 mammal, bird, reptile, amphibian, and fish species and calculated a Living Planet Index (LPI). The index measures the health of species in various environments and regions. While the LPI in temperate regions declined by a worrisome 36 percent from 1970 to 2010, in tropical climates the index dropped 56 percent. Latin American biodiversity took the biggest hit globally, plummeting 83 percent. This suggests that, on average, vertebrate species populations are about half what they were 40 years ago. The biggest recorded threats to the planet's wildlife are habitat loss and degradation as well as overexploitation of species. Biodiversity is declining rapidly due to land use change, climate change, invasive species, overexploitation, and pollution (Figure 21). These result from demographic, economic, socio-political, cultural, technological, and other indirect drivers (WWF, UNEP-WCMC).

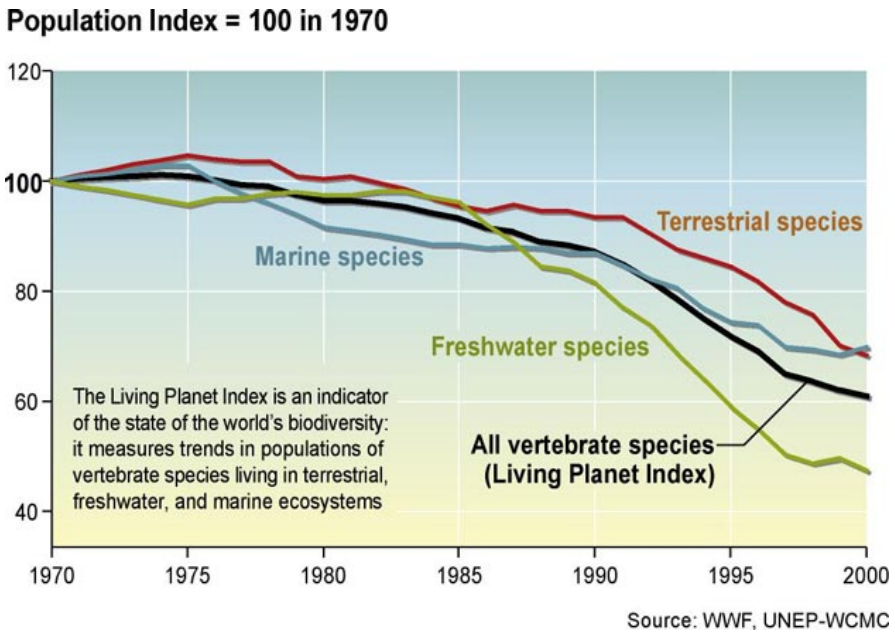


Figure 21: The Living Planet Index Showing the State of the World's Biodiversity

4.2 POPULATION DYNAMICS AND WILDLIFE TRENDS IN THE LAKE VICTORIA BASIN

Regional trends. Analysis of the past 30 years of wildlife trends in Kenya shows a total decline of 67 percent in wildlife between 1977 and 2013 with varying rates of species population decline (Ogutu et al. submitted; Figure 22a). Severely threatened populations include hartebeest (-92 percent), waterbuck (-87 percent), impala (-85 percent), topi (-81 percent), oryx (-79 percent), lesser kudu (-79 percent), eland (-79 percent), warthog (-71 percent), and Thomson's gazelle (-71 percent) (Ogutu et al. submitted).

In Uganda, high declines in wildlife populations, especially of topi (-90 percent), impala (-83 percent), hartebeest (-75 percent), as well as moderate declines in giraffe (-26 percent), Burchell's zebra (-20 percent), but an increase in elephant numbers (93 percent) between 1982 and 2006 was observed (Kaggwa et al. 2009; Figure 22b). The wildlife trends in Tanzania are equally threatening with three wildlife areas—

Burigi-Biharamolo, Katavi, and Tarangire—registering a decline of more than 60 percent of their wildlife. Moderate declines of wildlife population have been observed in the Serengeti (-43 percent) and a slight decline in Ugalla (-19 percent) and Greater Ruaha (-18 percent; TNRF 2008) (Figure 22b).

Other species whose populations are declining include lions, black rhino, African wild dog, and cheetah. Over the past 50 years, Africa's lion population has plummeted from over 200,000 in the 1960s to fewer than 25,000 today (LionAid.org). A rapid decline in lion population in East Africa—a stronghold for lions—mainly due to human-lion conflict and prey decline has been reported (The East African 2015). Currently, Tanzania has the highest lion population estimated at more than 12,000, while Kenya has about 2,000. This has forced the International Union for Conservation of Nature (IUCN) to classify the African lion as vulnerable on its updated Red List (www.iucnredlist.org/details).

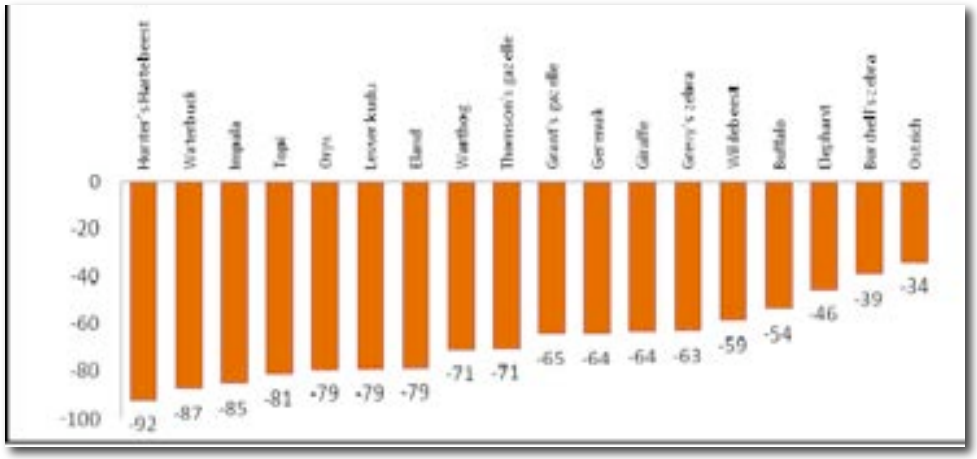


Figure 22a: National trends in wildlife numbers in the Kenyan rangelands between 1977 and 2013 (source: Ogutu et al. Submitted)

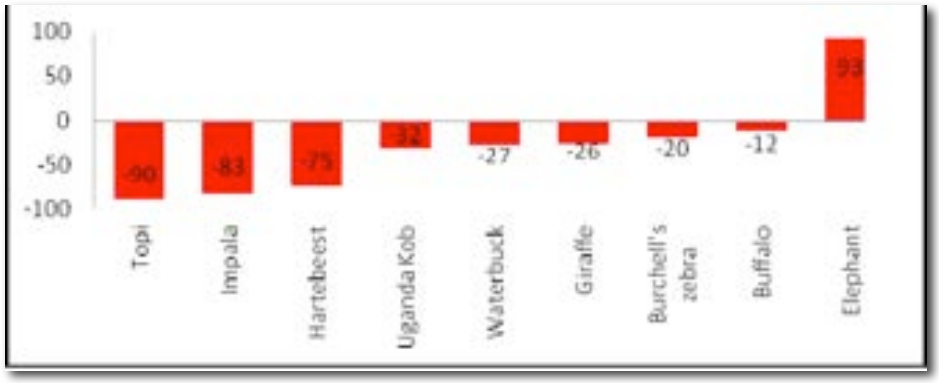


Figure 22b: National trends of selected wildlife in Uganda between 1980s and 2006 (source: Kaggwa et al. 2009)

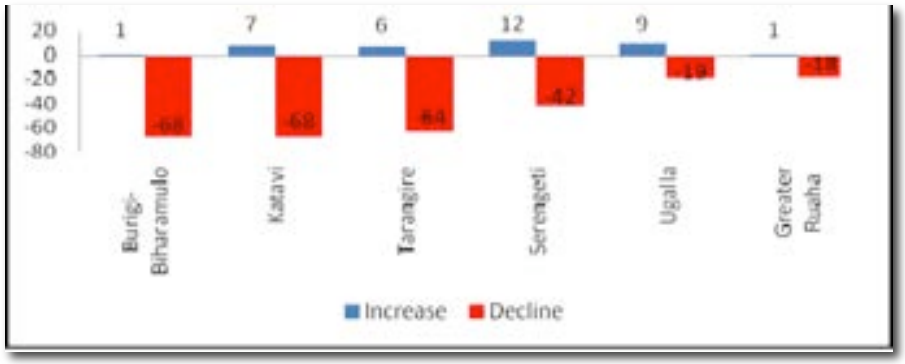


Figure 22c: National trends of selected protected areas in Tanzania between 1980s and 2008 (source: TNRF 2008)

4.3 Case Study: Serengeti-Mara Ecosystem (Tanzania-Kenya)

Across the Serengeti-Mara, an estimated 1.3 million wildebeest and 250,000 zebra make their annual migration in one of the most spectacular sights of the natural world. This area is identified as a hotspot by the Biodiversity Strategy Action plan for the Mara Basin. Key issues include ecosystem degradation by increased human pressure as a result of a growing human population (5.3 percent per year), land use change (grazing and settlement), uncontrolled and unregulated tourism, uncontrolled infrastructure development, invasive species (*Parthenium*), poaching, and water diversion and extraction. The impacts of these activities include habitat modification and fragmentation, a reduction in vegetation cover and species diversity, competition from invasive species, decline in large herbivores, and loss of habitat (LVBC and WWF-ESARPO 2010). These impacts will exacerbate vulnerability of the ecosystem to climate change.

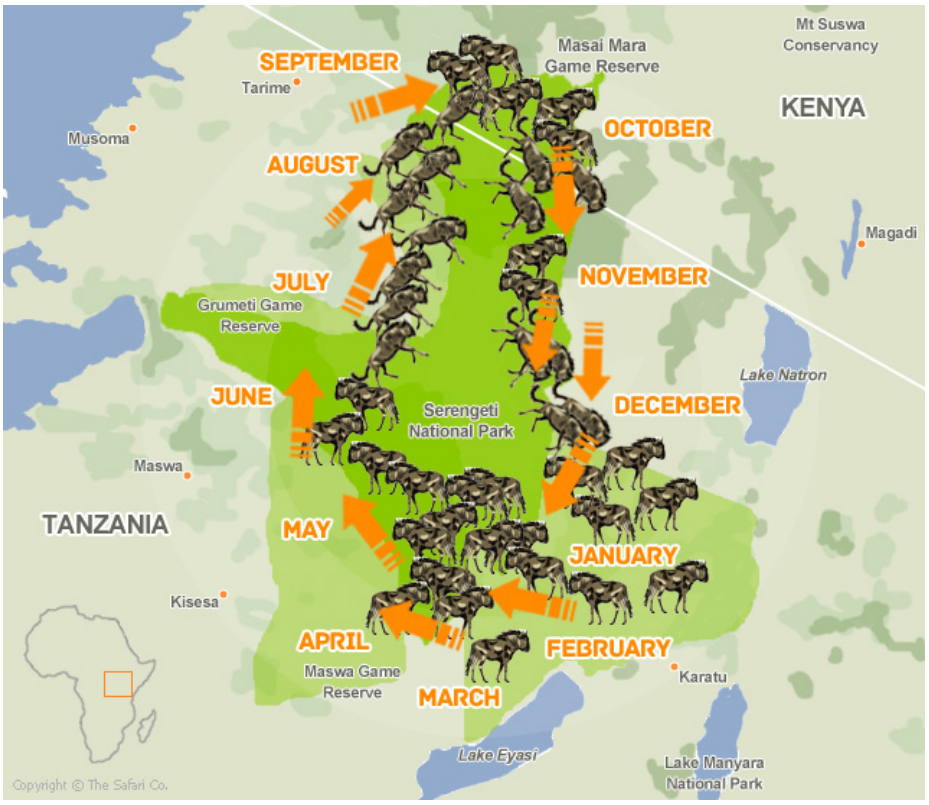


Figure 23: Seasonal Movements of the Wildebeest between Serengeti in Tanzania and Mara in Kenya

Analysis of the change in land cover in the Serengeti-Mara Ecosystem from 1975 to 1995 showed a significant change (Figure 24a). In Kenya, mechanized farming increased from 4,875 hectares to a total of 47,600 hectares, mostly concentrated in the Loita Plains. Smallholder settlements and Maasai bomas have increased in the ecosystem, which has changed the density and cover of vegetation. The Tanzanian part of the ecosystem showed climate-driven fluctuations and some forest succession, but negligible habitat conversion.

According to Ogutu et al. (2011) the wildlife trends indicate a severe decline within the Mara and the adjoining ranches between 1977 and 2009. Only the two gazelle species, impala, and giraffe remained numerically more abundant in the ranches than in the reserve. Buffalo were effectively eliminated from the group ranches. A few hundred wildebeest were resident in Mara during the wet season, although several thousand remained in the group ranches, and few of the migrant wildebeest augment the resident animals in the ranches in the dry season. Zebra showed a very similar pattern (Ogutu et al. 2011).

Cattle numbers in the ranches changed little, while the number of sheep and goats almost tripled between 1977 and 2009 and increments occurred in the inner and outer ranches. Further, the report indicates the numbers of both of cattle and sheep and goats counted within the reserve increased greatly over this period (Figure 24b). Ogutu et al. (2011), Serneels et al. (2001), and Homewood et al. (2001) all indicate anthropogenic factors and policy frameworks have influenced the trends in the two countries and appear to be the fundamental causes of change rather than climate-driven changes. Therefore, the expansion of cultivation, settlement fencing, and livestock stocking levels on pastoral ranches are key drivers of decline in the wildlife resources.

On the other hand, the number of wildebeest (approximately 1.3 million) and zebra (more than 200,000) have remained stable in the Serengeti National Park (Figure 25a). However, the sustainability of the migration will depend more on keeping the corridors open (Figure 25b), the flow of waters from the Mau to the Mara and Serengeti, and joint land use plans for the two areas.

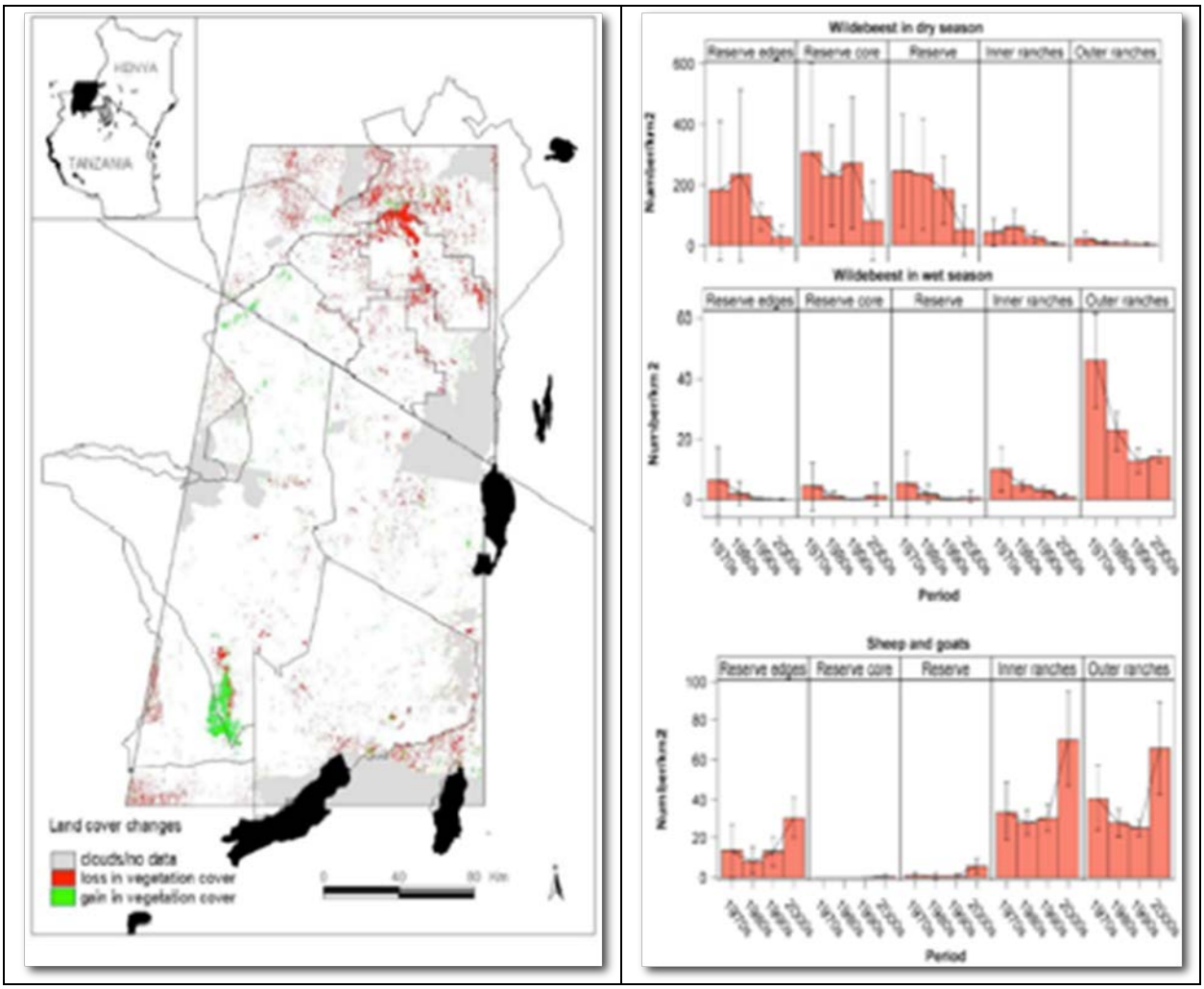


Figure 24: (a) Land Cover in the Serengeti-Mara Ecosystem (left) and (b) Changes in Wildebeest, Sheep, and Goat Population (right) in the Mara Ecosystem (source: Serneels et al. 2001, Ogutu et al. 2011)

Impacts of climate change on the wildlife:

- **Climate change impact studies for savanna and grassland fauna are few.** The proportion of threatened mammal species may increase to between 10 and 40 percent between 2050 and 2080 (Thuiller et al. 2006a). Changing migration routes especially threaten migratory African ungulates and their predators (Thirgood et al. 2004). Ogutu and Owen-Smith 2003 found that reduced summer rainfall could result in the local extirpation of some ungulates.

