Building Resilience to Climate Change on Mt. Elgon: Policy Implications and Recommendations

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About the Project

USAID/IUCN Implementing a resilience framework to support climate change adaptation (RFCC) in the Mt Elgon region of the Lake Victoria Basin project (2012-2015) is implemented by IUCN’s Eastern and Southern Africa Regional Office (ESARO) and Uganda Country Office (UCO) through their Water and Wetlands programme. The project is implemented in collaboration with the African Collaborative Centre for Earth System Science (ACCESS) based at the University of Nairobi, the Lake Victoria Basin Commission (LVBC) and Global Water Partnership Eastern Africa, with financial support from the United States Agency for International Development (USAID). The project’s goal is to enhance coordination and adaptation action between stakeholders using informed, timely, accurate and comprehensive information to promote societal and ecological resilience to adverse climate impacts within the Mt. Elgon Region, Lake Victoria Basin. The project aims to achieve this goal through the following four main objectives:

1. Improving scientific knowledge and demonstrating preparedness for a changing climate future in the Mt. Elgon region of the Lake Victoria Basin;

2. Demonstrating increased social and ecological resilience in hotspots of climate vulnerability using adaptation strategies which mainstream ecosystem services, economic diversification, adaptive management and learning in water and land management;

3. Influencing regional policy frameworks to better utilize systems approaches for building climate resilience and integrating these approaches across sectors and into poverty reduction strategies and national development plans; and

4. Enhancing learning at local to regional levels, through better access to information, networking, capacity building and leadership development.

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1. Introduction

Mt. Elgon is a trans-boundary ecosystem shared between Kenya and Uganda (Fig. 1). It is the 7th highest Mountain in Africa rising to 4,320 metres; it is an important watershed that nourishes a vast array of rivers, including the Nile; it maintains water quality, quantity and evenness of flow due to its varied vegetation types and altitudes; it is of high biodiversity importance; and is a key resource, providing ecosystem goods and services to a sizeable human and livestock population. Studies so far conducted on Mountain Ecosystems (Mt. Elgon included) indicates that the mountain ecosystems in Africa appear to be undergoing significant observed changes that are likely due to complex climate-land interactions and the climate change (IPCC, 2007).

Figure 1: Location of Mt. Elgon
2. Key Messages

Climate impacts on Mt. Elgon and need for continuous monitoring

The climate of Mt. Elgon is changing due to global warming, with resident communities reporting higher temperatures and more erratic, variable and intense rainfall accompanied by changes in the onset and cessation of rainy seasons and the distribution of rains within the season. The effects of these changes include reduced stream-flow, reduced groundwater recharge, increased soil erosion and landslides and changes to montane ecosystems. However, more work is still required in terms of generating more scientific data to enable quantification of these observed changes. In this regard, there should be a deliberate effort by policy makers to set up climate and environmental monitoring stations in the region to ensure that policy and management decisions for the montane ecosystem are based on a sound scientific evidence base. The monitoring will also help in assessing the changes of ecosystems and biodiversity as a result of climate change impacts as indicated below.

Climate change impacts on ecosystems and biodiversity

All future modeled scenarios (predictions) suggest that significant redistributions of plant species and vegetation types and development of new ecosystems may occur in the next 50-100 years in mountain regions (Graumlich and Francis, 2010) and this is supported by empirical data. Simulation of possible vegetation changes on Mount Elgon confirms this view. It is important to recognize that landscapes and habitats will continue to change under global warming, and it should therefore be recognized that ecosystems that are protected are still going to change and will keep changing and at varying rates and times and this fact will need to be considered when devising and implementing environmental protection measures (Graumlich and Francis, 2010) to ensure that the measures are resilient to the projected range of future changes.

Climate change impacts on ecosystem services and livelihoods and ecosystem-based adaptation

The impacts of climate change on land based resources on Mt. Elgon are generally negative, resulting in the communities’ continued reliance on already stressed resources, thus leading to a spiraling effect of the impacts on resource sustainability and livelihoods, thereby compromising their wellbeing and increasing poverty levels. Travers et al. (2012) noted that healthy ecosystems and their services provide opportunities for sustainable economic prosperity in conjunction with the provision of defense against the negative effects of climate change and conversely, that degradation of ecosystems results in increased climate change vulnerability for the communities that live in these ecosystems as well as for the ecosystems themselves.

Essentially, Ecosystem-Based Adaptation (EbA) approaches should be used to address these crucial links between climate change, biodiversity, ecosystem services and sustainable resource management (as opposed to other approaches) and this has been demonstrated and proven to work in Mt. Elgon under the USAID funded RFCC Mt. Elgon project. It is important to note that adaptation strategies in mountain systems must be formulated with the knowledge that climate
baselines will be in a dynamic state of change. In addition, adaptation strategies are currently constrained by lack of site specific long-term projections of potential climate impacts, hence the need to continuously improve on the scientific evidence base to help fine tune adaptation strategies. Adaptation measures implemented today, however good and robust are likely to fail in the future as a result of population growth and related dynamics. This therefore needs to be factored in. A study in the Rwenzori, for example, observed that a community’s initiative to plant trees was affected by land shortage and a growing population (KRC, 2012).

Disaster risk reductions is interlinked to climate change

There is growing scientific evidence that many mountain regions have become increasingly disaster-prone in recent decades, and are more frequently affected than other environments by destructive natural processes including earthquakes, volcanic eruptions, dam bursts or glacial lake out¬bursts, as well as avalanches and landslides (Kohler and Maselli, 2009). On Mount Elgon, there has been considerable loss of woodlands and forest cover due to deforestation and cultivation, particularly on steep concave slopes of the Mt. Elgon National Park in Uganda. These changes have induced a series of shallow and deep landslides in the area during rainfall events (Mugagga et al., 2012), with loss of human life, livestock and other assets. Certainly, the growing population, and the related expansion of settlements and infrastructure on the mountain increase the risk of landslide hazard, coupled with climate change-related expected increases of heavy rainfall. Since climate and related hazards are now clearly linked with issues such as food security, shelter, and migration within the region, it is important to manage disasters in a framework that links climate change adaptation and disaster risk reduction (cf. McBean and Rodgers, 2010).

Figure 3: Map of cumulative risks in the various river catchments of Mt. Elgon

Areas affected by landslides in Bumwalukani, Mt. Elgon, Uganda in 2012/13

A photo of a landslide in Nametsi, Mt. Elgon, Uganda 2012/13
Despite its importance, Mt. Elgon ecosystem is experiencing risks and disasters associated with climate change impacts such as flooding, hailstones, and to some extent landslides. This situation is exacerbated by land-use and land cover changes due to: deforestation, encroachment into the national park (especially on the Ugandan side); land fragmentation due to high population, high poverty levels, over reliance on natural resources; and riverbank degradation. These have caused far-reaching consequences on the ecosystem and people’s livelihoods.

Based on information on topography, watersheds, geology, soils, landuse/land cover changes, and population density, ACCESS were able to generate a relative cumulative risk map in GIS that integrates the mentioned information, with high risk areas being referred to as “Areas of Concern” and that were targeted for project intervention (ACCESS/IUCN, 2014). Validation of the map for areas of landslide risk and flooding risk was carried out on the ground and was found to be quite accurate.

Effective management mechanism is required

In the trans-boundary montane ecosystem like Mt. Elgon, there is need for structured programmes that will engage the communities in sustainable utilization of the resources available to them. Often, this is constrained by low institutional capacities to implement and enforce regulations, including inadequate financing, as well as lack of programmes for awareness creation and capacity enhancement at the local level. In addition, there is currently no trans-boundary institutional framework or financing arrangement to cope with the region specific climate change impacts and effects. Such institutional framework and its programme of work need to be implemented at the governmental level with support and/or participation from relevant stakeholders. In this regard, and with the help of this project, Lake Victoria Basin Commission is developing a Memorandum of Understanding between the two countries sharing Mt. Elgon and we hope this will transit into this kind of management framework being proposed here.
3. Overview of climate impacts on Mt. Elgon