- **Climate change has the potential to alter migratory routes (and timings) of species that use both seasonal wetlands (migratory birds) and track seasonal changes in vegetation (herbivores).** This may increase conflicts between people and large mammals, such as elephants, particularly in areas where rainfall is low (Thirgood et al. 2004). Bohrer et al. (2014) demonstrate that ungulates respond quickly to changes in forage and water availability, adjusting migrations in response to both large and small rainfall events. A three-year study on Marsabit protected area affirmed that elevational migration of individual elephants closely match the patterns of greening and senescing of vegetation in their home range. Elephants occupied lower elevations when vegetation activity was high, while they retreated to the evergreen forest at higher elevations when vegetation senesced. In the Mara Ecosystem in Kenya, seasonality in wet seasons

dictate vegetation productivity in the ecosystem and local wildlife migrations are evident between the Maasai Mara Reserve and the adjacent ranches and conservancies. During the wet season, wildlife species migrate to the group ranches and conservancies that form their dispersal areas. In the dry season, wildlife migrate back to the reserve due to availability of pasture and permanent water sources (Kenana et al. 2009).

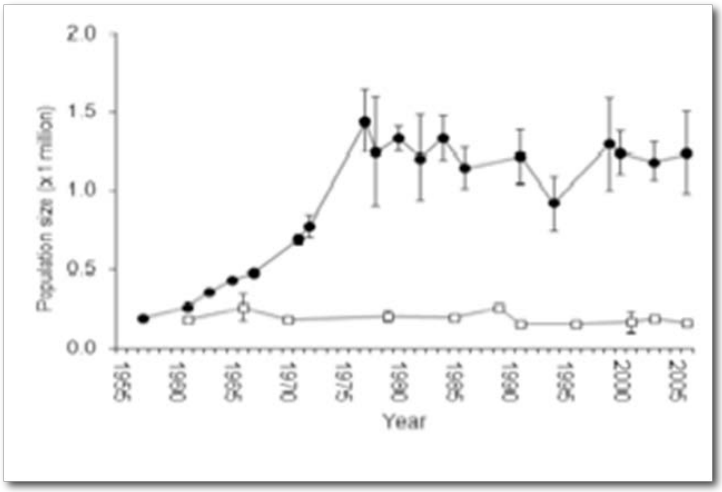


Figure 25a: Trends of wildebeest and zebra in the Serengeti Ecosystem

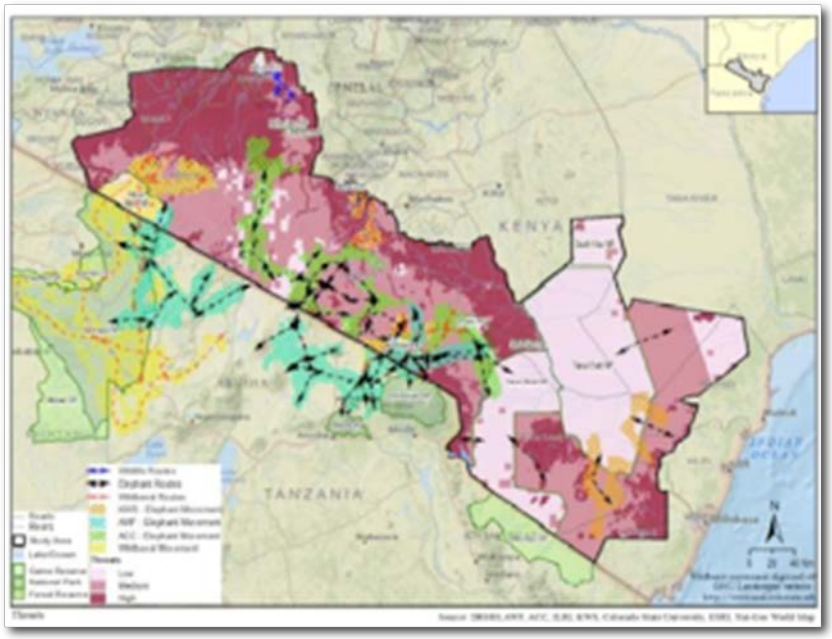


Figure 25b: Migratory routes for the wildebeest, zebra, and elephants in southern Kenya and northern Tanzania

- **Vegetation (habitats) will not respond quickly to changed climate, and wildlife will be unable to migrate to more suitable climatic conditions for lack of corridors between reserves.** Most wildlife in East Africa is conserved in reserve areas surrounded by anthropogenic land use (agriculture and livestock) and face high rates of fragmentation. The net effect is concentration of wildlife in specific areas, making them highly vulnerable to climate change. Moreover, wildlife would be slow in responding to changing habitat boundaries or climatic

envelopes. A study of wildlife status and distribution in the Mara Ecosystem shows that livestock distribution appears to concentrate more at the Mara National Reserve boundary. Over 30,000 cattle were counted within the 5-kilometer zone along the reserve (Figure 26). Of the total livestock counted, 50 percent were within the 10-kilometer reserve- community land interface. This massive population of livestock creates a barrier to wildlife movement and at the same time increases conflict through livestock predation (Kenana et al. 2009).

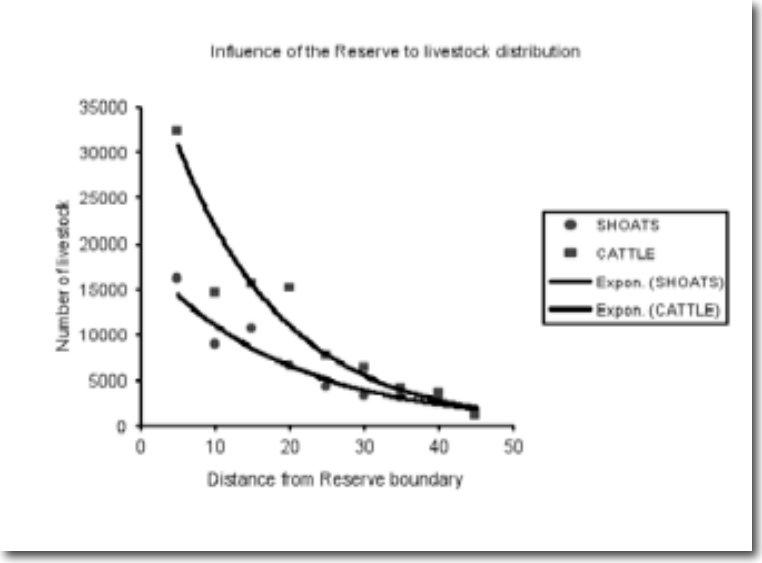


Figure 26: Influence of the Mara National Reserve on distribution pattern of livestock in dispersal areas, Livestock numbers are highest within the 10-kilometer zone to the reserve (source: Kenana et al. 2009)

- Persistent drought due to increase in temperature and unreliable rainfall is predicted to affect the life-cycle of most migratory wild species. According to the Tanzania NAPA (2007), the wildlife sector faces reduction in productivity of ungulates, shrinking of wildlife areas with resultant habitat loss, disappearance of wildlife corridors that impair wildlife movement, and dispersal with impacts on productivity. Changes in ecological systems will lead to the disappearance of some wild animal species. In Kenya, receding rangelands will threaten the livelihoods and way of life of pastoralists and agro-pastoralists, with long-term impacts on migration from drought-prone areas to urban areas, creating pressure on existing urban services (Darkoh et al. 2014). In Tanzania, severe droughts in the 1990s and 2000s are associated with pastoralists' patterns of shifting their herds toward southern Tanzania in search of pastures. This is considered to have led to the destruction of habitats, reduced biodiversity, and destruction of water sources as observed in Ihefu and Great Ruaha River (Kashaigili et al. 2009).

- Plants and animals can reproduce, grow, and survive only within specific ranges of climatic and environmental conditions. If conditions change beyond the tolerances of species, then they may respond by shifting the timing of life-cycle events (such as blooming and migrating), shifting range boundaries (such as moving pole-ward) or the density of individuals within their ranges, changing morphology (such as body or egg size), reproduction or genetics, or extirpation (loss of a population in a given location) or extinction (global loss of all individuals). Additionally, each species has its unique requirements for climatic and environmental conditions. Changes, therefore, can lead to disruption of biotic interaction (such as predator-prey relationships) and to changes of species composition as well as ecosystem functioning. The geographical range, seasonal activities, and migration patterns of many terrestrial species have shifted in response to climate

change (IPCC 2014). However, substantial uncertainties are inherent in these changes because vegetation across much of the continent is not determined by climate alone.

- Many studies of species abundance, composition, and distributions predict shifts related to changes in climatic regimes, often when species' tolerance thresholds for temperature and precipitation are exceeded. Habitat loss and fragmentation may also influence these shifts (Opdam and Wascher 2004). The case study on the assessment of vulnerability of biodiversity to climate change at the borderlands between Kenya and Tanzania indicates potential significant shifts in species and habitats over time resulting in conflicts between agricultural expansion, pastoralists, and biodiversity (USAID 2013). Long-term studies in many of the ecosystem within the LVB, as well as other studies in East Africa, have indicated that wet season rainfall is often the best predictor of animal abundance and survival rate and that rainfall exerts both cumulative (delayed) and immediate effects on abundance. Older animals respond to longer lags in rainfall than younger ones. Table 3 shows the results of a study on the effects of rainfall on animal abundance in Nairobi National Park from 1990 to 1999. This study illustrates the potential impact of increased or reduced rainfall on animal populations.

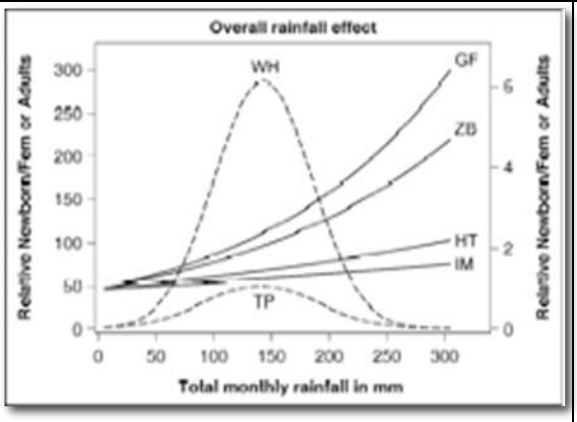
Table 3: Results of Statistical Tests of Significance of Effects of Rainfall on Annual Averages of Animal Abundance in Nairobi National Park 1990–1999

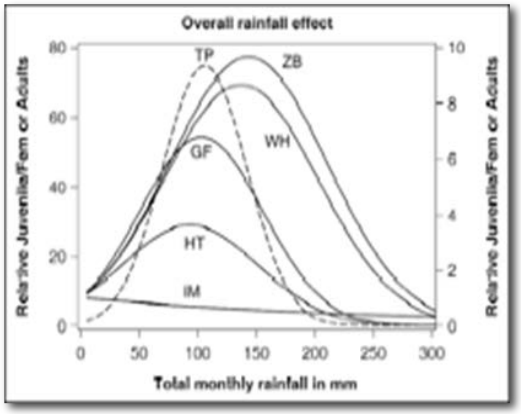
Species	Effect*	NDF	DDF	F	P>F
Kongoni	LMavwet6	1	18	3.68	0.0711
Eland	Mavdry5	1	18	3.16	0.0925
Buffalo	Mavlatewet4	1	18	12.16	0.0026
Giraffe	LMavewet5	1	18	10.43	0.0046
Thompson's gazelle	LMavannaul4	1	18	9.01	0.0077
Grant's gazelle	Mavewet6	1	18	7.97	0.0113
Impala	Mavewet6	1	18	37.06	0.0000
Waterbuck	Mavewet6	1	17	20.08	0.0003
Ostrich	LMavewet6	1	18	7.21	0.0151
Warthog	LMavewet6	1	17	14.79	0.0013
Zebra	Mavwet4	1	18	7.21	0.0151
Wildebeest	Mavewet6	1	18	11.09	0.0037

*Rainfall components are early wet, (October–January), late wet (February–May), wet (October–May), and dry (June–October) season, as well as annual (October–September). A numeric suffix in rainfall component name indicates the time window over which a moving average of the component was computed, e.g., Mavdry5 means 5-year moving average of dry season rainfall. L prefixes in rainfall component (x) name indicate LN(x).

Source: Ogutu et al. 2013.

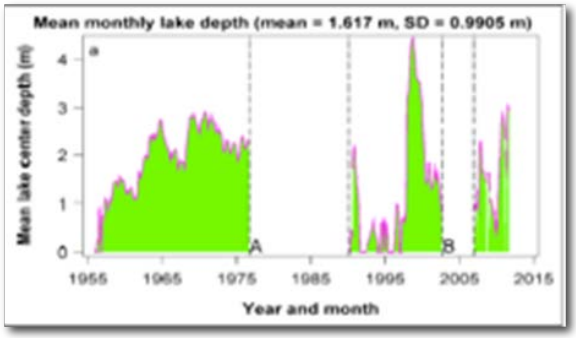
- **Rainfall exerts both cumulative (delayed) and immediate effects on animal abundance. Older animals respond to longer lags in rainfall than younger ones (Figures 27a and b).** In addition, animal abundance typically increases during periods of high but not excessive rainfall and decreases during episodes of drought and flood as illustrated by the effect of rainfall on waterbuck abundance (Figures 28a and b). Due to increased rainfall and rising water levels in Lake Nakuru between 1994 and 1997, the population crashed and has not recovered. The 1994–1997 zero depth indicates complete drying out of the lake, which had great impacts on the population of waterbuck, which had the highest density of species in the world (Ogutu et al. 2010).

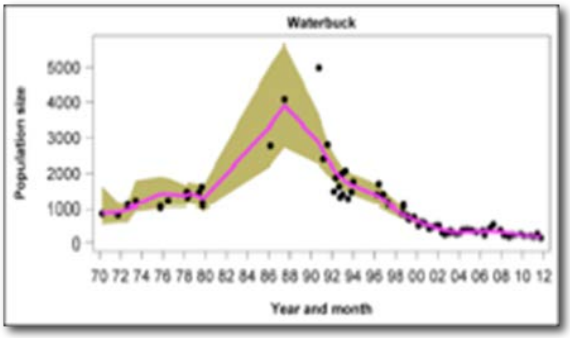




a. Newborns	b. Juveniles

Figure 27: Overall rainfall effect on newborn and juvenile Topi (source: Ogutu et al. 2012)





(a) Lake Nakuru Water Depth	(b) Waterbuck Population Size
Figure 28a: Temporal fluctuations in the monthly averages of the depth of Lake Nakuru from January1956 to 2011, Note: There were gaps in the data from 1976 to 1990 (gap A) and 2002 to 2006 (gap B) (source: Ogutu et al. 2010)	**Figure 28b: Impacts of the drying of Lake Nakuru between 1994 and 1997 and its impacts on the population of waterbuck (source: Ogutu et al. 2010)**

- Although phenological network studies differ with regard to regions, species, and events, data show clear impacts of climate change on species phenology. As an example, droughts delay the onset and reduce the synchrony of calving and fecundity rate and high early rainfall advances the onset of calving and increases synchrony of calving and fecundity rate in Kenya's southern rangelands (Figure 29).