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia (IPCC, 2013). Recent research shows that climate change will be more pronounced in high-elevation mountain ranges, which are warming faster than adjacent lowlands (World Bank, 2008), and that the pace of climate zone shifts will be higher in such regions than in lowlands (Mahlstein et al., 2013). In addition, aquatic ecosystems in such areas often lack resilience and are strongly dependent on temperature and stream flow regimes that are already documented to be changing (Rieman and Isaak, 2010). Some species, populations, and communities may be able to track the climate-related changes and simply “relocate” but upstream limits of available habitat and barriers to dispersal and migration will limit many others (Rieman and Isaak, 2010). Documented rapid loss of habitable climate space makes it no surprise that the first extinctions of entire species attributed to global warming are mountain-restricted species (Parmesan, 2006). Mountains therefore represent unique areas for the detection of climatic change and the assessment of climate-related impacts (Beniston, 2003). For Mt. Elgon, the important aspect, for example, is demonstrated by the finding that altitudinal ranges of vegetation ecosystems differ considerably on the wet and dry sides of Mt. Elgon (Hamilton, 1972), and that under dry sunny conditions, pollen taxa reach higher altitudes on the eastern than on western slopes (Hamilton, 1972; Flenley, 1979).

Based on literature review (strong scientific evidence base) and field-based observations, the following changes in climate variables are reported in tropical mountain areas, and some of these have been reported by stakeholders in Mt. Elgon area, note that these are direct changes observed in climate and are what generate the impacts and table 1 below gives examples of these impacts:

- Increase in solar radiation
- Increase in temperature and evaporation
- Increasing trend in daily maximum temperatures
- Increasing or decreasing trend in daily minimum temperatures depending on location
- Changes in cloudiness regimes
- More intense windstorms
- Increased frequency and intensity of rainfall extremes
- Changes in onset and cessation of rainy seasons
- Changes in rainfall distribution during rainy seasons
- Increase in short and intense rainfall events
- Increase in hailstones and frost
- Stronger and more frequent El Niño
Table 1: Examples of climate change impacts and related environmental effects reported on Mount Elgon

<table>
<thead>
<tr>
<th>Water</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>• More frequent, prolonged, intense, and</td>
<td>• Changes to montane species/ecosystems (altered habitats, communities,</td>
</tr>
<tr>
<td>extensive floods and droughts</td>
<td>growth, productivity, regeneration, phenology, biomass, carbon, invasive</td>
</tr>
<tr>
<td>• Increased intensity of runoff</td>
<td>species)</td>
</tr>
<tr>
<td>• Reduced or less reliable streamflow</td>
<td>• Disappearance or decline of species in the lowlands and at lower elevations</td>
</tr>
<tr>
<td>• Warmer water in streams/rivers</td>
<td>due to a net movement of species upslope ('lowland biotic attrition') or</td>
</tr>
<tr>
<td>• Reduced groundwater recharge and</td>
<td>human pressure, or both</td>
</tr>
<tr>
<td>groundwater levels</td>
<td>• Forest dieback during extended droughts</td>
</tr>
<tr>
<td>• Increased water stress</td>
<td>• Wildfire risk - altered patterns, frequency, severity and intensity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soils</th>
<th>Human and Ecosystem Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Changes in soil properties</td>
<td>• Changes in the epidemiology of vector-borne diseases, e.g. malaria</td>
</tr>
<tr>
<td>• Increased frequency and magnitude of</td>
<td>• Changes in air quality</td>
</tr>
<tr>
<td>landslides</td>
<td>• Increase in existing or new pests</td>
</tr>
<tr>
<td>• Increased soil erosion</td>
<td>• Increase in existing or new diseases</td>
</tr>
</tbody>
</table>
4. Ecosystem Services and Livelihoods

People living in mountain ecosystems in the developing world are particularly vulnerable to climate change as a result of their high dependence on natural resources for their livelihoods (Figure 2), comparatively higher exposure to extreme events, and widespread poverty and marginalization (Macchi, 2011). Climate change directly erodes natural capital, and thus the resource base for human enterprise (Graumlich and Francis, 2010).

Figure 2: Relationship between mountain ecological zones, ecosystem services and livelihood activities (the widths of the boxes convey relative importance of the ecosystem services in relation to the mountain zone).

Ecosystem Services

Each ecozone of a montane environment provides critical environmental services (Figure 2), and provides a resource base for mountain dwellers that may be impacted in several ways by climate change, altering their livelihoods and social amenities and structures (Table 2). Despite their limited area, tropical alpine environments provide important environmental services on both local and global scales, and these include biodiversity conservation, carbon storage, and water supply for cities, agriculture and hydropower (Buytaert et al., 2011). They also tend to have well developed wetlands that help to improve groundwater recharge, sediment accretion and pollution removal (Buytaert et al., 2011). In a study in eastern Uganda covering part of Mount Elgon, it was observed that over 90% of the households have attempted changing their farming operations in response to climate variability and extremes (Kansiime, 2012).