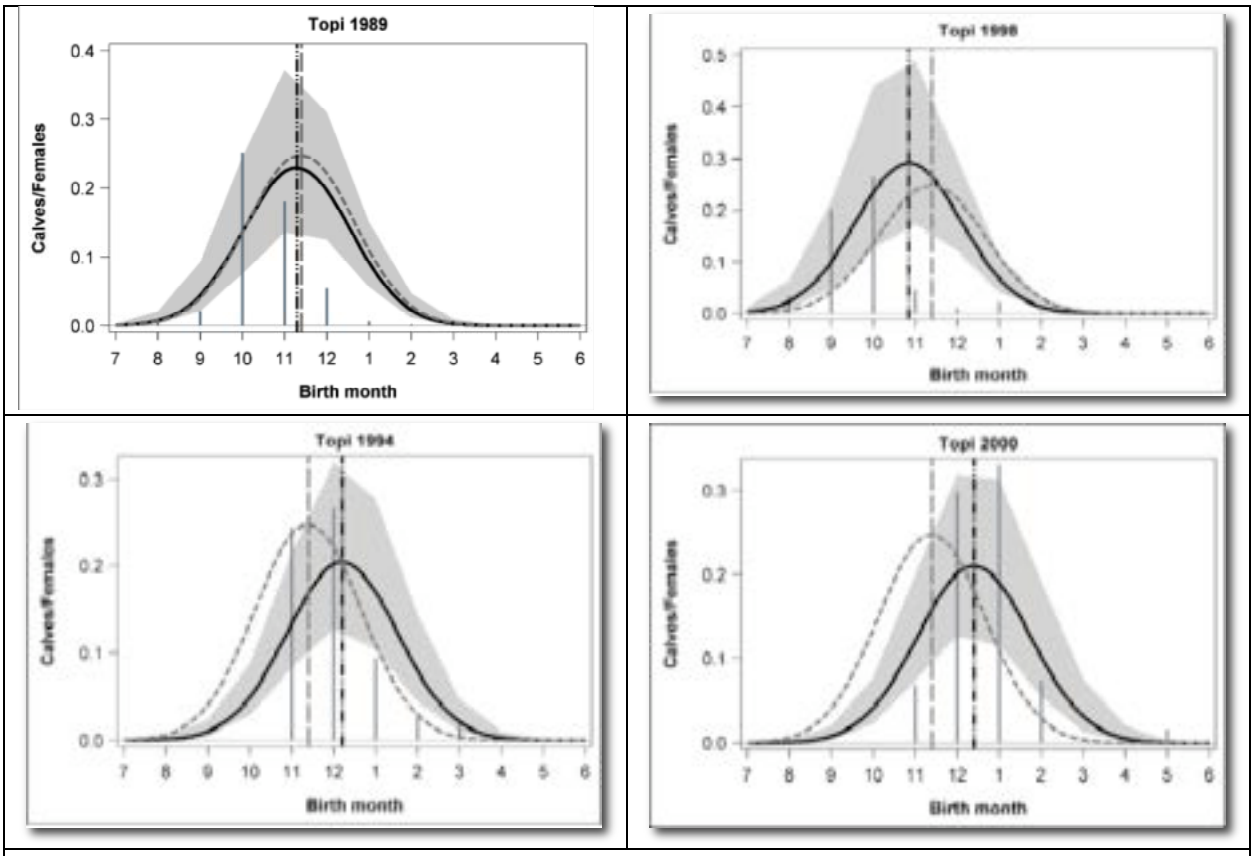


Figure 29: Distribution of the observed number of newborns (solid vertical bars), from the onset of the birth season (July) per adult female and the fitted model (solid black curve) with 95 percent confidence bands (shaded region).

The dashed black vertical line marks the location of the birth peak. The population-averaged model (dashed curve) and location of peak birth month (dashed vertical line) are shown in gray. This 15-year study of topi in the southern Kenya rangelands has shown births were distinctly synchronized (top left). Extreme droughts delayed onset and reduced synchrony of calving and natality rates (top right), but high rainfall advanced onset and increased synchrony of calving and natality rates (bottom figures) (Ogutu et al. 2012).

Changing rainfall seasonality has also been shown to alter plant phenology, leading to mismatches between plant phenology and the phenology of animal breeding.

- **Many primatologists have pointed out that the distribution and abundance of palatable plant species are among the main factors that affect the home range size of a primate.** Milton and May (1976) found that the home ranges of frugivorous and omnivorous species are larger than those of leaf eaters. The mountain gorilla changes its diet through the seasons, subsisting mainly on bamboo and bamboo shoots during the rainy period, but consuming a variety of fruits and seeds in the autumn. Seasonality of food resources is probably a central factor in range size and use.

- **In Rwanda (West province), documented ecosystem services provided by Volcanoes National Park show that changes in climate parameters like rainfall and temperature are already having a negative impact.** Extreme weather conditions and irregularities in season succession are negatively affecting the services rendered by Volcanoes National Park to the surrounding areas. During the days of observation, although one group of mountain gorillas had an altitudinal range of 2,400–2,600 meters and another group had a range of 2,900–3,050 meters, both

groups most commonly occupied the lower forest belt. Mountain gorillas have complicated seasonal movement patterns and long-term data show a correlation between mountain gorilla movement and seasonal changes.

- **Extreme events, such as the El Niño Sothern Oscillation (ENSO) floods of 1997–98 or persistent droughts, can have pronounced and long-lasting effects on water and vegetation and hence on animal populations (Figure 30)**. In this study, recovery of buffalo numbers to pre-drought levels took 8–9 years after the 1984–85 drought but was much slower, with buffaloes numbering merely 36 percent of their 1993 population (12,895 animals) 18 years after the 1993–94 drought despite intermittent periods of high rainfall (Dublin and Ogutu 2015).

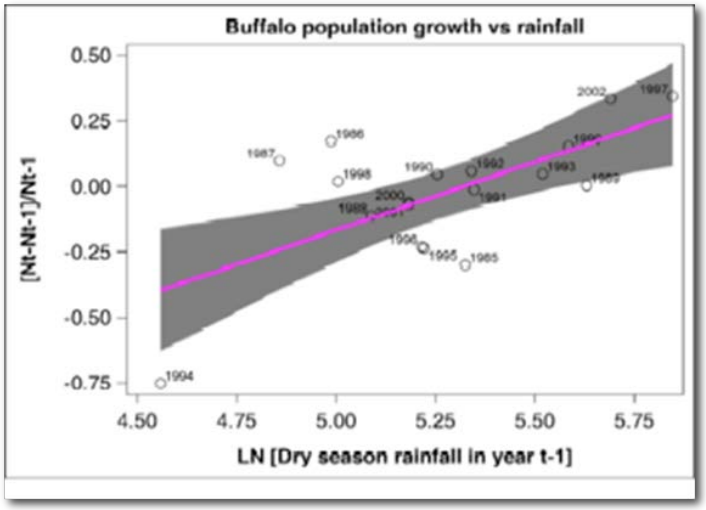
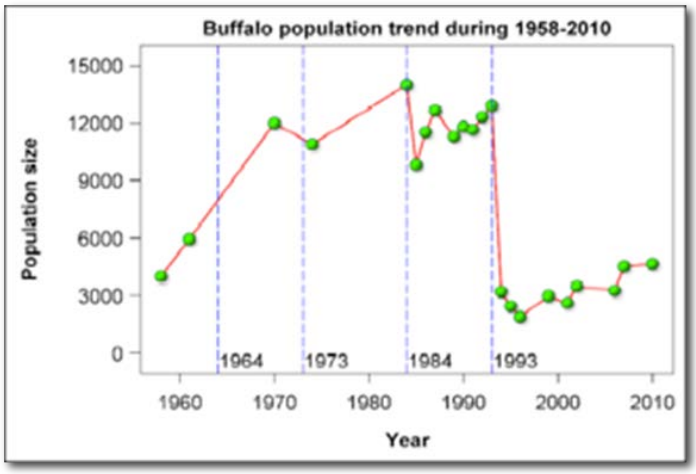


Figure 30: (a) Impact of rainfall on buffalo population recruitment, the study on the impacts of droughts on buffalo indicates severe declines in the population in 1994; (b) the population has not recovered since (source: Dublin and Ogutu 2015)



- **The projected rapid rise in temperature combined with other stresses, such as the destruction of habitat from land use change, could easily disrupt the connectedness among species and transform existing communities, which could lead to numerous localized extinctions.** Key indicators of a species' risk of extinction or extirpation directly affected by rapid global warming include range size, species population density, and the abundance

of its preferred habitat within its range. Decreases in any of these factors can lower species population size (Wilson et al. 2004 in IPCC 2007).

- **Invasive species and other species with high fertility and dispersal capabilities have been shown to be highly adaptive to variable climatic conditions (Malcolm et al. 2002).** Droughts and floods are often associated with outbreaks of epizootics of infectious diseases, such as anthrax and Rift Valley Fever, which can be disastrous to wildlife and livestock. A prominent cause of range contraction or loss of preferred habitat within a species range is invasion by non-native species.

- **A change in the intensity or duration of the rainy versus drought seasons could change relative breeding rates and, hence, genetic structures in these populations (Poole 1989, Rubenstein 1992).** The natural selection of individual plants and animals with resilient characteristics will, as these individuals pass their genes to offspring, drive the evolution of species more adapted to changed climate conditions. For example, in African elephants (*Loxodonta africana*), breeding is year-round, but dominant males mate in the wet season and subordinate males breed in the dry season.

Impact on vegetation:

- **Climate change is likely to be a major threat to the continued existence of some large protected areas (including ones that protect migratory species) that have been designated to conserve Africa's biodiversity.** It is expected that vegetation will migrate to optimize new suitable habitats and niches based on water and nutrient availability. For some species, in some locations, the geographical range of suitable habitats will shift outside the current protected area boundaries and hence be unavailable (Poole 1989, Rubenstein 1992). Mountain ridges, by contrast, represent major obstacles to dispersal for many species and will constrain upward migration on slopes (Foster 2001, Lischke et al. 2002, Pounds et al. 2006). Because temperature decreases with altitude by 5–10°C per kilometer, relatively short-distanced upward migration will be possible. This will reduce species' geographical ranges affecting biodiversity, as well as species distribution. Where warmer and drier conditions are projected, mountain vegetation is expected to be subject to increased evapotranspiration. This could lead to increased drought, which has been projected to induce forest dieback in continental climates, particularly in the interior of mountain ranges (Bugmann et al. 2005).

- **Changes in temperature and rainfall affect the hydrological cycles of rivers and lakes.** High temperatures and less rainfall during already dry months in the Tanzanian river catchments could, as an example, affect the annual flow to the Pangani River by reductions of 6–9 percent and flow to the Ruvu River by 10 percent (WWF 2006). The Pangani Basin is also fed by the glaciers of Mount Kilimanjaro, which have been melting alarmingly fast. The people living around the base of Kilimanjaro depend on water from melting glaciers and fog for drinking, irrigation, and hydropower.

4.4 Human-Wildlife Conflict

- Human-wildlife conflict occurs mainly when wildlife requirements encroach on human population, normally with a cost for both people and the wild animals (IUCN 2005). This conflict can be associated with various factors, including but not limited to economic development, natural factors, human interference, and migration for security and food reasons. For example, in Rwanda's Volcanoes National Park, the most frequent crop raiders are buffaloes, mountain gorillas, and golden monkeys in that order. Other animal raiders include porcupines, antelopes,

and occasionally, elephants. Most of the impacts include destruction of famers, human injury, and death (Figure 31).

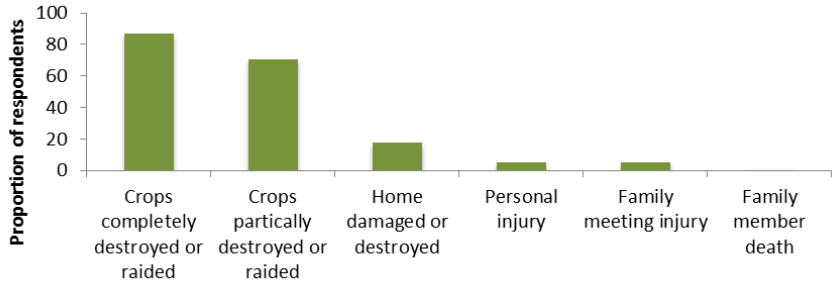


Figure 31: Wildlife-human conflicts *(source:* Big Life Foundation Post Implementation Survey 2016)

- Kenya has a compensation scheme for livestock killed by lions as well as a compensation scheme for loss of human life or injury (Wanjau 2002). The latter scheme has often been criticized for being insufficient and for not considering the dependents of the deceased (Obunde, Omiti, and Sirengo 2005). To address those concerns, the scheme was revised in the Wildlife Conservation and Management Act of 2013. Under the new law, compensation of up to five million shillings is provided for loss of life, three million shillings is provided for injury occasioning permanent disability, and a maximum of two million shillings, depending on the extent of injury, is provided for all other injuries. Compensation of loss or damage to crops, livestock, or other property from wildlife is also provided for. In Rwanda, to minimize human-wildlife conflicts, the wildlife laws were amended to include compensation for damage caused by wildlife (Law No. 26/2011 of 27/07/2011). Community conservation efforts in Rwanda have seen the reintroduction of lions in the Akagera National Park after 15 years of absence. The park, with the support of the community, is using various ways to increase awareness of the importance of conservation. In Uganda, a revenue-sharing fund is used to give back to communities that bear the costs of living next to protected areas and create good relationships and partnerships with protected area management (UWA 2011). This Gorilla Levy Fund, established in 2006 for Bwindi and Mgahinga, collects US$5 from every gorilla tourism permit.

5. TOURISM

5.1 GLOBAL TRENDS IN TOURISM

Tourism is an important sector for international commerce and is a major source of income for many developing countries. It contributes 9 percent to the global GDP, 1 out of 11 jobs, US$1.5 trillion in exports, 6 percent of world's exports, and 30 percent of service exports (UNWTO 2015). International tourist arrivals hit a record 1,133 million worldwide in 2014 up from 1,087 million in 2013 (a 4.3 percent increase), and demand for tourism continues to be strong in the source markets and destinations (UNWTO 2015). Africa's international tourist numbers grew by about 2 percent, equivalent to an increase of one million arrivals, reaching a total of 56 million tourists. Tourism contributed US$36.4 billion to Africa in 2014 (UNWTO 2015). However, the region has the lowest international tourist arrivals and receipts compared to other regions of the world. Europe has the highest international tourist growth rate (3 percent) having received 15 million more international tourists with 583 million arrivals (UNWTO 2015). Nature-based tourism is the major tourist attraction for many African countries, including East Africa.

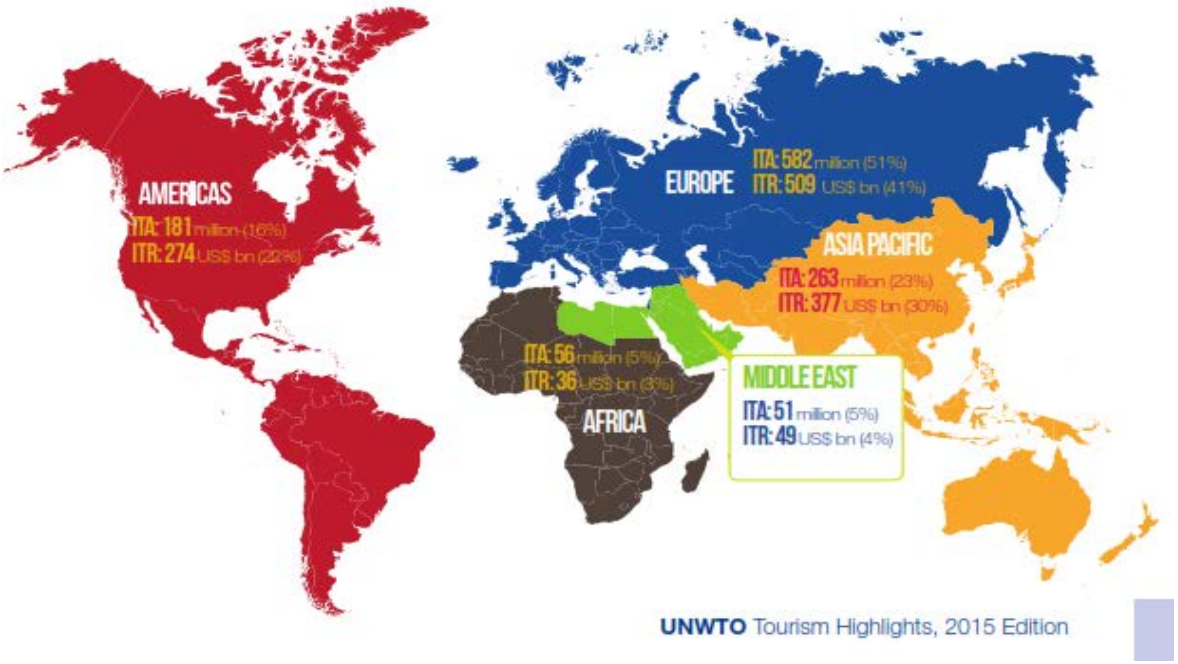


Figure 32: Global International Tourism Arrivals and Receipts Per Continent

International tourist numbers have been projected to increase by 3.3 percent a year over the period 2010–2030. International tourist arrivals will increase by 43 million per year in 2030. Based on these projections, international tourist arrivals worldwide are expected to reach 1.4 billion by 2020 and 1.8 billion by 2030 (Figure 33).

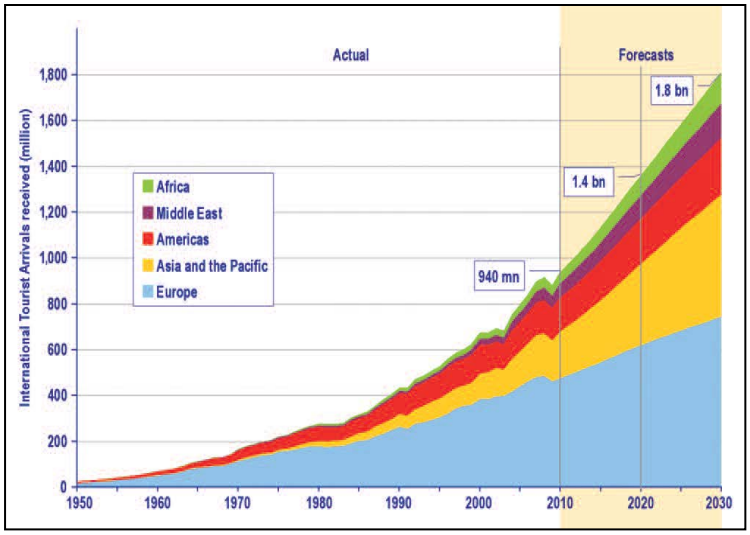
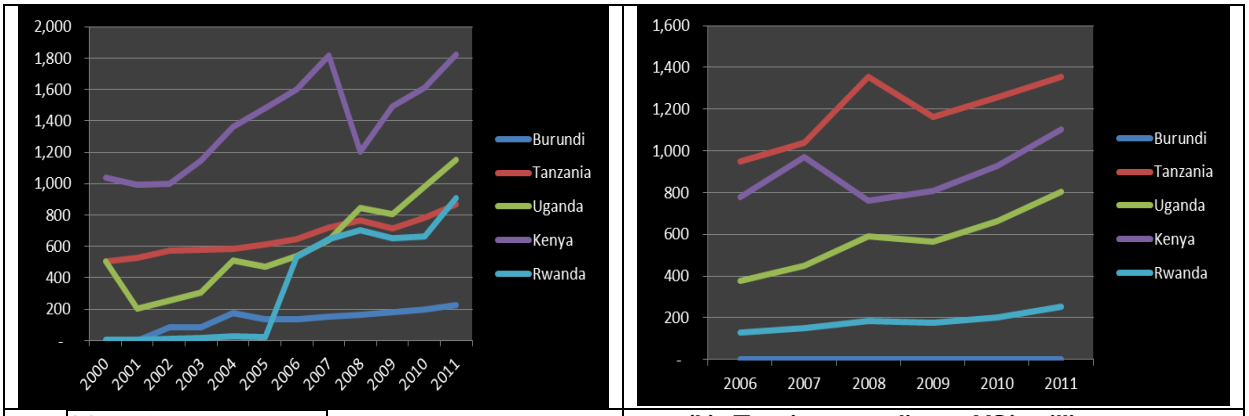


Figure 33: UNWTO Tourism Towards 2030: Actual trend and forecast 1950-2030 (source: UNWTO 2015)

5.2 Regional Trends in Tourism

The number of tourists visiting the EAC countries generally increased between 2000 and 2011 as indicated in the Figures 34a and b. The number of tourists visiting the EAC rose from 2 million in 2002 to 5 million in 2011 and tourism expenditure in the region rose from US$2.2 million in 2005 to US$3.5 million in 2011. There are differences in terms of the tourist generating regions for the different East African countries. In 2011, 76 percent of Uganda's tourists were from Africa, while the rest came from Oceania (Government of Uganda 2012).



(a) Visitors, thousands | **(b) Tourist expenditure, US$ million**

Figure 34: Foreign visitors/tourists visiting East Africa (source: http://www.eac.int/)

According to the national report on tourism in Rwanda, travelers increased from 27,000 in 2004 to 1,080,000 in 2012, tourism-related revenues increased from US$15 to US$282 million. The statistics of tourist arrivals in Burundi are incomplete and less accessible, which prevents effective development planning of the sector. The country's travel and tourism industry, however, remains undeveloped and only contributes marginally to the country's GDP (3.8 percent). Visitor numbers have only increased marginally since the 2001 peace agreement. Insecurity in the region has contributed to a sudden decline in number of tourist visits, with Kenya being the most affected country. The number of arrivals declined from 1,780,768 in 2012 to 1,519,600 in 2013, revenues also declined from 96 billion Kenya shillings to 87 billion Kenya shillings.

5.3 Socioeconomic Contributions

Tourism is an important source sustainable growth, job creation, and poverty alleviation across Africa (Table 4), but without the draw of its spectacular wildlife, future tourism development and millions of people depending on it will suffer (UNWTO Secretary-General Taleb Rifai, 2014). Of the five countries, tourism contributes significantly to GDP in Kenya and Tanzania (Groner 2003).

Table 4: Magnitude of Tourism in East Africa

Country	International arrivals (thousands) (UNWTO Highlights, 2014)	Receipts (millions) (UNWTO Highlights, 2014)	Direct employment (WTTC,2011)	Total contribution to GDP (%) (WTTC, 2011)
Burundi	N/A	$2 (2012)	36,000	5.1
Kenya	1,619 (2012)	$935 (2012)	247,300	13.7 (3rd)
Rwanda	815 (2012)	$282 (2012)	54,200	8.4
Tanzania	1,043 (2012)	$1,713 (2012)	432,100	13.3 (1st)
Uganda	1,197 (2012)	$1,135 (2012)	202,100	8.2

The tourism sector contributes an average of 12 percent to GDP in Kenya (http://www.eac.int/). In Tanzania, it contributes 14 percent and employs 30,000 people (United Republic of Tanzania, 2007). In Burundi, tourism contributes about 3.8 percent to GDP. It contributes to poverty reduction and peace-building by ensuring that development and employment opportunities are created in the country. Rwanda has many tourist attractions, the main one being Volcanoes National Park and the mountain gorillas. The tourism sector is the second major source of foreign currency in Rwanda.

In 2012, Kenya was leading on tourist arrivals, but the numbers declined in 2013. Rwanda and Tanzania had more tourists in 2013 than the previous years, while arrivals in Burundi and Uganda were unchanged. The data available do not indicate the gender issues regarding the tourist arrival statistics. Uganda's tourism sector has also significantly improved over the years and currently contributes 8.2 percent to the GDP (World Travel and Tourism Council Data, 2011) and is the major foreign exchange earner for the country. Much of the tourism activity across the EAC Partner States is nature-based. It is a sector where women and youth have found a place to work. According to the Rwanda Tourism Authority, the industry generated $304.9 million in 2014, becoming the country's largest foreign exchange earner. This was an increase of 4 percent compared to $293.6 million in 2013. The total number of visitors rose to 1.22 million, compared to 1.12 million visitors in 2013.

5.4 Specific Impacts on Tourism due to Climate Variability and Climate Change

Tourism in developing countries, including East Africa, might be subject to changes in tourist behavior due to increasing environmental awareness. Tourism may be affected by changes in water and vegetation, as well as by fuel prices and by shifts in demand for particular activities or destinations.

Although scientific evidence is still lacking, it is probable that flood risks and water pollution–related diseases in low-lying regions (coastal areas), as well as coral reef bleaching due to climate change, could have a negative impact on tourism (McLeman and Smit 2004, IPCC 2007). However, modelling climate change as well as human behavior, particularly personal preferences, choices, and other factors, is exceedingly complex.

The wildlife and protected areas on which much EAC tourism depends are mainly in the arid and semi-arid areas, which are characterized by low and erratic rainfall as well as high evapotranspiration rates. Climate change impacts on tourism may include shifts in preference from major tourist destinations such as Serengeti and Mara to less-visited areas and reduction of revenue from tourism. Fire also is a serious threat to tourism since the effects may result to the loss of endemic biodiversity. Prolonged droughts may result in changes in vegetation and ecological zones, thus affecting the distribution of wildlife in some areas. A severe drought in the Amboseli ecosystem resulting in a reduction in the wildebeest population by more than 85 percent in 2009 (MEMR 2012). By 2010, the population was only 3,000 animals, down from over 15,000 before the drought, the lowest observed for more than 30 years (MEMR 2012).

The impacts of climate change on migratory routes of wildlife, including degradation of arid and semi-arid ecosystems that are major wildlife habitats, are likely to worsen the already threatening poverty situation. Unfortunately, there are no gender disaggregated data on the role of tourism in sustaining development within the EAC Partner States.

Changes in hydrological cycles may affect the range, migration, and distribution of plant and animal species. Hydrological cycles in Great Rift Valley lakes, currently affected by high water levels, disrupt wildlife and make some destinations, such as Lake Nakuru, unavailable or less attractive to tourists. Hydrological changes in Lake Manyara and Lake Nakuru may alter the migration and breeding patterns of bird species, such as flamingos, that are a popular attraction. In Kenya, the Budalangi floods resulting from the swelling of the Nzoia and Yala rivers displace over 25,000 people (Odala et al. 2006).

5.5 Gender and Livelihood Factors

Some gender disaggregated data that are needed in this section include population statistics—numbers, structure, and distribution—as well as data relating to tourism activities (gender disaggregated data on number of women, men, and youth employed, nature of employment, and hours of work). The information is useful in explaining the contribution of terrestrial sector (particularly, tourism) to promoting gender equality and women's empowerment as well as its role in the country's GDP and employment creation. Such a contribution is important in sustaining livelihoods in both urban and rural areas. However, data are lacking on the number and age of women, men, and children who have become vulnerable to climate change impacts due to degradation within terrestrial ecosystems.

The population of East Africa is characterized by high levels of poverty and a majority of the population directly depends on ecosystem resources for survival. Women obtain firewood from the forests, while many communities rely on forest resources for medicinal plants, building materials, and cultural activities, hence their importance for sustainable future communities. The population between the ages of 15 and 39 may have potential for increasing pressure on ecosystems when trying to meet daily needs. In 2014, young people in Burundi, Rwanda, Tanzania, and Uganda accounted for at least 30 percent of the total population. In Kenya, it was between 20 and 29 percent (UNFPA 2014). When not properly managed, the projections for 2050 and 2100 could be disastrous to ecosystems due to demand for more land for agriculture and food security, urbanization, infrastructure (water, transport, health, and energy) and human and animal migrations from deteriorating terrestrial ecosystems and livelihood systems.

The demand for additional land for human activities has led to deforestation of many forest ecosystems in Burundi, Kenya, Tanzania, and Uganda. Pressure on land resources has contributed to clearance of forests, followed by human settlement, leading to health risks (highland malaria) and landslides, thus threatening human lives. Heavy use of biomass fuels among low-income populations also contribute to greenhouse gas emissions, which are responsible for climate change, thus increasing the vulnerability of many human populations with low adaptive capacity, a situation with greater impacts on women, youth, and children. Failure to address population increases would lead to unsustainable biodiversity;

environmental resources that maintain livelihood systems; enhanced environmental deterioration; negative impacts on water, food, and energy security; negative economic growth; lack of social progress and social security; adverse health impacts and reduced life expectancy; and inadequate capacity to adapt to and mitigate climate change.

6. MAPPING VULNERABILITY HOTSPOTS FOR THE TERRESTRIAL SECTOR

Mapping of terrestrial sector hotspots was based on the three factors that determine the extent to which a system is susceptible to climate change: exposure, sensitivity, and adaptive capacity. An iterative process was used to identify possible indicators that would allow measurement and quantification of these factors (Table 5). In the end, only suitable indicators were selected, based on spatial coverage and availability of data. The indicators covered all countries in the EAC. Some indicators were later dropped because they either were not feasible or did not cover the entire LVB. This included land use plans (not available), temporal NDVI (a layer on land use-land cover (LULC) dynamic was enough to explain vegetation changes over time), drought frequency (not available), and frequency of fire (in protected areas, fire is not always a threat and is sometimes used as a management tool).

Based on analysis of the indicators shown in Table 5, spatially explicit indicators were identified and mapped using geographic information system (GIS) tools to generate a vulnerability map for the terrestrial sector in the LVB. The details of the methodology and results from the analysis are presented below.

Table 5: Indicators Used to Assess Vulnerability Components

No.	Vulnerability component	Factor	Possible indicator
1	Exposure	Rainfall	i. Annual rainfall variability (CV)
			ii. Occurrence (frequency) of drought and floods over the years
		Temperature	iii. Monthly min & max temperature
			iv. CV for min & max
2	Sensitivity	LULC	i. LULC dynamic
		NDVI	ii. NDVI dynamic
		Human population	iii. Population dynamic
		Animal population	iv. Level of protection (NP, GCA, NR, GR, FR) v. Wild animal & Livestock population dynamics
		Topography	vi. Slope (%)
3	Adaptive capacity	Protected areas	i. Conservation status (conservancies, wildlife management areas, community-based conservation development)
		LUP	ii. Presence/absence of LUPs

Note: CV = Coefficient of Variability, LULC = Land use/Land cover, NDVI = Normalized Difference in Vegetation Index, NP = National Park, GCA = Game Controlled Area, NR + Nature Reserve, GR = Game Reserve, FR = Forest Reserve, WMA = Wildlife Management Area

Exposure: The coefficient of variation for annual rainfall (Figure 35), as an exposure layer, was generated using a spatial analysis tool for climatological analysis of historical rainfall and temperature data generated from the PREPARED GeoCLIM tool. Five levels of variability were mapped, areas with low to very high annual rainfall variability, based on 1984–2014 historical rainfall data.

The figure shows high variability of rainfall on the southeastern side of the LVB, which includes the Serengeti-Mara Ecosystem compared to other parts of the basin. This could have negative impacts on the terrestrial sector that could lead to lead to unreliability in vegetation growth. As a result, habitat for wild animals and pasture for livestock will be negatively affected.

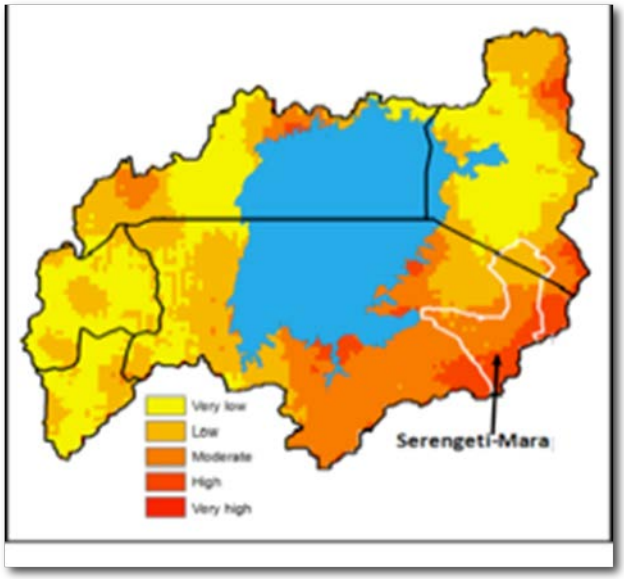


Figure 35: Exposure map based on Rainfall variability (1984–2014) on the LVB

Sensitivity: The GIS data for identified indicators were obtained from the Regional Centre for Mapping of Resources for Development (RCMRD). These included 2015 human population density, cattle density, goat density, and LULC dynamic (1985–2014). The GIS layers were further processed using ArcGIS software to produce different levels of vulnerability. The vulnerability classes for human and livestock population in the LVB are as shown in Figures 36, 37, and 38.

Generally, a higher density of either human or livestock is expected to negatively affect the terrestrial sector because of increased demand and competition for natural resources generated. Figure 36 shows that the western side of Lake Victoria and the Serengeti-Mara ecosystem are thinly populated by both humans and livestock. However, the areas adjacent to the Serengeti-Mara ecosystem are densely populated by livestock and in some sections cultivation is right on the park border, fueling constant conflict as wild animals destroy crops or are illegally hunted. As a result, the ecosystem is progressively losing area, species, and habitats.

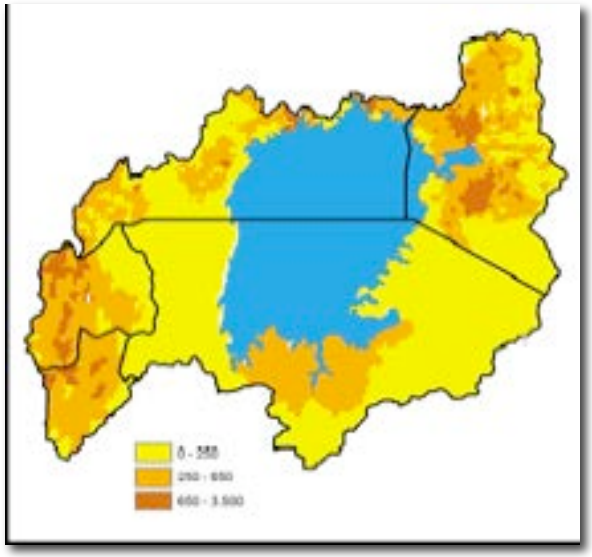


Figure 36: 2015 human density in the LVB (source: RCMRD)

Dense population is shown over most areas of the basin decreasing toward the Mara-Serengeti. Encroachment of human activities is shown in the ecosystem.

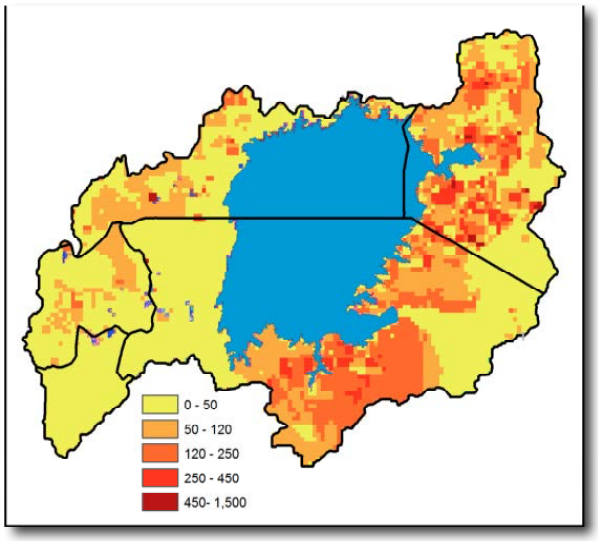


Figure 37: Cattle density in the LVB (source: RCMRD)

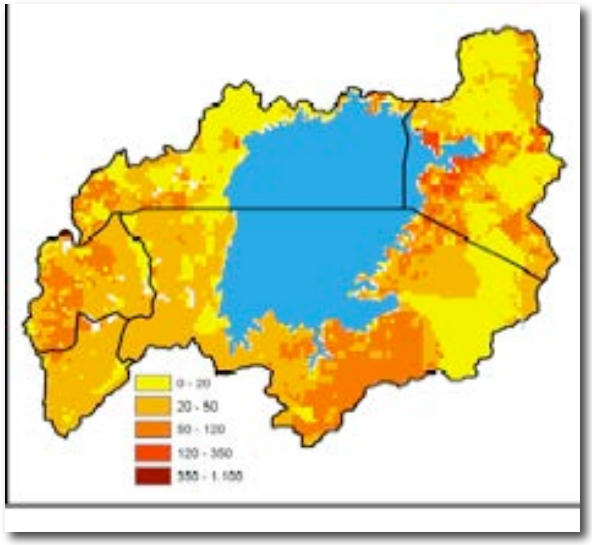


Figure 38: Goat density in the LVB (source: RCMRD)

This is confirmed by previous studies such as Borner et al. (1987), which showed that the population of Thomson's gazelles in Serengeti National Park declined by almost two-thirds over a 13-year period (1970s–1985) because of predation, interspecies competition, and disease. Other literature has reported a decline of rhinoceros, elephants, wild dogs, and roan antelope because of poaching and infection with transmissible diseases, such as distemper and rabies.