Table 2: Resultant Impacts/Effects of Climate Change on Ecosystem Services

<table>
<thead>
<tr>
<th>Ecosystem Services</th>
<th>Livelihood Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulating</td>
<td>Tourism, mountaineering services</td>
</tr>
<tr>
<td>Provisioning</td>
<td>Tourism, mountaineering services, biodiversity conservation</td>
</tr>
<tr>
<td>Supporting</td>
<td>Tourism, agriculture, small-scale livestock production &amp; grazing, timber, food &amp; medicinal products, fuelwood, hunting, bee-keeping, small-scale hydropower generation, water supply schemes, biodiversity conservation</td>
</tr>
<tr>
<td>Cultural</td>
<td>Pastoralism, small to large scale agriculture, livestock production, timber, fishing, tourism, mining, fuelwood, hunting, bee-keeping, water supply schemes, sand harvesting</td>
</tr>
</tbody>
</table>

Table 2: Resultant Impacts/Effects of Climate Change on Ecosystem Services

- Less availability of water (potable)
- Damage to infrastructure
- Changes and damage to existing ecosystems resulting in disruption of livelihoods
- Reduction in tourism
- Reduced job opportunities
- Enhanced food insecurity (crop destruction, etc.)
- Water use conflicts
- Reduced value of ecosystem goods and services
- Increased injury to and loss of life for humans and animals including livestock
- Higher insurance premiums
- Erratic and reduced power supply from hydroelectric power plants
- Unsustainable land uses e.g. overgrazing, wetland drainage
- Upslope advance of agriculture
- Loss of cultural, religious sites
- Mental stress
- Migration
5. Impacts of human actions on the environment

The Mt. Elgon region has seen dramatic changes in land use over recent decades (Figure 4). There has been a marked reduction in forest cover due to clearing of land for agricultural production. Satellite observations since the early 1970s to present show this trend. Many of the effects of the changes observed in climate variables are enhanced by human activities that directly impact the landscape and play a role alongside natural climate feedback mechanisms to modify local to regional climates and environments (Table 1). These include deforestation, increased surface temperatures, decreased precipitation, development and expansion of urban areas (heat island effects), and drainage of wetlands (increased local surface temperatures). Disturbance often lowers the upper limit of a species, and this is particularly apparent on Mt. Elgon, where disturbance has lowered the upper boundary of the Montane Forest Belt, thus lowering the altitudinal extension of the forest species (Hamilton, 1972). In the case of lower altitudinal limits of species ranges, extension is encouraged by one or both of two factors: reduced competition and more favourable moisture conditions (Hamilton, 1972). Conditions of reduced competition occur both artificially (forest clearings, grazed land, etc.) and naturally (forest gaps, unstable soils, unfavourable microclimates etc.). With great land-use pressures in Mount Elgon, including deforestation and heavy grazing combined with extreme rainfall, flashfloods and flooding will likely increase. Greater variability in water flow resulting in either too much water or too little water will also increase the vulnerability of mountain livelihoods (Kaltenborn et al., 2010).

![Figure 4: Map showing land use/land cover change on Mt. Elgon, 1973-2013](image-url)
Simulation of climate change influence on land cover on Mt. Elgon

On Mt. Elgon, the climate models did not show significant changes in precipitation but they do predict a significant increase in temperature. A simulation was therefore carried out to project how tree cover would shift upwards to follow rising temperature zones (Figure 5). This was a very simple demonstration using temperature alone as the driver, recognising that the response may be more muted as a consequence of other interacting drivers such as phenology, soil type and moisture content, species interactions etc. that were not taken into account due to lack of data. However, this shift is supported by paleoecological reconstructions on East African mountains (including on Mount Elgon) that show that the treeline on all mountains was depressed by several hundred meters relative to the present tree line as a consequence of the cool period with a mean temperature decrease of 4°C and up to 30% decrease in mean annual rainfall compared to the present during the Last Glacial Maximum 18,000 years ago (Olago et al., 2007). Hamilton’s (1972) observations on Mount Elgon suggest that the upper limit of a species range is more closely determined by temperature conditions than the lower, and extension is greatest in areas of more favourable water balance.