Four levels of weighting for vulnerability (0, 1, 2, and 3) were generated from the LULC change map. Degradation of vegetation—changes from forests, woodlands, and grassland to other cover categories—were given the highest vulnerability value (3) while areas that remained unchanged, such as forest to forest, were given a value of zero.

Other changes that are not critical to the vulnerability of the terrestrial sector, such as change from agriculture to settlement, were also assigned a value of zero. Further analysis of LULC dynamics between 1985 and 2014 (Figure 39) revealed that only about 15 percent of forest and woodland cover remained unchanged. Agriculture was found to be the main driver of the observed degradation, contributing more than 60 percent. Other activities, such as cutting of trees for charcoal and timber, contributed about 25 percent of the change. The contribution of settlement expansion was found to be very low, less than 1 percent.

As depicted in Figure 40, most of the conversions from forest and woodland to agriculture occurred around and close to Lake Victoria. The degradation of this vegetation cover has reduced the ability of forest/woodland ecosystem to provide essential services, such as clean drinking water, outdoor recreation, and quality wildlife habitat, especially as populations grow and demands for these services increase.

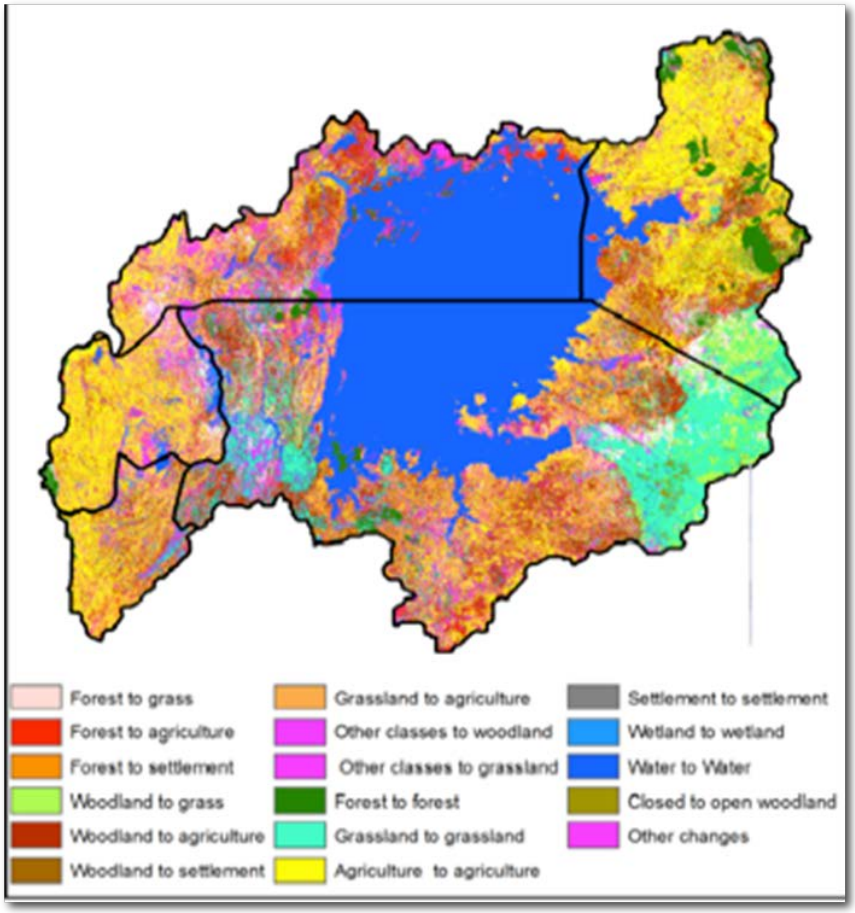


Figure 39: Land use/land cover change between 1985 and 2014 in the LVB (source: RCMRD data)

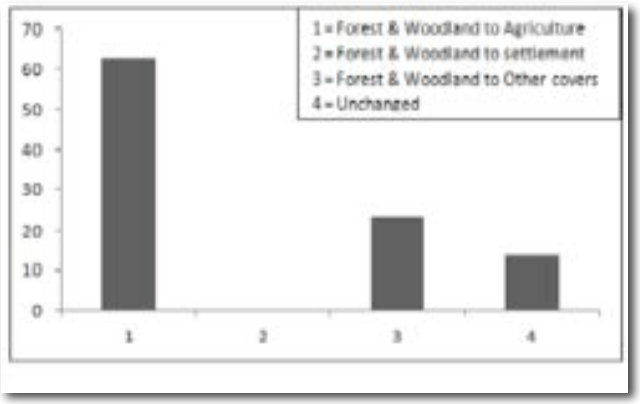


Figure 40: Drivers of deforestation in the LVB

Adaptive capacity: A layer of protected areas (Figure 41) was developed to depict different levels of protection. Generally higher levels of protection are expected from national parks, national reserves, forest reserves, and game reserves. However, the threats include bush meat trade, poaching, human-wildlife conflicts, human population, and encroachment, loss of migratory corridor, and dispersal areas. Based on the criteria developed by Kiringe and Okello (2007) the adaptive capacities of the protected areas were allocated as shown in Figure 41.

Overall vulnerability: Multiple stressors are needed to assess the vulnerability of a sector to current climate change. In this case, exposure, sensitivity, and adaptive capacity layers, developed in the previous sections, were combined using spatial analyst tools in ArcGIS software, i.e. weighted sum overlay, to assess the vulnerability of the terrestrial sector. All layers were given equal weights. Figure 42 shows the result from this combination for the LVB.

Based on the results from climate change–related vulnerability assessment and mapping (Figure 42), the Serengeti-Mara Ecosystem (Kenya-Tanzania) has been identified as a hotspot for terrestrial ecosystems, wildlife, and tourism. The ecosystem is under pressure from many factors, including population pressure, agricultural expansion, and livestock invasion, making it highly vulnerable to climate change leading to tipping in a system that is critically threatened. Other cross-border sites that have been recognized as hotspots critical for conservation in terms of biodiversity, economic value, and social aspects include the Nyungwe-Kibira Ecosystem (Rwanda-Burundi) and Mount Elgon Ecosystem (Kenya and Uganda), which have a forest component. These hotspots are shown in Figure 41. A brief description of these areas follows.

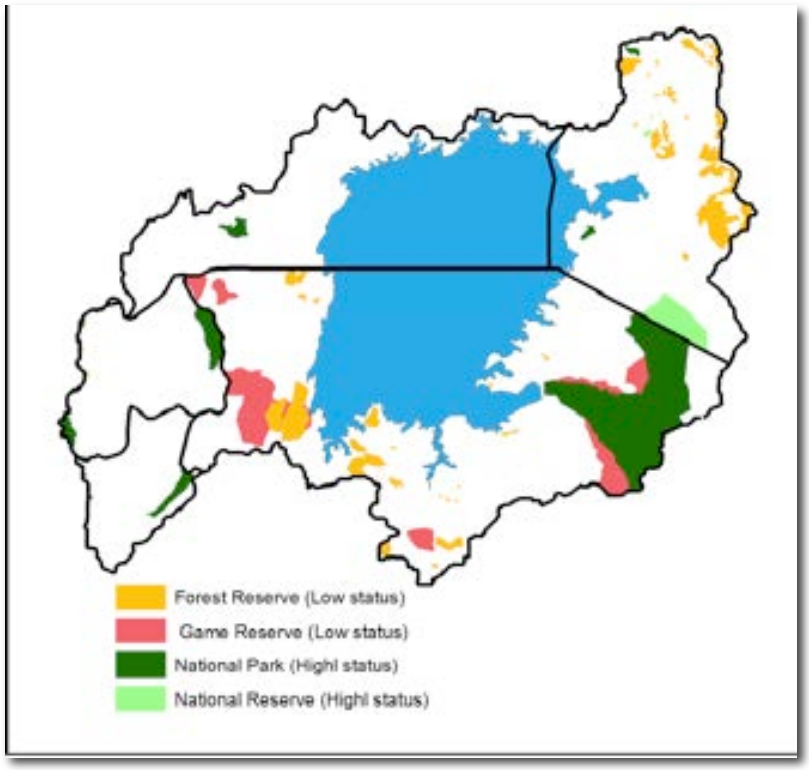


Figure 41: Adaptive capacity for the protected areas in the LVB

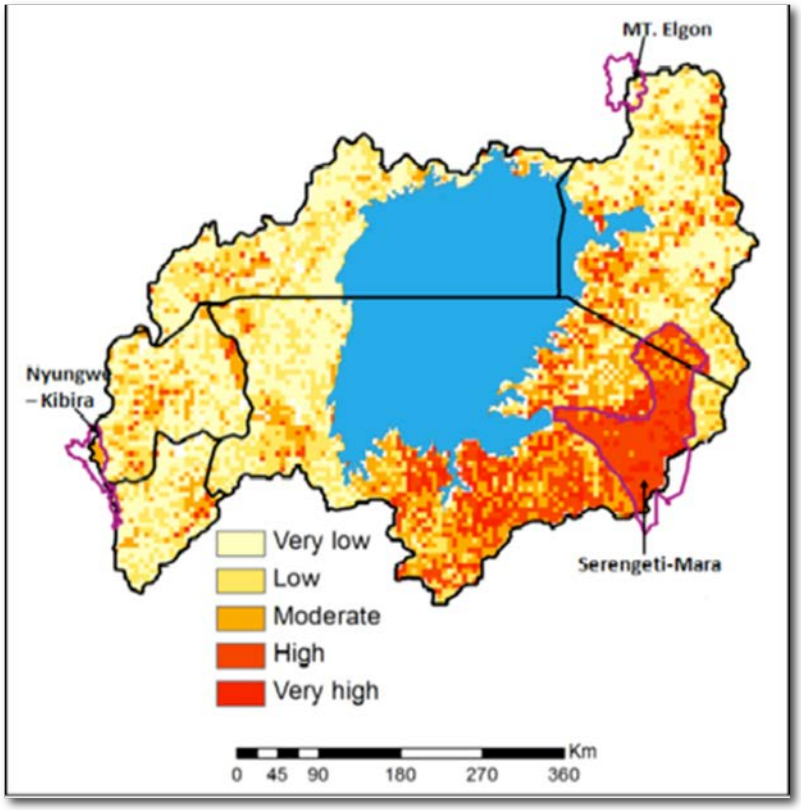


Figure 42: Vulnerability map for terrestrial ecosystems including forests, wildlife and tourism in the LVB

6.1 The Serengeti-Mara Ecosystem

This ecosystem covers an area of approximately 25,000 square kilometers (LVBC and WWF-ESARPO 2010) and consists of:

- Tanzania: Serengeti National Park (SENAPA) and adjoining Ngorongoro Conservation Area (NCA), Maswa Game Reserve, Ikorongo-Grumeti Game Reserves and Loliondo Game Controlled Area, Ikona Open and Wildlife Management Area (WMA), and Makao Open and WMA.

- Kenya: Masai Mara National Reserve (MMNR) and associated wildlife dispersal areas of Koiyaki, Lemek, OlChorro Oirowua, Olkinyei, Siana, Maji Moto, Naikara, Siapei, Naboisho, Lower Mau, and Mosiro.

The Serengeti-Mara plains are internationally famous for having the highest density and most diverse combination of large herbivores on earth. Some of these herbivores are renowned for their seasonal migration between the Mara and Serengeti plains. The ecosystem hosts about 1.3 million migratory wildebeests, more than 200,000 plain zebras, more than 300,000 Thomson's gazelles, more than 3,000 elephants, about 3,000 lions, about 9,000 spotted hyenas, and many other antelope and carnivore species.

The migration of wildebeest and zebras in Serengeti-Mara ecosystem is important both ecologically and as a tourist attraction. But rising human populations, increasing agriculture, and urbanization are altering wildebeest migratory corridors and their populations are declining throughout the region. The loss of these animals would not only jeopardize tourism but also drive declines in biodiversity and ecosystem services. Urgent efforts are needed to protect wildebeest migratory corridors and dispersal areas to ensure these great migrations for the future (UNEP 2013b). Tourism generated by the ecosystem is estimated at US$1.2 billion in Kenya in 2012 and US$1.3 billion in Tanzania in 2011 (KNBS 2013). Tourism in the Serengeti-Mara, primarily to observe the wildebeest migration, brought Tanzania about US$550 million in 2008 (Mitchell et al. 2009).

The Mara River is the main source of available surface water both for wildlife and human use. Other important rivers in the ecosystem include the Sand, Orangi-Grumeti, and Mbalageti. The June peak in river flows in Mara corresponds with the wildebeest migration. Although the river has always been permanent, drought and erratic rainfall, coupled with unprecedented destruction of the water catchment area (especially the Mau Forest complex), caused the river to dry up completely in 2009.

6.2 Nyungwe-Kibira Ecosystem

Encompassing an area of 1,141 square kilometers and altitudinal range between 1,600 meters and 2,950 meters, the Nyungwe forest is the largest protected area in Rwanda, and when considered together with the conterminous Kibira National Park (covering 400 square kilometers) in Burundi, they form one of the largest protected tropical mountain forests in Africa.

The Nyungwe Forest National Park in southwestern Rwanda is one of the most biologically important Afromontane forests of the Alberine Rift. It is one of the six key landscapes identified for conservation in the rift (Seimon and Plumptre 2012). The Nyungwe-Kibira forest is recognized for its conservation importance and high levels of endemism. It is Africa's foremost biodiversity hotspot (Plumptre et al. 2007). The national park protects a complex mosaic of vegetation types, including montane forest, savanna grassland, bamboo forest, and high-altitude wetlands.

The Nyungwe Forest National Park's ecosystem plays a vital role in intercepting precipitation and channeling run-off in the headwaters of Africa's two largest hydrological networks, the Nile and Congo

basins (Chao et al. 2012). Services provided by the ecosystem are critical to the sustainability of local farming systems, primary industries (tea production, coffee washing stations, etc.) and the country's economy, through the provision of water and hydroelectricity (for local consumption and export to neighboring Burundi) as well as regulation of local and regional climatic conditions.

Profound land use changes have totally transformed the neighboring environs, to the extent that it exists as a forest island remnant in a landscape completely transformed by human action from its past natural state. Climate change presents a host of potential impacts across the Nyungwe ecosystem, introducing new threats and acerbating others (such as deforestation) to the species and human populations that depend upon its biodiversity resources and the ecological services that the protected forests provide. Climate change has already resulted in more frequent and longer droughts in Nyungwe National Park, resulting in more frequent bushfires (Seimon 2012).

On the Burundi side, the Nyungwe forest was mostly destroyed by farmers and pastoralists in search of fertile agricultural land and pasture for cattle.. This exploitation has mainly affected *Entandrophragma excelsum, Symphonia globulifera, Prunus africana, Hagenia abyssinica,* and *Podocarpus latifolius falcatus.* The destruction of these valuable species leads in all cases to the installation of secondary forest.

6.3 Mount Elgon Ecosystem

Mount Elgon Forest is northeast of Lake Victoria on the border between Kenya and Uganda. It is centered around 1°14'09"N: 34°35'31"E, the general coordinates are 0°48'–14°30' and 34°22'–35°10'. Mt Elgon National Park in Kenya covers 169 square kilometers, while 1,110 kilometers in Uganda is also a national park. The ecosystem has at least three other protected areas, including the Namatala Central Forest Reserve in Uganda and the Trans-Nzoia Forest Reserve and Chepkitale National Reserve in Kenya (USAID 2014). It is the seventh highest mountain in Africa rising to 4,320 meters.

The Mount Elgon ecosystem is an important watershed and a major catchment for many tributaries draining into major rivers that lead to large bodies of water, including lakes Victoria, Kyoga, and Turkana and joining the Nile river system. In Kenya, the forest forms the upper catchment area for two major rivers, Nzoia and Turkwel. It also provides water to the Malakisi River that crosses an area of small farms south of the mountain before entering Uganda. The forest has a particularly diverse, unique, and threatened biota, making it a priority for species conservation in Kenya (Akotsi and Gachanja 2009). The forest contains globally threatened species, including some endemic to the Afromontane region and others endemic to Mount Elgon, making the area a priority for species conservation and a major attraction for tourists. The ecosystem has 37 globally threatened species (22 mammals, 2 insects, and 13 bird species). These include the cave elephants, giant hog, oribi, Rothschild giraffe, turacos, and red-fronted parrots (Mwaura 2011). Important wildlife includes elephants and buffaloes, small antelopes, forest monkeys, and more than 300 species of birds. Some of the rare animal species include the blue monkey (*Cercopithecus mitis mitis*), Sykes monkey (*Cercopithecus albogularis*), and the black and white casqued hornbill (*Bycaniste subcylindricus*). Mount Elgon is famed for caves that are regularly visited at night by herds of "salt-mining elephants," bushbuck, duicker, and buffalo, all in search of the salt that abounds in the mineral rich earth. Members of local communities get herbs, ornamentals, banana stalks, fruits, honey, fuelwood, and poles for building and bamboo shoots for vegetables (USAID 2013). Mount Elgon is popular with domestic tourism for education and research purposes. The ecosystem's birds are an emerging attraction for international tourists.

Mount Elgon Forest is a priority area for the Lake Victoria Basin Commission. Kenya's Mount Elgon ecosystem was declared a Biosphere Reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2003 in recognition of its importance as a water tower and its diverse habitats. A comparison of vegetation cover on the mountain in the 1960s and 1999 by the Mount Elgon Integrated Conservation and Development Project (2001), show that the indigenous forest cover declined by a third,

from 53,281 hectares (49 percent of the protected area) to 35,140 hectares (33 percent of the protected area).

A rapidly growing population in the area around the mountain puts very high pressure on this unique ecosystem, making it highly vulnerable to the impacts of climate change. Generally, Uganda has one of the world's highest Total Fertility Rates and the fertile soils of the Elgon highlands have attracted very high population densities that have affected the mountain ecosystem. Previous studies have indicated considerable loss of woodlands and forests because of encroachment onto steep concave slopes (36 to 58 degrees) that induced a series of shallow and deep landslides in the area. Land under woodlands and forest cover was reduced by 58 percent and 34 percent, respectively, while agricultural fields increased by 241 percent from 2,024 hectares in 1995 to 6,895 hectares in 2006 (Mugagga et al. 2011). The anthropogenic activities associated with overexploitation of the mountain through settlements and agriculture around the Elgon highlands led to an extreme event in which villages on the foothills of Mount Elgon were buried by landslides in 2010 and 2013 causing massive destruction of human life, livestock, and property. During such disasters, women and children are often more affected. Photographs illustrate the state of Bududa communities in Mount Elgon whose lives were affected by the landslides.

Other threats include livestock grazing, illegal logging, high demand for forest products, poaching, invasive species, and forest fires. Continued degradation and forest loss in the Mount Elgon ecosystem will undermine the area's crucial role as a water catchment for the surrounding region and will reduce the viability of the ecosystem itself (UNEP 2009).

7. SECTOR POLICY, LEGAL, AND INSTITUTIONAL PREPAREDNESS FOR CLIMATE CHANGE

This section looks at the policy, legal, and institutional framework and climate change–related initiatives pertaining to the terrestrial ecosystems in the EAC and its Partner States. The report draws from regional and national frameworks as well as contribution by nongovernmental organizations (NGOs), the private sector, and local communities. An analysis of existing and emerging issues is presented at the end.

7.1 REGIONAL LEVEL

7.1.1 EAC Regional Policy, Legal, and Institutional Framework

The EAC Partner States are signatories to several Multilateral Environmental Agreements and their related protocols and treaties. These include the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol, the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), the Convention on International Trade in Endangered Species (CITES), and the Ramsar Convention on Wetlands of International Importance, among others. The EAC Partner States are implementing these agreements through the preparation of National Communications (1st and 2nd), National Adaptation Programs of Action (NAPAs), National Adaptation Plans (NAPs), and more recently, Nationally Appropriate Mitigation Actions (NAMAs), including Reducing Emissions from Deforestation and Degradation (REDD+) programs.

The EAC Secretariat has focused on improving regional cooperation on climate change through a variety of policy instruments, plans, and strategies. The EAC has developed a Ministerial Declaration on Climate Change and Food Security, Climate Change Declaration, and Common Negotiation Position on Climate Change, and Article 100 of the Treaty on Meteorological Services intended to harmonize the collection, management, and dissemination of meteorological information. The EAC's Climate Change Policy aims to support the implementation of urgent and immediate adaptation priorities identified in the NAPAs, NAPs and climate change strategies of Partner States. Each Partner State is required to create an enabling policy, legislative, and institutional environment to operationalize the policy's provisions (EAC 2011a).

The EAC Treaty requires Partner States to undertake and to develop a regional strategy for tourism promotion aimed at maximizing benefits from sustainable tourism and wildlife resources. The EAC region is now being promoted as a single tourism and wildlife destination including joint participation at the World Travel Markets.

Further, the EAC has also formulated a Biodiversity Strategy and Action Plan for the Mara River Basin whose overall objective is to conserve biodiversity through maintenance of the ecosystem integrity of the basin (LVBC and WFF–ESARPO 2010). The EAC Environment and Natural Resource Management Bill addresses the problems of environmental degradation and biodiversity loss, and helps to safeguard the resources that are vital for climate change adaptation strategies in the region. Relevant to the terrestrial ecosystem, the Protocol for Sustainable Development of Lake Victoria Basin identifies sustainable environment and natural resources, management of transboundary resources, conservation of biological diversity, management of forests, wildlife resources, mountain ecosystems, rangeland management, tourism development, and soil and land use management as priorities.

7.1.2 EAC Regional Institutional Framework

The EAC has several regional institutions to support mitigation and adaptation of climate change. These include:

i. The Nile Basin Initiative (NBI), which was established to achieve socioeconomic development through equitable use of, and benefit from, the water resources of the Nile Basin.

ii. The Lake Victoria Basin Commission (LVBC), a specialized institution of the EAC responsible for coordinating the sustainable development of the LVB.

iii. The Regional Centre for Mapping of Resources for Development (RCMRD), which is mandated to provide geo-information and information technology applications.

iv. The Lake Tanganyika Authority was established by Burundi, Tanzania, Democratic Republic of Congo, and Zambia to oversee the coordination of natural resources around Lake Tanganyika.

v. The IGAD Climate Prediction and Applications Centre (ICPAC) covers 24 countries in eastern and southern Africa and aims to provide climate early warning information for sustainable development.

Most of the EAC Partner States receive aid from bilateral and multilateral donors for terrestrial sector protection. In addition, there is a tripartite program in the East African region that focuses on smart agriculture and climate change, managed under the EAC, Southern Africa Development Community (SADC), and Common Market for Eastern and Southern Africa (COMESA).

Other relevant regional initiatives include the following:

- Rwanda hosts the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and two of its transboundary projects, the Kagera River Basin Transboundary Integrated Water Resources Development Project covering Rwanda, Burundi, Tanzania, and Uganda.
- Serengeti-Luangwa Ecosystem Management Project focuses on building a sustainable institutional mechanism for stakeholder collaboration in ecosystem management and community participation in natural resource management.
- The WWF Mara Basin Initiative has a mission to promote sustainable forests and water resources management in the Mau Forest and its surrounding areas.
- The Friend of Mau Watershed project is promoting restoration and watershed protection in the upper region of the Mau Forest complex.
- Community-based initiatives at the regional level such as the Community-based Adaptation in Africa project, which is implemented in eight African countries, including Kenya, Tanzania, and Uganda, and the Adaptation Learning Program.

While regional initiatives are in place, their contribution to global mitigation is still limited. In addition, these provisions tend to be gender neutral with no specific concern for women and girls.

7.2 National Level

7.2.1 Policy and Legal Framework

Each of the five EAC Partner States has enacted laws and developed policy and legal frameworks to govern the terrestrial ecosystems, forests, wildlife, and tourism. These can be summarized in the following categories:

- **National Constitutions:** These provide for protection and preservation of the environment and natural resources of the Partner States.

- **National Environment Acts:** These cover cross-sectoral issues, including conservation and sustainable management of the environment, proper management of pollution and air quality standards, and protection of the ozone layer. They provide for environment impact assessment (EIA) for development projects that are likely to affect the environment and natural resources and give authority to environmental management authorities/councils to coordinate environment issues.

- **Forests Acts:** These provide for establishment, control, regulation, and sustainability of forests, protection and conservation of biodiversity, establishment of nature and forest reserves, and EIAs in forest areas before development.

- **Wildlife and Tourism Acts:** These provide for protection, control and conservation of biodiversity, management and use of wildlife, establishment and management of wildlife conservation and protected areas; species protection; wildlife user rights and international trade in wildlife. They advocate for harmonization of tourism, wildlife, and land use policies and provide for community participation in management of wildlife (LVBC and WWW–ESARPO 2010).

7.2.2 Institutional Framework and Climate Change Initiatives at the National Level

The relevant Partner State ministries keep changing and currently include:

- Burundi Ministry of Water, Environment, Spatial Planning, and Urban Development
- Kenya Ministry of Environment, Natural Resources, and Regional Development Authorities
- Rwanda Ministry of Natural Resources (MINIRENA)
- Tanzania Ministry for Environment under the Vice President's Office
- Uganda Ministry of Water, Lands, and Environment.

The main relevant role of these ministries is formulation and coordination of policies, strategies and action plans, and monitoring and implementation of international conventions. Other relevant ministries include those involved in planning, such as the Ministry of Devolution and Planning in Kenya, which is responsible for national development. That responsibility includes mainstreaming climate change into national plans, such as the five-year mid-term plans under Vision 2030. Also relevant are the energy ministries as they are tasked to facilitate provision of clean, sustainable, affordable, and secure energy for national development while protecting the environment. The key environment, forest, wildlife, and tourism agencies are summarized in Box 3.

Box 3: Key Relevant Sector Ministries and Agencies in EAC Partner States

- **Environment agencies:** the National Commission for the Environment and the Directory of Environment and Climate Change (Burundi); the Burundian Office for the Protection of the Environment; National Environment and Management Authority (Kenya and Uganda); Rwanda Environment Management Authority; and the National Environment Management Council (Tanzania). Their primary function is coordination of environment issues, development of regulations and codes, enforcement of environment standards, and preparation of state of the environment reports. They are also responsible for greenhouse gas inventories and preparation of National Communications. Additionally, the National Institute for the Environment and Nature Conservation (Burundi) is responsible for safeguarding environment and nature conservation including implementation of national and international conventions while Rwanda Natural

Resources Authority is responsible for promotion, supervision, and monitoring of the implementation of issues relating to the promotion and protection of natural resources in programs and activities of all national institutions.

- **Forestry agencies and research institutions** mandated to conserve and manage forest resources and conducting research in forestry and disseminate research findings.
- **Wildlife agencies and research institutions** mandated to conserve and manage wildlife resources and conduct and coordinate wildlife research.
- **Tourism ministries, boards, agencies, and education centers** that are important in formulation and implementation of government policies on tourism development and wildlife conservation, as well as development of strategies for promotion of these sectors. The boards are involved in promotion of tourism destinations.
- **Climate agencies** that are mandated to collect the relevant climate data and dissemination, including prediction and issuing early warning.
- **Climate change coordination units and committees** that are housed under various government ministries mandated to coordinate climate change protocols.
- **Other agencies** that are responsible for responding to disaster and those involved in climate financing that also link to the terrestrial sector. Additionally, other innovative mechanisms include establishment of climate funds for academic and research institutions that have established climate change research centers to provide information related to climate change.

7.3 National Climate Change Initiatives

Each EAC Partner State is implementing initiatives aimed at addressing climate change, directly or indirectly. These initiatives and experiences in natural resource management, biodiversity use, and ecosystem-based responses such as afforestation, rangeland regeneration, catchment rehabilitation, and community-based natural resource management can be harnessed to develop effective and ecologically sustainable local adaptation strategies.

7.3.1 Nongovernmental Organizations

Many NGOs are involved in climate change vulnerability assessment and baseline surveys, as well as research in climate change, advocacy, policy development, awareness, capacity building, governance, information (gathering, packaging, and dissemination), gender mainstreaming, monitoring and early warning, disaster risk reduction and preparedness, livelihood and humanitarian support, technology transfer, and energy (Gachanja 2014).

7.3.2 Private Sector

Impacts of climate change on the tourism industry (dependent on nature and wildlife populations), water, and energy (dependent on hydropower) presents the private sector with unique risks and opportunities that may significantly affect business operations, supply, competitiveness, and profits. The private sector is therefore a key player in climate change issues and is involved in investment and technology (Gachanja 2014). In areas such as the Mara and the Northern Rangeland Trust (NRT) in Kenya and as well as some parts of Tanzania, wildlife conservancies continue to conserve over 60 percent of wildlife outside of protected areas as well as provide socioeconomic benefit from wildlife-based tourism to local communities.

7.3.3 Local Communities

Many communities are involved in afforestation, reforestation, and conservation of wildlife resources in the EAC and LVB region. Local and traditional knowledge has been critical in building resilience and adaptive capacity, and in shaping responses to climatic variability and change among communities. For instance, Burundians have a tradition of respecting, in a quasi-religious way, certain ecosystems and elements of animal and plant biodiversity. In the country's tradition, cutting trees in the Kibira forest was banned (Republic of Burundi 2007). This high-altitude forest was regarded as a "symbol of alliance between the sky and the earth" and only the king was allowed to hunt there. Traditional conservation also concerned certain thickets considered sacred. These were fragments of forests prohibited to exploitation and bearing the name of "Intatemwa" literally "what one should not cut" or "Ikidasha," literally "what one should not burn." In Kenya, the way of conserving "Kaya forests" has been through traditional rules prohibiting their use so that they continue to be considered sacred sites. Agro-forestry is also another traditional way.

7.4 Analysis of Adaptation Capacity

Despite progress in the development of policies and regulations, East Africa remains vulnerable to the effects of climate change due to the considerably limited adaptive measures combined with widespread poverty and the existing low levels of development.

7.5 Emerging Issues

National adaptation planning and implementation policies and strategies are still in their early development stage. However, countries have national policies and strategies governing the use and extraction of various natural resources which, if implemented, would help deal with climate change issues, including adaptation. Further, some EAC Partner States (Burundi, Tanzania, Rwanda, and Uganda) have developed climate change strategies, action plans, and NAPAs that identify immediate, urgent, and priority project activities necessary to enhance adaptive capacity to climate change impacts. Tourism policies, in particular, provide for the development, management, marketing, and regulation of sustainable tourism activities and services.

7.6 Mainstreaming or Integration of Climate Change in Policies and Strategies

Mainstreaming of climate change in policies and laws is in its infancy in many of the EAC Partner States. Many of these policies and laws, however, indirectly address food and water security among other issues directly related to climate change. Kenya and Rwanda have made significant progress toward mainstreaming environmental sustainability and climate issues in policies, strategies, planning, and budgeting processes to address the climate risks faced by key sectors. In Rwanda, the government has made it a requirement that all sectors ensure environment and climate change priorities are appropriately reflected in their budget submissions in accordance with the environment mainstreaming guidelines. This has enabled government to move environment and climate change objectives from simply planning documents to ensuring sufficient resources are allocated to achieve these objectives. In Kenya, this has been achieved through the Vision 2030 Medium Term Plan 2013–2017, which has mainstreamed climate change as per the NCCAP recommendations. Uganda has drafts of both a climate change policy and a REDD+ strategy. There are no climate-specific components in the tourism and wildlife policies indicating the lack of climate change focus in the existing policies with free-standing climate-specific policy documents such as NAPAs. There is need for strong policies that address mitigation and adaptation as well as providing guidance on how these can be mainstreamed across all sectors concerned with terrestrial ecosystems.

Inadequate funding: Funding to address adaptation is limited in the EAC region, but countries have taken steps to address the limitation. For instance, in 2012 the Government of Rwanda established the Fund for Environment and Natural Resources (FONERWA) as a vehicle through which additional environment and climate change finance is channeled, programmed, disbursed, and monitored. No other East African country has established a similar fund. Although EAC Partner States are members of various international climate change protocols, and have bilateral and multilateral linkages, the extent to which sector institutions have been able to access climate finance is still limited.

Institutional framework and coordination: Most of the existing climate change–related capacity building in local communities in Kenya is attributed to NGOs (Gachanja 2014). However, low institutional capacity and limited specialized civil society and private sector organizations in the environmental management and climate resilience subsector constrain implementation of the national strategy and mainstreaming work across sectors in some East African countries, especially in Rwanda (REMA 2014). Competition for resources among NGOs, lack of coordination leading to duplication of activities, and poor mechanisms and strategies for phasing out projects and programs with effect on the ability of local communities to take over and sustainably run the activities from their own resources is a challenge (Groner 2003).

Knowledge, information, and awareness: The capacity of EAC Partner States to generate climate change knowledge has developed significantly. These information, knowledge, and skills are critical to help local communities enhance ecosystem conservation and respond to the effects of climate change. Institutions of forest management, wildlife management, and other relevant government ministries and counties play an important role in helping communities deal with climate risk perceptions, their ability to assess risks and to plan and implement risk management and adaptation options. However, systematic assessment of the accessibility of this information and knowledge is lacking.

In the LVB, Global Environment Facility support has enabled Burundi to build capacity by focusing on self-assessment of capacity that will strengthen management of the global environment; development of the National Climate Change Adaptation Plan (PANA); building capacity for improving the quality of greenhouse gas inventories; and development of the Strategy and Action Plan for Sustainable Land Management. However, getting this information in a central point has been a challenge in almost all the EAC Partner States (Gachanja 2014 and REMA 2014). A majority of citizens are unfamiliar with the concepts of climate change and global warming. Climate change awareness has also been rated low in Kenya (Mutimba et al. 2010).

Economic and technological factors: Ecosystems management benefits from technological advancements used in trends monitoring (such as remote sensing and geospatial technologies), ecosystems assessments, and communication. Given the threat posed by climate change, systematic ecosystem monitoring will be critical to provide timely data and information necessary for adaptation planning. All EAC Partner States have been promoting technologies to increase energy efficiency through use of improved cook stoves to stem the threat to forestlands through deforestation to supply wood fuel. Adoption of biogas is still in early stages. Institutions supporting climate-sensitive sectors need financial, human, and technical resources to support adaptation to climate change.