Figure 5: Map showing the projected impact of temperature on forest gain/loss on Mt. Elgon
6. Climate change adaptation

Climate change has the potential to impose additional pressures on water availability and accessibility, with key impacts related to extreme events – droughts and floods. Increased temperature will result in increased crop stress and crop water needs, with potential impacts on food security in the region. It is on this basis that adaptation measures in mountain areas are increasingly becoming necessary and examples of such measures are shown in table 3.
### General
- Reduction of non-climate stresses/stressors
- Favour actions that are robust to uncertainty - “no regrets” actions
- Increase/improve education and awareness
- Early warning systems and communication strategies
- Skills enhancement for proposed adaptation activities, investment and training

### Forests
- Reforestation/regeneration
- Implement fire management within and outside forest
- Forest rehabilitation with a mix of local tree varieties
- Selection of species for planting
- Maintenance or enhancement of genetic diversity
- Use of seed sources adapted to expected future conditions
- Maximize reproductive tree population sizes
- Minimize harvesting impacts through reduced impact logging
- Minimize forest fragmentation
- Pest management

### Ecosystems & Biodiversity
- Protect refugia and special ecosystem elements
- Set up refugia and migration corridors
- Increase and protection of riparian vegetation
- Restore river and stream channels to their natural morphologies
- Reduce disturbance on fragile mountain grasslands
- Focus conservation activities in areas identified as climate refugia and/or areas likely to be suitable future habitat

### Agriculture & Food Security
- Irrigation
- Plant high yielding and drought resistant crop varieties
- Agroforestry
- Crop rotation
- Water use efficient technologies
- Information and early warning systems
- Cultivation of diversified native species
- Breeding of diversified native species
- Soil moisture retention methods
- Using gray water

### Water Supply
- Construction of dams
- Managed aquifer recharge
- Diversion of water
- Treatment and recycling of wastewater
- Development of water allocation plans
- Rainwater harvesting
- Water retention terracing
- Infiltration ditches, small barrages, water mirrors (small lakes), and rustic canals
- Reconnecting stream reaches

### Livestock & Fisheries
- Intensive management of lowland pastures
- Production of livestock foodstuffs to reduce pressure on mountain pastures
- Improved grazing management practices
- Community-based regulation of grazing intensity and frequency
- Aquaculture
- Conservation of post harvest fishery products

### Energy
- Renewable resources - promote wind, solar and biogas energy
- Reduce fuel-wood use through improved stoves
- Energy efficient buildings

### Livelihoods
- Diversification with less reliance on land based resources
- Supporting income-generating activities and small-scale cottage industries such as production of dried fruits and vegetables; bee-keeping; silk worm rearing and cocoon production; milk and wool production and processing; and crafts.
- Improving access to markets
- Adaptation skills enhancement
- Training, education and awareness raising
- Management of resource use conflicts
- Collective management of resources
- Strengthen ecotourism
- Build small-scale infrastructure or live barriers to protect crops/infrastructure against floods, landslides, etc.
- Enhanced disease surveillance programmes

### Table 3: Common adaptation measures/interventions in mountain areas, includes adoption of proven traditional technologies
7. Conclusions

Mt. Elgon is a trans-boundary ecosystem shared between Kenya and Uganda and is an important watershed in the East Africa region, nourishing a vast array of rivers, including the Nile, and is of high biodiversity importance. Mount Elgon is a key resource, providing ecosystem goods and services to a sizeable human and livestock population. It is one of the mountain ecosystems in Africa that appears to be undergoing significant observed changes that are likely due to complex climate-land interactions and the climate change. Based on literature review and field-based observations, there have been noticeable changes in climate, particularly in terms of increasing temperatures, and more variability in frequency and intensity of rainfall. This has led to a number of impacts including increased frequency of droughts and floods in the lower altitude zones, reduced and less reliable stream-flow and groundwater levels, changes to montane species and ecosystems, increased incidences of landslides, among others. These impacts of climate change on the land based resources on Mount Elgon are generally negative, resulting in the communities’ continued reliance on already stressed resources, thus leading to a spiraling effect of the impacts on resource sustainability and livelihoods, thereby compromising their wellbeing and increasing poverty levels. This is exacerbated by increased risks of natural disasters such as landslides and flooding, and human actions such as deforestation. The need for adaptation is immediate and crucial, and the strategies must be formulated with the knowledge that climate baselines will be in a dynamic state of change.
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