Gender balance and pro-poor approaches: Women have knowledge and coping strategies that give them practical understanding of innovation and skills to adapt to climate change impacts that they could contribute to the cause. Climate change affects men and women differently. The different gender groups may provide gender-specific mitigation and adaptation options that could inform global and region-specific policies. The poor and women are more vulnerable to climate change and account for about 70 percent of the population. A concern for gender representation in climate bodies ensures that the implementation of adaptation activities does not exacerbate inequalities and other vulnerabilities by helping to offer specific

needs of the most vulnerable gender groups and allow equal participation of men and women in decision making and implementation of activities at the regional and national levels.

Improvement in the policy consultation process is also needed to make it more consultative and to avoid top-down policy formulation. The voices of the poor, especially women, the majority living in rural areas who are largely marginalized should be taken into account.

8. POLICY SUGGESTIONS

Most studies of terrestrial biological systems have found notable impacts of global warming over the past three to five decades. These include longer growing seasons in middle and higher latitudes, production range expansions at higher elevations and latitudes, some evidence for population declines at lower elevation or latitudinal limits to species ranges, and vulnerability of species with restricted ranges, leading to local extinctions. Other factors, such as land use, have been shown to significantly limit migration and acclimatization capacities of wildlife.

Since Africa is exposed to a range of stressors that interact in complex ways with longer-term climate change, adaptation needs are broad, encompassing institutional, social, physical, and infrastructure needs, ecosystem services and environmental needs, and financial and capacity needs. The following policy mitigation and adaptation suggestions have been made to address the capacity gaps identified by this study.

a. *Climate-smart policies:* While many legal and policy guidelines related to environmental and natural resources protection are in place, they have shortcomings in their focus on climate change. Climate change needs to be integrated into these existing provisions.
b. *Inadequate policy harmonization and enforcement*: Many policies and laws are insufficiently enforced and poorly harmonized. While these gaps urgently need to be addressed, a strong linkage between the existing policies and strategies related to terrestrial ecosystems and climate change is also necessary.
c. *Lack of sector-based climate change strategies:* Broad climate change strategies and action plans have been prepared in most countries, but sector strategies are just evolving. Kenya is the process of preparing a wildlife climate change strategy. Similar strategies for other climate-sensitive areas, including for the tourism sector, are needed.
d. *Inequitable gender representation both at policy and institutional level:* Gender needs to be integrated into all aspects of climate change policies and programs by considering the view that men and women have different needs that need to be accounted for in gender-focused climate change policies and programs. A deliberate effort is needed to involve both men and women in policy design and implementation toward more equitable and effective outcomes. Women and men at both the local and national levels should be engaged in such processes.
e. *Institutional coordination and green economy framework:* While recognizing that efforts have been made to improve coordination, there is need for improvement and monitoring of different entities engaged in protection of terrestrial ecosystems, including those that directly deal with climate change for a common goal. Most established institutions pursue their own sector-based priorities and approaches. A holistic approach is needed. Resolving well-documented institutional challenges of natural resource management, including poor coordination, monitoring, and enforcement, is fundamental to more effective climate governance. Establishment of dedicated and well-funded climate change national institutions would enhance coordination. Moreover, an operational framework is needed that facilitates coordination of different initiatives around a green economy and sustainable development. This will address challenges of low levels of awareness and support the integration of climate change risks into sector strategies, District Development Plans, and Performance Contracts as embraced by Rwanda and Kenya.
f. *Limited ownership of donor-funded climate change interventions:* Lack of country ownership of interventions supported by development partners has been identified as a capacity gap (LVBC and WWF–ASARPO 2010). Strategies to ensure continuation of these interventions at program design stage would improve ownership.
g. *Lack of centralized databases:* Most data related to environment and climate change are scattered. A more centralized database is needed to provide easy access of such information to potential users. Furthermore, data on gender and climate change are limited, which makes it difficult to gauge gendered

impacts on ecosystems and their management, as well as to extract lessons related to gender that can inform policy and practice in the region.

h. *Reliability of climate data:* With increased unreliability of weather patterns, accurate local weather information is a central input for planning and monitoring of climate-sensitive sectors at all levels. In some countries, national statistics are lacking resulting in the absence of reliable data on climate.

i. *Limited involvement of marginalized communities:* The involvement of the vulnerable and exposed members of local communities in assessing and choosing adaptation responses is critical to building adaptive capacity. Culture, or the shaping of social norms, values, and rules—including those related to ethnicity, class, gender, health, age, social status, cast, and hierarchy—is crucial for adaptive capacity as well as to breaking down barriers to successful local adaptation.

j. *Inadequate institutional capacity:* Weak institutional capacity, poor infrastructure leading to low levels of development, financial constraints, low accountability, and lack of transparency are some of the threats to good governance in the EAC Partner States. Increased funding and resolving governance issues are critical in strengthening climate change institutions.

k. *Access to climate finance*: Access to climate finance is essential for meeting the region's goal of adapting to and contributing to the mitigation of climate change. Finance is also critical in factoring complex, cross-cutting environment and climate change issues into strategic planning and implementation in all five Partner States. To effectively secure resources from existing global funding mechanisms capacity needs to be developed in resource mobilization in relevant government ministries in all five countries.

l. *Limited research:* Research to assess and quantify the impact of climate change on different sectors and systems and the socioeconomic consequences of the loss of ecosystems and of economic activities, as well as of certain mitigation choices (biofuels and their links with food and livelihood security, for example) and adaptation to climate change is also limited. The EAC may explore mechanisms to support research, such as through setting up a research fund. A mechanism or a platform to convert information to knowledge is also needed to guide adaptation strategy in a way that will sustain the momentum of climate science.

m. *Land use planning:* Developing integrated land use plans to mitigate interaction of land use and climate is needed. This may also include harmonized policy and coordinated land use planning in management of ecosystems shared between countries. Harmonization of different protocols is also needed especially as the Partner States are members of various regional bodies.

n. *Incentives to promote conservation:* Incentives need to promote management of fragile and endangered ecosystems. These incentives should include payment for ecosystem services, easements, and other financial instruments. The private sector should be involved in supporting these initiatives to ensure their long-term sustainability. The initiatives need to be supported by appropriate policy and legal instruments, and they should support devolved governance. The devolved system should empower people to manage resources sustainable through capacity building and investment.

o. *Rehabilitation of degraded ecosystems:* Rehabilitation of degraded ecosystems is important as less and less land is available for conservation. A local review to reclassify habitats and ecosystems as critically endangered, most endangered, endangered, or normal in relation to climate change and other drivers will help prioritize actions.

REFERENCES

AfDB (African Development Bank), 2011: Burundi Country Strategy Paper, 2012–2016. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Burundi%20-%20CSP%202012-16.pdf.

Akotsi, E.F.N, and M. Gachanja, 2009: Changes in Forest Cover in Kenya's Five "Water Towers" 2000–2007.

AMCEN (African Ministerial Conference on Environment), (undated): Fact sheet climate change in Africa—What is at stake? Excerpts from IPCC reports, the Convention, & BAP Compiled by AMCEN Secretariat.

Athman, C., J. Evenden, and M. Chaveas, 2006: Technical Assistance to the US Government Mission Burundi on Natural Resource Management and Land Use Policy. US Forest Service International Programs, Department of Agriculture and Republic of Burundi, Mission dates: September 9-22, 2006.

Banana, Y.A., P. Byakagaba, A.J.M. Russell, D. Waiswa, and A. Bomuhangi, 2014: A review of Uganda's national policies relevant to climate change adaptation and mitigation. Insights from Mt. Elgon. Working Paper 157. Centre for International Forestry Research.

Bank of Tanzania and National Bureau of Statistics, 2014: The 2012 International Visitors' Exit Survey Report.

BBC World Service Trust, 2010: Uganda Talks Climate: The Public Understanding of Climate Change, Research Report, British Council, http://www.africatalksclimate.com.

Beck, J., G. Chegetse, J. Ko, and S. Sieber, 2010: Burundi Environmental Threats and Opportunities (ETOA), USAID.

Bernard, M., K. Darkoh, M. Khayesi, and J.E. Mbaiwa, 2013: "Impacts and responses to climate change at the micro-spatial scale in Malawi, Botswana and Kenya," in M.A. Salih (ed.). *Local Climate Change and Society*. Routledge, Oxon.

Bohrer, G., P.S.A. Beck, S.M. Ngene, A.K. Skidmore, and I. Douglas-Hamilton, 2014: "Elephant movement closely tracks precipitation driven vegetation dynamics in a Kenyan forest-savanna landscape." *Movement Ecology* 2(2).

Borner, M., C. D. FitzGibbon, Mo. Borner, T. M. Caro, W. K. Lindsay, D. A. Collins, and M. E. Holt. "The Decline of the Serengeti Thomson's Gazelle Population." *Oecologia* 73, no. 1 (1987): 32-40.

Broxton, P.D., X. Zeng, D. Sulla-Menashe, and P.A. Troch, 2014: "A Global Land Cover Climatology Using MODIS Data." *J. Appl. Meteor. Climatol.* 53:1593–1605. doi: http://dx.doi.org/10.1175/JAMC-D-13-0270.1.

Bugmann, H., B. Zierl, and S. Schumacher, 2005: Projecting the impacts of climate change on mountain forests and landscapes. Global Change and Mountain Regions: An Overview of Current Knowledge, U.M. Huber, H.K.M. Bugmann and M.A. Reasoner (eds.), Springer, Berlin, 477-488.

Burundi, Republic of, 2007: National Adaptation Plan of Action to Climate Change (NAPA), Ministry for Land Management, Tourism and Environment.

Chao, N., F. Mulindahabi, J. Easton, A.J. Plumptre, A. Seimon, A. Martin, and R. Fimbel, 2012: Long-Term Changes in a Montane Forest in a Region of High Human Population Density. In, A. Plumptre (ed.), Long-term changes in Africa's Rift Valley, New York: Nova Science Publishers.

Cramer, W., A. Bondeau, F.I. Woodward, I.C. Prentice, R.A. Betts, V. Brovkin, P.M. Cox, V. Fisher, J.A. Foley, A.D. Friend, C. Kucharik, M.R. Lomas, N. Ramankutty, S. Sitch, B. Smith, A. White, and C. Young-Molling, 2001: "Global response of terrestrial ecosystem structure and function to CO_2 and climate change: results from six dynamic global vegetation models." *Global Change Biol.* 7: 357–373.

Darkoh, M.B.K., M. Khayesi, J.E. Mbaiwa (2014): "6 Impacts and responses to climate change at the micro-spatial scale in Malawi, Botswana and Kenya. *Local Climate Change and Society, 109.*

Davidson, O., K. Halsaes, S. Huq, M. Kok, B. Metz, Y. Sokona, and J. Verhagen, 2003: "The development and climate nexus: the case of Sub-Saharan Africa." *Climate Policy* 3SI: S97–S113.

Dublin, H., and J.O. Ogutu, (2015): "Population regulation of African buffalo in the Mara–Serengeti." *Wildlife Research* http://dx.doi.org/10.1071/WR14205

EAC (East African Community), 2003: Protocol for Sustainable Development of the Lake Victoria Basin, EAC, Arusha, Tanzania.

——————, 2006: Protocol on Environment and Natural Resources, EAC, Arusha, Tanzania.

——————, 2010: EAC Transboundary Ecosystems Management Bill, 2010.

——————, 2011a: The EAC Climate Change Strategy, EAC Secretariat, Arusha, Tanzania.

——————, 2011b: The EAC Master Plan, EAC Secretariat, Arusha, Tanzania

The East African 2015: Conservation Group Adds the African Lion to the Red List of Endangered Animals July 10, 2015 retrieved from http://www.theeastafrican.co.ke/news/African-lion-added-to-Red-List-of-endangered-animals--/2558-2782512-dguvixz/index.html

Foster, P., 2001: "The potential negative impacts of global climate change on tropical montane cloud forests." *Earth Sci. Rev.,* 55: 73–106.

Fritzsche, K., S. Schneiderbauer, P. Buseck, S. Kienberger, M. Buth, M. Zebisch, and W. Kahlenborn, 2014: *The Vulnerability Sourcebook.* Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Gachanja, M., 2014: Lesson learning from national climate compatible development planning in Kenya.

Gitay, H., S. Brown, W. Easterling, B. Jallow, J. Antle, M.J. Apps, R. Beamish, T. Chapin, W. Cramer, J. Frangi, J. Laine, L. Erda, J. Magnuson, I. Noble, J. Price, T. Prowse, T. Root, E. Schulze, O. Sirotenko, B. Sohngen, and J. Soussana, 2001: "Ecosystems and their goods and services." in J.J. McCarthy (ed.) Climate Change 2001: Impacts, Adaptation and Vulnerability: contribution of Working Group II to the third assessment report of the IPCC. Cambridge University Press, New York. 1032 p.

Groner, S., 2003: The vision and strategy framework for the management and development of the Lake Victoria Basin. Main Report. EAC, Arusha, Tanzania.

Henderson, V.J., 2014: Is climate change driving urbanization in Africa? London School of Economics, Adam Storeygard, Tufts University Uwe Deichmann, World Bank.

Hepworth, N.D., 2010: Climate change vulnerability and adaptation preparedness in Tanzania. Heinrich Böll Foundation, Nairobi, Kenya.

Hepworth, N., and M. Goulden, 2008: Climate Change in Uganda: Understanding the implications and appraising the response, LTS International, Edinburgh.

Homewood, K., E.F. Lambin, A. Kariuki, I., Kikula, J. Kivelia, M.Y. Said, S. Serneels, and M. Thompson, 2001: "Long-term changes in Serengeti-Mara wildebeest and land cover: pastoralism, population or policies?" *Proceedings of the National Academy of Science*, 22, 12544–12549.

Huete, A., K. Didan, T. Miura, E. P. Rodriguez, X. Gao, and L. G. Ferreira (2002), Overview of the radiometric and biophysical performance of the MODIS vegetation indices, Remote Sens. Environ., 83, 195 – 213

Hulme, M., R. Doherty, T. Ngara, M. New, and D. Lister, 2001: "African climate change: 1900–2100." *Climate Research* 17: 145–168.

ICPAC (Climate Prediction and Application Centre, Kenya) and Stockholm Environment Institute (Oxford, UK), 2009: DFID Economic Impacts of Climate Change. Kenya, Rwanda, Burundi (Kenya Report).

IPCC (Intergovernmental Panel on Climate Change), 2001: Climate Change 2001: Impacts, Adaptation and Vulnerability. Cambridge: Cambridge University Press.

——————, 2002: Climate Change and Biodiversity, H. Gitay, A. Suárez, R.T. Watson, D.J. Dokken (eds.).

——————, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge: Cambridge University Press.

——————, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp

——————, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

——————, 2013: Climate Change 2013: The Physical Science Summary for Policy Makers.

——————, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the IPCC [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

——————, 2014: Climate change 2014: Impacts, Adaptation, and Vulnerability. Chapter 22, Africa.

——————, 2014: Mitigation of Climate Change. Technical Summary. IPCC, Geneva, Switzerland.

IUCN (International Union for the Conservation of Nature), 2009: Eastern and Southern Africa Forest and Woodlands Situational Analysis.

Jones, T., T. Caro, and T.R.B. Davonport (eds.), 2009: Wildlife Corridors in Tanzania. Unpublished report. Tanzania Wildlife Research Institute (TAWIRI), Arusha, Tanzania.

Kaggwa, R., R. Hogan, and B. Hall, 2009: Enhancing Wildlife's Contribution to Growth, Employment and Prosperity. UNDP/NEMA/UNEP Poverty Environment Initiative, Kampala Uganda.

Kashaigili, J.J., K. Rajabu, and P. Masolwa, 2009: "Freshwater management and climate change adaptation: experiences from the Great Ruaha River catchment in Tanzania." *Climate and Development* 1(3): 220–228.

Kenana, L.M., H.T. Maliti, E.M.. Kanga, D.M. Kyale, S.K. Bakari, E.T. Massawe, S. Kiambi, and D. Mijele, 2009: Report on wildlife population status and trends for the Mara Ecosystem: Mara Research Station, KWS.

Kenya, Government of Kenya, 2007: Ministry of the State for Planning and National Development, Nairobi, Kenya.

——————, 2010: The National Climate Change Response Strategy. The Ministry of Environment and Mineral Resources. Nairobi, Kenya.

——————, 2013: The National Climate Change Action Plan. The Ministry of Environment and Mineral Resources. Nairobi, Kenya.

Kimutai, D.K., N.M. Machoke, and S.N. Mwiu, 2010: Total aerial count for Amboseli-West Kilimanjaro and Magadi-Natron cross-border landscape, October 2010. A technical Report for KWS, Kenya and TAWIRI, Tanzania.

Kiringe, J.W., and M.M. Okello, 2007: "Threats and their relative severity to wildlife protected areas of Kenya." *Applied Ecology and Environmental Research* 2, 49–62.

KNBS (Kenya National Bureau of Statistics), 2013: Economic survey 2013 highlights. Ministry of Devolution and Planning. http://www.knbs.or.ke/Economic%20Surveys/Cabinet_Secretary_Presentation_on_ Economic_Survey_May_2013.pdf

Lischke, H., A.F. Lotter, and A. Fischlin, 2002: "Untangling a Holocene pollen record with forest model simulations and independent climate data." *Ecol. Model.,* 150: 1–21.

LionAid 2014 retrieved from https://lionaid.org/lion-conservation.php

LVBC (Lake Victoria Basin Commission), 2007: Regional Transboundary Diagnostic Analysis of the Lake Victoria Basin.

LVBC and World Wide Fund for Nature-ESARPO, 2010: Biodiversity Strategy and Action Plan for sustainable management of the Mara River Basin. WWF, Global Water for Sustainability, USAID, EAC.

Magagga, F., V. Kakembo, and M. Buyinza, 2012: "Land use changes on the slopes of Mount Elgon and the implications for the occurrence of landslides." *Catena* 90: 39–46.

Malcolm, J.R., C. Liu, L. Miller, T. Allnut, and L. Hansen (eds.), 2002a: Habitats at Risk: Global Warming and Species Loss in Globally Significant Terrestrial Ecosystems. WWF World Wide Fund for Nature, Gland.

Malcom, J.R., A. Markham, R.P. Nelson, and M. Garaci, 2002: "Estimated migration rates under scenarios of global climate change." *Journal of Biogeography* 29: 835–849.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds.) 2001: Climate Change, 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the IPCC, Cambridge University Press, Cambridge, 237–342.

McLeman R. and B. Smit (2004): Climate change, migration and security, Commentary No. 86, Ottawa: Canadian Security Intelligence Service

Mduma, H., C.S. Musyoki, D. Maliti Kyale, S. Nindi, K. Hamza, R. Ndetei, M. Machoke, D. Kimutai, D. Muteti, M. Maloba, S. Bakari, and E. Kohi, 2014: Aerial Total Count of Elephants and Buffaloes in the Serengeti-Mara Ecosystem.

MEMR (Ministry of Environment and Mineral Resources, Kenya), 2012: Mapping Wildlife Dispersal Areas and Migratory Routes/Corridor (Part I): Southern Kenya Rangelands (Draft Version March 2012). MEMR. Nairobi, Kenya.

MEWNR (Ministry of Environment, Water, and Natural Resources, Kenya), 2015: Kenya's Natural Capital: A Biodiversity Atlas.

Milton K, and M.I. May (1976): Body weight, diet and home range area in primates. Nature 259:459–462

Mitchell, J., J. Keane, and J. Laidlaw, 2009: Making success work for the poor: Package tourism in Northern Tanzania. ODI/SNV.

Mittermeier, R.A., P. Robles-Gil, M. Hoffmann, J.D. Pilgrim, T.B. Brooks, C.G. Mittermeier, J.L. Lamoreux, and G.A.B. Fonseca, 2004: Hotspots Revisited: Earths Biologically Richest and Most Endangered Ecoregions. CEMEX, Mexico City, Mexico.

Moser, D., S. Dullinger, T. Englisch, H. Niklfeld, C. Plutzar, N. Sauberer, H.G. Zechmeister, and G. Grabherr, 2005: Environmental determinants of vascular plant species richness in the Austrian Alps.

Mount Elgon Integrated Conservation and Development Project, 2001: Aerial photography and land cover mapping of Mt. Elgon Forest.

Mugagga, F., V. Kakembo, and M. Buyinza, 2012: "Land use changes on the slopes of Mt. Elgon and the implication for the occurrence of landslides." *Catena* 90: 39–46.

Muhire, I., and F. Ahmed, 2015: "Spatialtemporal trends in mean temperatures and aridity index over Rwanda." *Theor Appl Climatol* 123: 399. https://doi.org/10.1007/s00704-014-1353-2.

Museruka, C., C. Ndayisaba, A. Mutabazi, and F. Nsabukunze, 2011: "Assessment of Temperature Changes in Upper Akagera Basin: Case of Rwanda." *Nile Basin Water Science & Engineering Journal* 4(2).

Mutimba, S., S. Mayieko, P. Olum, and K. Wanyama, 2010: Climate change vulnerability and adaptation preparedness in Kenya. Heinrich BöllStiftung. East and Horn of Africa.

Mwaura, A., 2011: Mount Elgon Transboundary Ecosystem: Western Conservation Area, Kenya. KWS.

National Forest Authority, 2009: National Biomass Study retrieved from http://www.nfa.org.ug/index.php/products-services/biomass-monitoring

Nemani, R.R., C.D. Keeling, H. Hashimoto, W.M. Jolly, S.C. Piper, C.J. Tucker, R.B. Myneni, and S.W. Running, 2003: "Climate-driven increases in global terrestrial net primary production from 1982 to 1999." *Science* 300: 1560–1563.

Neumann, R.P., 1992: "Political ecology of wildlife conservation in the Mt. Meru area of northern Tanzania." *Land Degradation and Rehabilitation*. 3: 99-113. Doi: 10.1002/ldr.3400030203.

Obunde, P.O, J.M. Omiti, and A.N. Sirengo, 2005: Policy dimensions in human wildlife conflicts in Kenya: evidence from Laikipia and Nyandarua districts. IPAR

Odala, E.O., D.O. Olago, and W. Ochola (eds.), 2006: Environment for Development: An ecosystem Assessment of Lake Victoria Basin, UNEP/Pan African START Secretariat.

Ogutu, J.O., and N. Owen-Smith, 2003: "ENSO, rainfall and temperature influences on extreme population declines among African savanna ungulates." *Ecol. Lett.* 6: 412–419.

Ogutu, J.O., N. Owen-Smith, H-P. Piepho, and M.Y. Said, 2011: "Continuing wildlife population declines and range contraction in the Mara region of Kenya during 1977-2009." *Journal of Zoology*, 285: 99–109.

Ogutu, J.O., N. Owen-Smith, H-P. Piepho, M.Y. Said, S.C. Kifugo, S. Robin, R.S. Reid, H. Gichohi, P. Kahumbu, and S. Andanje, 2013: "Changing wildlife populations in Nairobi National Park and adjoining Athi-Kaputiei Plains: collapse of the migratory wildebeest." *Open Conservation Biology Journal* 7: 11–26.

Ogutu, J.O, N. Owen-Smith, H-P. Piepho, B. Kuloba, and J. Edebe, 2012: "Dynamics of ungulates in relation to climatic and land use changes in an insularized African savanna ecosystem." *Biodivers Conserv* (2012) 21: 1033. https://doi.org/10.1007/s10531-012-0239-9.

Ogutu, J.O., H-P. Piepho, H.T. Dublin, N. Bhola, and R.S. Reid, 2008: "El Niño-Southern Oscillation, Rainfall, Temperature and Normalized Difference Vegetation Index Fluctuations in the Mara-Serengeti Ecosystem." *African Journal of Ecology* 46, 132–143.

Ogutu, J.O., H-P. Peipho, H.T. Dublin, N. Bhola, and R.S. Reid, 2010: "Rainfall extremes explain interannual shifts in timing and synchrony of calving in topi and warthog." *Popul Ecol* 52:89–102.

Ogutu, J.O., H-P. Piepho, M.Y. Said, G.O. Ojwang, S.C. Kifugo, P.W. Wargute, and L.W. Njino, (submitted) 2016: "Extreme wildlife declines and concurrent increase in livestock numbers in Kenya rangelands." *PLoS ONE*.

Opdam, P., and D. Wascher, 2004: "Climate change meets habitat fragmentation: linking landscape and biogeographical scale level in research and conservation." *Biol. Conserv.* 117:285–297.

OECD (Organisation for Economic Cooperation and Development), 2013: Establishing and understanding post - 2020 climate change mitigation commitments. Climate Change Expert Group, Paper No. 2013 (3). France.

Parmesan, C., and G. Yohe, 2003: "A globally coherent fingerprint of climate change impacts across natural systems." *Nature* 421: 37–42.

Petursson, J.G., P. Vedeld, and J. Kaboggoza, 2006: Transboundary biodiversity management challenges; the case of Mt. Elgon, Uganda and Kenya.

Plumptre, A.J., T.R.B. Davenport, M. Behangana, R. Kityo, G. Eilu, P. Ssegawa, C. Ewango, D. Meirte, C. Kahindo, M. Herremansd, J. K. Peterhanse, J.D. Pilgrim, M. Wilson, M. Languy, and D. Moyer, 2007: "The Biodiversity of the Albertine Rift." *Biological Conservation* 134:178n94.

Poole, J.H., 1989: "Announcing Intent: the aggressive State of Musth in African Elephants." *Animal behaviour* 37: 140–152.

Pounds, J.A., M.R. Bustamante, L.A. Coloma, J.A. Consuegra, M.P.L. Fogden, P.N. Foster, E. La Marca, K.L. Masters, A. Merino-Viteri, R. Puschendorf, S.R. Ron, G.A. Sanchez-Azofeifa, C.J. Still and B.E. Young, 2006: "Widespread amphibian extinctions from epidemic disease driven by global warming." *Nature* 439: 161–167.

REMA (Rwanda Environment Management Authority), 2009: State of the Environment and Outlook Report. REMA, Kigali, Rwanda.

——————, 2010: Draft Second National Communication to the United Nations Framework Convention on Climate Change. Kigali, 2011.

——————, 2014: lesson learning from national climate compatible development planning in Rwanda.

Rubenstein, D.I., 1992: "The greenhouse effect and changes in animal behaviour: Effects on social structure and life history strategies" in *Global warming and biological diversity*, R.L. Peters and T.E. Lovejoy (eds.) Yale University Press, 180–192.

Rusch, G.M., S. Stokke, E. Røskaft, G. Mwakelebe, H. Wiik, J.M. Arnemo, and R.D. Lyamuya, 2005: "Human-Wildlife Interactions in Western Serengeti, Tanzania." *NINA Rapport* 85(47): 85. http://www.nina.no/Publikasjoner/Publication.aspx?pubid=2626.

Rwanda, Republic of, 2006: The National Adaptation Programme of Action to Climate Change. Ministry of Lands, Environment, Forestry, Water and Mines.

Seburanga, J.L., B.A. Kaplin, E. Bizuru, and E.N. Mwavu, 2013: "The folk biology of South American-native shrub, Mimosa pigra L. [Leguminosae] and its invasive success in Rwanda." *International Journal of Biodiversity and Conservation* 5(8): 486-497. DOI: 10.5897/IJBC12.115.

Seimon, A., 2012: Climatology and Potential Climate Change Impacts of the Nyungwe Forest National Park, Rwanda. WCS Technical Report, Wildlife Conservation Society, New York, USA, 45pp.

Seimon, A., and A.J. Plumptre, 2012: "The Albertine Rift" in M. Cross, J. Hilty, and C. Chester (eds.), *Conservation and climate disruption: Landscape science and practice in a changing climate.* Island Press.

Serneels, S., and E.F. Lambin, 2001: "Impact of land-use changes on the wildebeest migration in the northern part of the Serengeti-Mara Ecosystem." *Journal of Biogeography* 28(3): 391–407, March 2001.

Serneels, S., M.Y. Said, and E.F. Lambin, 2001: "Land cover changes around a major East African wildlife reserve: the Mara Ecosystem (Kenya)." *International Journal of Remote Sensing* 22: 3397–4320.

Sinclair, A.R.E., and P.M. Arcese (eds.), 1995: *Serengeti II: Dynamics, Management, and Conservation of an Ecosystem*. University of Chicago Press, Chicago, USA.

Sinclair, A.R.E., S.A.R. Mduma, and P. Arcese, 2000: "What Determines Phenology and Synchrony of Ungulate Breeding in Serengeti?" *Ecology* 81(8): 2100–2111.

Songorwa, A.N., 2004: "Human Population Increase and Wildlife Conservation in Tanzania: Are the Wildlife Managers Addressing the Problem or Treating Symptoms?" *African Journal of Environmental Assessment and Management* 9: 49–77.

Spehn, E., and C. Körner, 2005: "A global assessment of mountain biodiversity and its function" in *Global Change and Mountain Regions: An Overview of Current Knowledge,* U.M. Huber, H.K.M. Bugmann, and M.A. Reasoner (eds.), Springer, Berlin, 393–400.

Sun, C., B. Kaplin, K.A. Kristensen, V. Munyaligoga, J. Mvuklyumwami, K.P. Kajondo, and T.C. Moermond, 1996: "Tree phenology in a tropical montane forest in Rwanda." *Biotropica* 28: 668–681.

Tanzania, United Republic of, 2007: The National Adaptation Programme of Action. Vice Presidents Office, Tanzania.

TNRF (Tanzania Natural Resource Forum), 2008: Wildlife for all Tanzanians: Stopping the loss, nurturing the resource and widening the benefits. An information pack and policy recommendations, unpublished report. Tanzania Natural Resource Forum, Arusha, Tanzania.

Thirgood, S., A. Mosser, S. Tham, G. Hopcraft, E. Mwangomo, T. Mlengeya, M. Kilewo, J. Fryxell, A.R.E. Sinclair, and M. Borner, 2004: "Can parks protect migratory ungulates? The case of the Serengeti wildebeest." *Anim. Conserv.* 7: 113–120.

Thomas, C.D., A. Cameron, R.E. Green, B. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M. Ferriera De Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. Van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips, and S.E. Williams, 2004: "Extinction risk from climate change." *Nature* 427:145–148.

Thuiller, W., O. Broenniman, G. Hughes, J.R.M. Alkemades, G.F. Midgley, and F. Corsi, 2006a: "Vulnerability of African mammals to anthropogenic climate change under conservative land transformation assumptions." *Global Change Biol.* 12: 424–440.

Uganda, Republic of, 2007: Climate Change Uganda National Adaptation Programme of Action (NAPA), Kampala, Uganda.

——————, 2010: National Development Plan (2010/11–2014/15).

——————, 2012: Ministry of Tourism, Wildlife and Heritage: Sectoral Statistical Abstract: Ministry of Tourism, Wildlife and Heritage.

————, 2014: *Fifth National Report to the Convention on Biological Diversity*—National Environmental Management Authority, Ministry of Water and Environment.

Uganda Wildlife Authority (UWA) 2011. Draft guidelines for revenue sharing between wildlife protected areas and adjacent local governments and communities.

UNEP (United Nations Environment Programme), 2006: Africa Environment Outlook 2. UNEP, Nairobi, Kenya.

————, 2009: "Kenya: Atlas of Our Changing Environment." Division of Early Warning and Assessment (DEWA), UNEP.

————, 2012: The role and contribution of Montane forest and related ecosystem services to the Kenya Economy. http://www/unep.org/pdf/montane_forests.pdf.

————, 2013a: Adaptation to climate change induced water stress in the Nile Basin. Vulnerability Assessment Report. Division of Early Warning and Assessment (DEWA), UNEP, Nairobi, Kenya.

————, 2013b: Thematic focus: Ecosystem management, Environmental governance, Climate change. Saving the Great Migrations: Declining wildebeest in East Africa? http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=107.

————, 2015: Adaptation gap report. Summary report, 2015.

UNFPA 2014: State of the World Population 2014 "The Power of 18 Billion – Adolescents, Youth and the Transformation of the Future"

UNWTO (United Nations World Tourism Organisation), 2015: Tourism Highlights. Report, UNWTO.

————, 2014: Tourism highlights, 2014 edition.

USAID (United States Agency for International Development), 2010: Burundi Environmental Threats and Opportunities Assessment (ETOA), USAID, Washington DC, USA.

————, 2013: Planning for resilience in East Africa through Policy, Adaptation, Research and Economic Development (PREPARED). Scoping Study on Vulnerability, Impact and Adaptation Assessment (VIA).

————, 2014a: PREPARED. Approach and methodology for the Lake Victoria Basin Vulnerability, Impacts and Adaptive Assessment (VIA).

————, 2014b: PREPARED. Lake Victoria Basin Ecosystems Profile Assessment Report.

Vanacker, V., M. Linderman, F. Lupo, S. Flasser, and E. Lambin, 2005: "Impact of short term rainfall fluctuation on inter annual land cover changes in Sub-Saharan Africa." *Global Ecology and Biogeography* 14: 123–135.

Väre, H., R. Lampinen, C. Humphries, and P. Williams, 2003: "Taxonomic diversity of vascular plants in the European alpine areas" in *Alpine Biodiversity in Europe: A Europe-wide Assessment of Biological Richness and Change*, L. Nagy, G. Grabherr, C.K. Körner, and D.B.A. Thompson (eds.), Springer Verlag, Berlin, 133–148.

Wanjau, M.W. 2002: People/crocodile conflicts in Kenya: policy changes required to effectively manage the conflicts. Report to Kenya Wildlife Services

Whyte, I.J., and S.C.J. Joubert, 1988: "Blue wildebeest population trends in the Kruger National Park and the effect of fencing." *South African Journal of Wildlife Research* 18, 78.

"World Bank Group. "Potsdam Institute for Climate Impact Research and Climate Analytics. 2013. Turn Down the Heat : Climate Extremes, Regional Impacts, and the Case for Resilience. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/14000 License: CC BY-NC-ND 3.0 IGO."

"World Bank. 2012. Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/11860 License: CC BY-NC-ND 3.0 IGO."WTTC (World Travel and Tourism Council), 2011: Travel and Tourism economic impacts.

WWF (World Wide Fund for Nature), 2006: Climate Change Impacts on East Africa, A Review of the Scientific Literature by WWF. World Wide Fund For Nature, Gland, Switzerland.

——————, 2014: Living Planet Report 2014: Summary. (Melellan, R., Iyengar, L., Jeffries, B. And N. Oerlemans (eds)). WWF, Gland, Switzerland.

www.iucnredlist.org/details/15951/0: IUCN Red List of Threatened Species.

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov