THE REPUBLIC OF UGANDA

Popular Version

ECOSYSTEM BASED ADAPTATION IN MOUNTAIN ELGON ECOSYSTEM

Vulnerability Impact Assessment (VIA) for the Mt Elgon Ecosystem

December 2013

Acknowledgements

The Vulnerability Impact Assessment (VIA) for Mt. Elgon ecosystem was commissioned by the United Nations Development Programme (UNDP) Uganda Country Office on behalf of a partnership comprising of UNDP, International Union for the Conservation of Nature (IUCN), United Nations Environment Programme (UNEP) and Government of Uganda (GoU). The assessment was undertaken under the ambit of the Ecosystem Based Adaptation (EBA) project of UNDP Uganda. This popular version presents highlights of the main report prepared by a team of experts from the National Forestry Resources Research Institute (NaFORRI)[1] and the School of Forestry, Environmental and Geographical Sciences (SFEGS) of Makerere University[2], with a team of Assistants from NaFORRI[3].

The assessment benefited enormously from the guidance and direction of members of the VIA Task Force[4]; district technical personnel in the departments of Forestry, Environment, Fisheries, Community Development, Planning, Agriculture, Health, Veterinary and Population in the districts of Kween, Kapchorwa, Sironko and Bulambuli and representatives of various local communities.

Our gratitude also goes to the Inter-Governmental Authority on Drought (IGAD) headquarters in Nairobi, the Department of Meteorology, the Directorate of Water Development (DWD) in Uganda's Ministry of Water and Environment (MWE), and Mr. Council Dickson Langoya for permitting use of vital datasets for this assessment. Technical input from the Directorate of Environmental Affairs – MWE, professional peers and specialists in various fields is equally acknowledged.

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Foreword

Climate Change is a reality and presents one of the greatest challenges of our time. Africa is the most vulnerable continent to its impact. The impacts have been multi-sectorial and have included flooding, drought and food insecurity in Uganda. This is both a livelihood and a serious multi-faceted development challenge. There is growing awareness of the impact of climate change which has resulted in a large number of agencies, organizations, research institutes, and political bodies seeking to understand the patterns of vulnerability and how to adapt.

The Vulnerability Impact Assessment (VIA) for the Mt. Elgon Ecosystem was commissioned by the United Nations Development Programme (UNDP) on behalf of United Nations Environment Programme (UNEP) at the request of the Ministry of Water and Environment. The Ministry is the Implementer of the Ecosystem Based Adaptation (EbA) in the Mountain Elgon Ecosystem Programme in Uganda.

The districts of Kween, Kapchorwa, Sironko and Bulambuli where the programme is being implemented are some of the most vulnerable areas to climate change in Uganda as exemplified by the most recent climate change impacts such as landslides experienced in the area, together with the spillover effects in the neighboring districts. This is the first VIA that is site specific on the Mt. Elgon ecosystem on the Ugandan side using data sets that were collected, backed up by the indigenous knowledge of the densely populated communities leaving in these areas.
The VIA among others, highlights' to us the importance of maintaining the functionality of our ecosystems so that we continue getting the ecosystem services therein, which is the essence of sustainable development. This is in line with the Ministry's mission of "promoting and ensuring the rational and sustainable utilization, development and effective management of water and environment resources for socio-economic development of the country".

The approach used in this VIA is recommended bearing in mind the multidisciplinary nature of natural resources management. This, to a great extent contributed to and ensured the success of the various national processes. The VIA is a good decision making tool which supports the design of EbA options and I am hopeful it will be found useful by our stakeholders both at national and regional levels.

My sincere gratitude goes to the different stakeholders for their commitment, time, knowledge and data provided during the development of this VIA. Special thanks also go to UNDP, UNEP and International Union for Conservation of Nature (IUCN) who conceived this EbA partnership with financial support from Germany's Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU).

FOR GOD AND MY COUNTRY

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List of acronyms

CGCM	Coupled Global Climate Model
EBA	Ecosystem-Based Adaptation (to Climate Change)
GCMS	Global Circulation Models
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
MENP	Mount Elgon National Park
MWE	Ministry of Water and Environment
NaFORRI	National Forestry Resources Research Institute
NDVI	Normalized Different Vegetation Index
SFEGS	School of Forestry, Environmental and Geographical Sciences
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
VIA	Vulnerability Impact Assessment

1.0 INTRODUCTION

1.1 The reality of climate change

Climate change is one of the biggest challenges facing the world today. Uganda is already experiencing climate-related problems like unreliable rains, drought, famine, floods and landslides. These problems affect natural resources and people in many different ways. When temperatures rise as they are expected (0.7^{oC} – 1.5^{oC} by 2020) such problems will not only become more common, but also more serious. The poor are in even more danger since they will not have the resources to enable them adapt to the new challenges brought about by changes in climate.

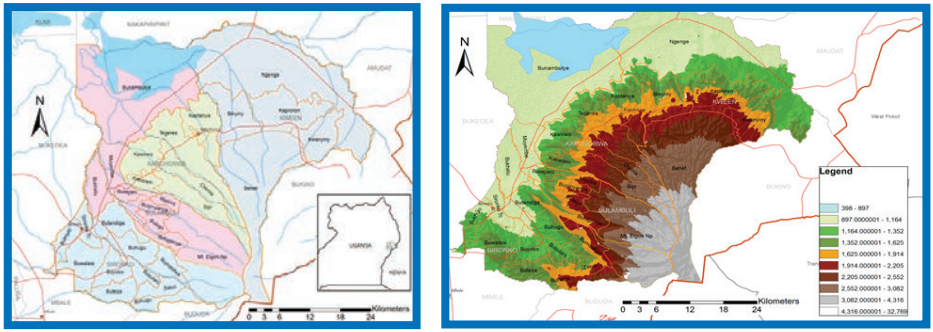
Although many people depend on the goods and services provided by Uganda's mountain ecosystems, these regions are among those likely to be most affected by climate change. Mt. Elgon, situated along the border between Uganda and Kenya has attracted special attention in this regard, because of its richness in plant and animal life, as well as being an important source of water for many of the rivers and streams that pour into lakes Victoria, Turkana and Kyoga. About two million people are estimated to depend on the Mt. Elgon ecosystem. And as this population grows even higher (at a rate of up to 4% every year), the functions of the Mt. Elgon ecosystem are under more and more threat from human activities e.g. encroaching on protected areas and cultivation of steep slopes, swamps and riverbanks. Already, frequent landslides, soil erosion and declining soil fertility are proof that conditions are getting worse. It is feared that climate change will make this undesirable situation even worse.

1.2 The Mt. Elgon Ecosystem-based Adaptation (EBA) Project

The Ecosystem-based Adaptation (EBA) Project is a partnership between the Government of Uganda (GoU), United Nations Environment Program (UNEP), United Nations Development Program (UNDP) and the International Union for the Conservation of Nature (IUCN). It seeks to put in place long-lasting measures for enabling people to adapt to impacts of climate change in mountain ecosystems. The EBA project is carrying out activities in four Mt. Elgon districts of Kapchorwa, Kween, Bulambuli and Sironko (Eastern Uganda), identified as particularly vulnerable to climate change impacts. The project seeks to strengthen Uganda's capacities to increase ecosystem resilience for promoting EBA options; and to reduce the vulnerability of communities, especially those in mountain ecosystems and associated floodplains.

1.3 The Vulnerability Impact Assessment for Mt. Elgon Ecosystem

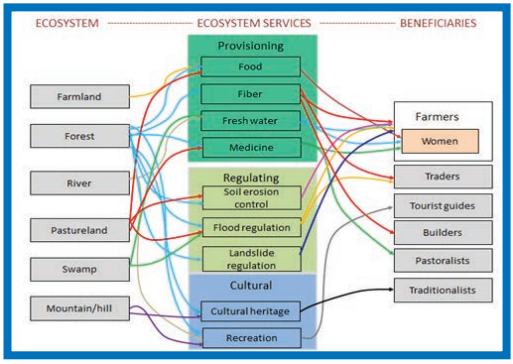
This VIA was intended to provide supporting information and maps to enable the detailed design, monitoring and evaluation of ecosystem based adaptation to climate change in the Mt. Elgon region. The assessment focused on understanding the ways in which people's lives are linked to ecosystems; mapping vulnerability to the most relevant types of climate change impacts and giving projected future ecosystem service supply in the Mt. Elgon region. The VIA covers the four project districts (Kapchorwa, Kween, Bulambuli and Sironko); and cuts across the three major slope categories in each district i.e. upslope (>1,625 m asl), mid-slope (1,164-1,625 m asl) and down-slope (398-1,164 m asl).



Zoning of Mt. Elgon region according to elevation

2.0 ECOSYSTEMS AND PEOPLE

Mt. Elgon provides a variety of ecosystem services or benefits upon which local communities depend. These have been grouped as provisioning (e.g. food, fibre, water, medicine), regulating (e.g. erosion regulation, flood regulation, landslide regulation), supporting (e.g. pollination and soil fertility) and cultural (e.g. recreation, cultural heritage) services. We refer to ecosystems as those specific places or areas where these ecosystem benefits come from. The major ecosystems identified by local communities in the Mt. Elgon region are farmlands, rivers and streams, forests/trees, pasturelands, swamps and mountains/hills. In order to ensure sustainable supply of ecosystem benefits, it is important to identify their sources and maintain these places in good condition. We therefore need to have a good understanding of the links between the ecosystems, the ecosystem services that come from them, and the activities of different people who benefit from them.



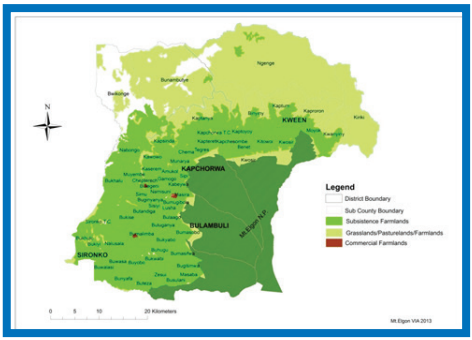
Linkages between key ecosystems, ecosystem services and ecosystem beneficiaries

2.1 Farmlands

Farmlands are a very important ecosystem in the Mt Elgon region because they are the dominant land use type and basis for agriculture, which is the source of living for most people. Over the years, farmlands have kept expanding as people convert forests, swamps and other places into croplands. Farming systems vary along the slope.

Agriculture on the upper slopes is more intensive characterized by lush gardens of coffee, bananas, Irish potatoes and beans; while lowlands farming systems are more extensive, dominated by growing of maize, groundnuts, sorghum, millet, cotton, soya beans, sweet potatoes, sunflower and rice. The main ecosystem service from farmlands is provision of food, although its production is both subsistence and commercial.

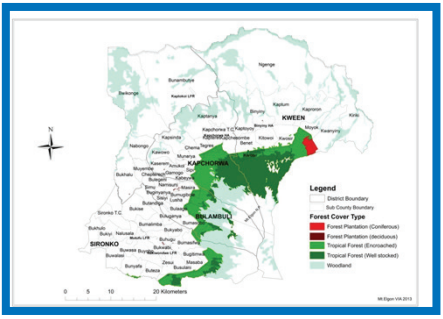
Gardens of Irish potatoes in Benet, cultivated on previously forested part of Mt. Elgon N.P



Farmland coverage in Bulambuli, Sironko, Kapchorwa and Kweken districts

2.2 Forests

Much of the original vegetation in the Mt. Elgon region has been replaced by farmlands and grasslands. The only existing natural forests remain in the upslope areas where they fall within the Mt. Elgon National Park (MENP). Even these are under a lot of pressure due to increasing human population and declining land productivity. Forests supply many benefits e.g. provision of food (e.g. bamboo shoots, honey, wild fruits etc.), fuel wood, staking materials, building materials, medicines, fresh water and craft materials. They also regulate soil erosion and flooding, in addition to being of cultural and recreation value. Expansion of farmlands into previously forested areas has made it increasingly difficult for communities to access many of these benefits from forest ecosystems.



Forest and woodland cover in the Mt. Elgon region

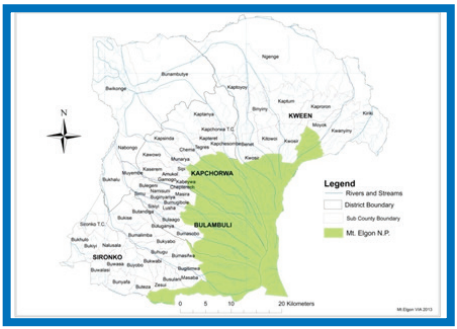
Bamboo from the forest is used for staking climbing beans

2.3 Rivers, streams and swamps

Many rivers flow from the top of Mt. Elgon to the lowlands, making it an important water tower for the region. Several wetlands systems (rivers and swamps) are also found within

the region. In Kapchorwa and Kween districts, three quarters of the wetlands are found in the plains of Ngenge and the others in MENP. These wetlands provide local people with a variety of ecosystem benefits, such as herbal medicines, food (yams, maize, sugarcane, bananas, vegetables and fish, especially catfish and lungfish), fresh water, building poles, fibre and firewood. Human activities carried out along river and swamp systems are reducing their capacity to serve environmental purposes like purification of water and regulation of floods.

Many rivers flow from the top of Mt. Elgon to the lowlands, making it a water tower of the region



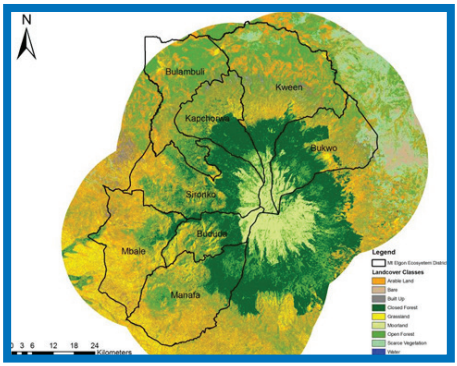
Rivers and streams in Sironko, Bulambuli, Kapchorwa and Kween districts

Except for areas that are inaccessible due to terrain, most river catchments are used for agriculture (i.e. growing of vegetables, paddy rice, yams and sugarcanes) especially during the dry season. Rivers such as Atari, Sironko, Namatale, Ngenge, Kaptakwoi and Muyembe have been particularly affected leading to soil erosion, siltation and flooding. Competition for the limited water from the wetlands during drought is a major source of wrangles between grazers and farmers. Other human activities done in wetlands and along riverbanks include sand mining, re-channeling of river water to gardens, livestock rearing, unsustainable fishing, and removal of craft materials and herbal medicines.

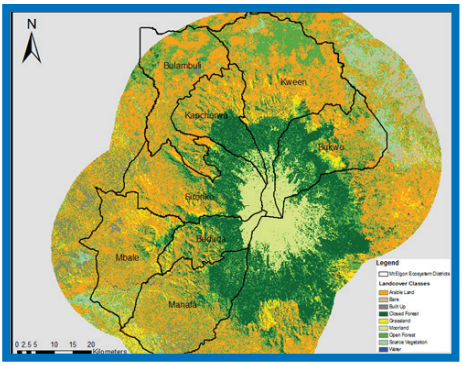
3.0 VULNERABILITY OF LOCAL COMMUNITIES AND ECOSYSTEMS SERVICES

3.1 Changing land use patterns

What we see in any landscape is the result of a combination of natural and man-made processes. Land use changes in the Mt. Elgon region were analysed using satellite images and participatory methods. Generally, forest cover in the region has clearly reduced over the last decade. Mid-slope and down slope areas are more degraded compared to upslope, where human activities are to some extent limited by the steep terrain and climatic conditions.



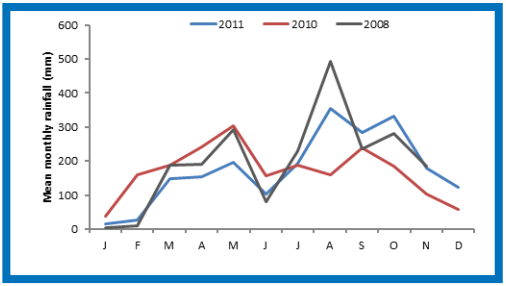
Mt. Elgon ecosystem land cover in 2001 re-classified from LandSat Imagery



Mt. Elgon ecosystem land cover in 2011 re-classified from LandSat Imagery

3.2 Changing climatic patterns

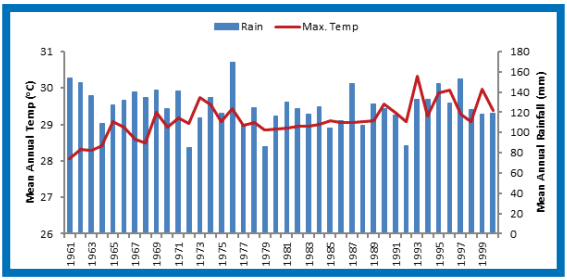
Temperatures in the Elgon region are influenced a lot by altitude (height above sea level). Low-lying places like Bunambutye, Bwikhonge, Ngenge etc. experience higher temperatures compared to areas at higher elevation such as Benet, Bulaago and Bumasifwa. The amount of rain received also varies with altitude, with the upper slopes receiving relatively more rain than low-lying areas. The rains occur in two main seasons (March – May and August – October).



Mean annual rainfall patterns at Buginyanya weather station for 2008, 2010 and 2011

Historically, both rainfall and temperatures have increased over the years. Between 1961 and 2000, temperatures in the region increased by 0.2°C. The change is not as clear for rainfall as it is for temperature, although overall, mean annual rainfall has increased.

Amidst these changes, the Mt. Elgon region is experiencing several climate-related hazards e.g. strong winds, lightning, soil erosion, crop pests and diseases, flooding, landslides, drought, famine, human diseases etc. The importance attached to each of these hazards varies from place to place, but for the Mt. Elgon region, most people agree that landslides, flooding, soil erosion and drought or intense dry seasons pose the biggest threats to people and natural resources.



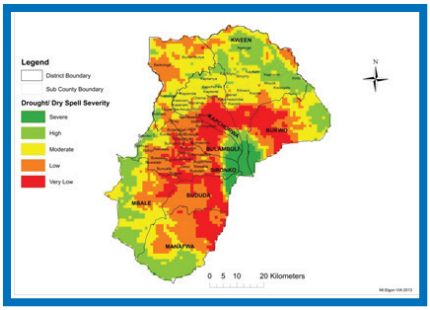
Mean annual temperature and precipitation (1961 – 2000) for Mt. Elgon region (extracted from Tororo weather station).

3.3 Vulnerability to hazards related to climate change

3.3.1 Drought

Drought is a temporary reduction in water or moisture below the normal or expected amount for a specified period. Drought is understood differently by people in different places. The period of reduced rainfall that is referred to as drought may vary from a few weeks to several years depending on the situation in a particular area. In the Mt. Elgon region, rainfall shortages last about four months although even during the so-called dry months some rains may be experienced.

It appears Mt. Elgon experiences prolonged dry periods (drought severity indices 0.50 to 0.99) and not drought in the strict sense of the word. Indeed, prolonged dry periods characterized by dry winds from the semi-arid areas were recurrently reported by communities in low-lying parts of Bulambuli and Kween districts bordering the semi-arid Karamoja and Teso sub-regions. The sub-counties most prone to such dry spells include Ngenge, Kiriki and Kaproron in Kween district; Kawowo in Kapchorwa district; and Bukhalu, Nabongo, Muyembe, Bwikonge and Bunambutye in Bulambuli district. These dry spells result in poor crop yields, water shortage, scarcity of pastures and in worst case scenarios even famine.

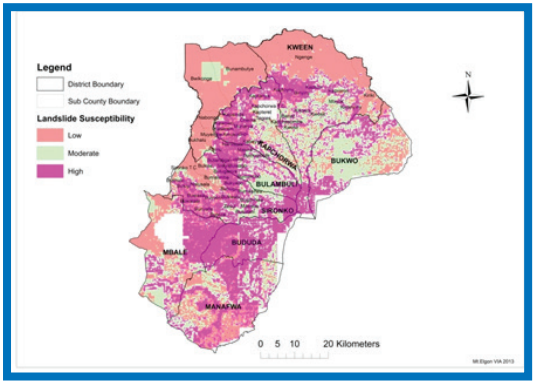


Drought severity in Mt. Elgon region based on Normalized Different Vegetation Index (NDVI) for 2003-2012[5]

5: Note that using the Normalized Different Vegetation Index (NDVI) method to analyze drought severity in Mt. Elgon region, the top of Mt. Elgon appears to have high drought severity whereas it is known to receive high amounts of rainfall. This is due to use of reflectance for estimating drought severity in the NDVI method. Due to the limited vegetation and large expanse of bare ground and rocky surfaces at the top of Mt. Elgon, reflectance values as estimated by NDVI depicts it as having higher drought severity. In spite of this, the NDVI remains a widely used method for computing drought severity. While interpreting drought severity estimated using NDVI, geographical knowledge (including prevailing climate) of the area under consideration is therefore vital.

3.3.2 Landslides

A landslide refers to mass movement of soil mainly on steep slopes caused by soaking up too much water from excessive rain. Mt. Elgon experiences frequent landslides due to the steep slopes, too much rain coupled with human activities such as deforestation. Mid slope and upslope areas especially steep inward-curving slopes facing the north-east, where deforestation and cultivation have taken place are more exposed to landslides. The sub counties of Bukiyi, Buwasa, Buwalasi, Buteza, Bunyafa, Buhugu and Bukwabi in Sironko district; Simu, Masira, Sisiyi and Bulago in Bulambuli district; Kaptanya, Kapsinda and Kawowo in Kapchorwa district; and Kaptoyoy, Binyiny and Kaptum in Kween district are particularly vulnerable. Landslides do not only mess up people's main sources of livelihood, but also disorganize lives in many ways, if not causing death. Where landslides have taken place, people tend to respond by planting trees to prevent a similar thing from happening again in future.



Landslide susceptibility (hazard) map for the Mt. Elgon region

3.3.3 Flooding

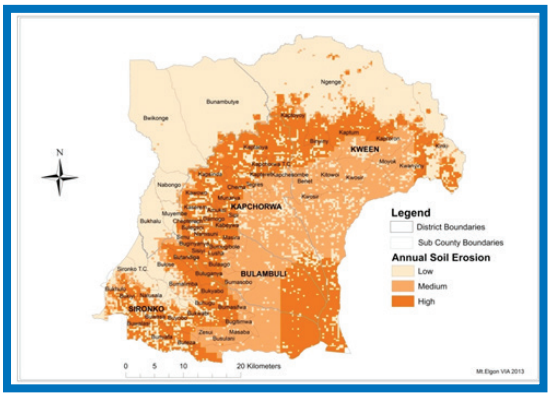
A flood is an overflow of water that covers land which is usually dry. In the Mt. Elgon region, floods usually occur in low-lying places in situations of rains above the normal or as a result of rivers bursting their banks. This problem is, in many instances, made more likely by silting of rivers, reclaiming of swamps and blocking of drainage channels. Flooding occurs fairly regularly in particular flood-prone locations and is closely associated with the drainage system (rivers and streams) in mid and upslope areas. The courses of rivers Sironko, Namatala, Simu, Sisi, Ngenge, Cheborom, Kiriki, Tabok, Sipi and Muyembe are particularly prone to flooding. Apart from destruction of homes and other household property, flooding seriously affects people's health and agricultural activities.

Flood prone areas in the Mt. Elgon region

3.3.4 Soil erosion

Soil erosion is the breaking up and moving of soil particles by forces of water and/or wind. The Mt. Elgon ecosystem experiences different types of soil erosion e.g. sheet (surface flow across a wide section of land), rill (shallow and narrow tunnels), gulley (deep and wide tunnels) and landslide/mudslide.

The extent of this problem is closely associated with slope category. While soil erosion is a widespread problem in the Mt. Elgon region, the most prone sub counties include: Kaptoyoy, Binyiny and Kaptum of Kween district; Kawowo, Kapsinda and Sipi in Kapchorwa district; Bulegeni, Buginyanya and Sisiyi in Bulambuli district and Bukyabo, Bumasifwa and Buwalasi in Sironko district. Because most people in the Mt. Elgon region depend on agriculture for food and income, soil erosion is one of the main factors contributing to poverty and food insecurity.



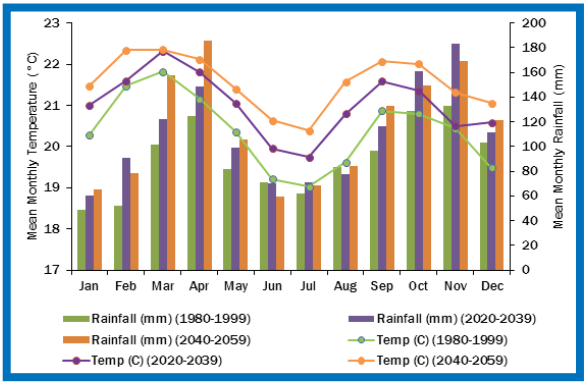
Soil erosion severity in the Mt. Elgon EBA project areas

Coupled Global Climate Model (CGCM3) of the Canadian Centre for Climate Modeling and Analysis. Based on this model and the B2 emission scenario [which predicts a high level of environmental and social consciousness brought about by clear evidence that impacts of natural resource use, such as deforestation, soil depletion, over - fishing, and pollution, pose a serious threat to the continuation of human life].

4.0 CURRENT AND FUTURE SUPPLY OF ECOSYSTEM SERVICES

4.1 Future climate scenarios

There are several ways of predicting how future climate conditions are likely to be. For this VIA, the method used (Coupled Global Climate Model)[6] predicts temperatures in Mt. Elgon region to rise by 0.5-0.6°C for the next 20 to 50 years, while rainfall will increase by 18.7 mm over the next 20 years. In terms of seasons, the present drier months of June, July and August are expected to receive even less rain (reductions of up to 6 mm in the 2020-2039 period, and 10.9 mm in the 2040-2059 period). These changes are likely to affect the supply of ecosystem benefits from Mt. Elgon in more than one way.



Global circulation model prediction of climate change in the Mt. Elgon region (2020-2039 and 2040-2059) based on mean historical climate record (1980-1999)

4.2 Future supply of ecosystem services

4.2.1 Food provision

Food is one of the main benefits people get from the Mt. Elgon ecosystem. Considering that food production in the region is sustained by smallholder farmers through rain-fed agriculture, crop yields are quite sensitive to climatic change and extreme events. As such, the ecosystem's capacity to provide food is equally vulnerable. Although the current picture shows food production in the Mt. Elgon region as adequate, continuous cultivation of land and temperature rises in future may reduce crop yield per unit area. Hopefully, the changing climatic conditions, especially the reduction in rainfall during the months of June – August, could favour introduction of new food crops that may strengthen food security. However, the rising temperatures and unreliable rains as well as increasing climate hazards such as floods and droughts could also subject soils to higher risk of climate-induced degradation.

4.2.2 Fresh water supply

The presence of several water sources makes the Mt. Elgon ecosystem a vital water tower. Rain provides the main recharging means of the many rivers, streams and swamps in the region. Fresh water supply relies on both surface and ground water sources. Although surface water sources are the most common and supply most of the fresh water used by communities, they tend to be at risk to extended dry spells. Future supply of fresh water is expected to be affected by climate-related events such as erosion, floods and landslides. Therefore, future provision of clean water is projected to get worse amidst increasing demand. In the same way, the amount of clean fresh water will reduce as a result of contamination from unprotected water catchments and poor sanitation, in a situation of increased rainfall intensity. In low-lying parts of the ecosystem, fresh water availability is feared to be compromised by increased temperatures and higher rates of evaporation during the long dry spells, causing drying up of water sources (wells and springs) and general scarcity of water.

4.2.3 Soil erosion regulation

Soil erosion is a serious problem affecting agricultural production. Controlling it depends a lot on the vegetation cover in the ecosystems. Given the mountaneous landscape, land cover types, heavy rainfall and nature of soils, soil erosion in most parts of the Mt Elgon region is likely to rise as the remaining vegetation cover is converted to cropland or deforested land. Soil erosion will be increased by the likely increase in water runoff due to the increased rainfall amounts expected in future. Although the projected increase in temperature may not have direct effects on soil loss, it is expected to enhance soil erodibility thereby speeding up the impact of increased rainfall on soil erosion.

4.2.4 Flood regulation

Flooding is currently prevalent along major drainage systems and in low-lying plains. Flooding in one place, however, is closely linked to land use and climatic processes taking place elsewhere, especially in upstream places. The Elgon ecosystem's capacity to regulate flooding in future will be of more importance considering that more and more people are settling and cultivating in flood-prone areas like riverbanks and wetlands. With both peak rainy seasons registering higher rainfall in March – April and October – November, susceptibility to flooding is expected to increase during such months. A significant increase in stream flow has been predicted for the region in the coming decades as a result of increased rainfall. Human activities especially converting of forests into agricultural land are feared to reduce the natural capacities of upstream areas to prevent flooding. Natural forests areas are expected to reduce by 38% between 1995 and 2032, thereby causing a notable decline in flood regulation services. The extent of flooding is likely to increase further as a result of changes in the catchment's areas through human settlement, agriculture and other forms of interference with natural drainage.

5.0 CONCLUSIONS AND RECOMENDATIONS

Mt. Elgon region is gifted with many ecosystems, from which people obtain benefits of many kinds. Farmland, forests, streams, rivers and swamps among the most important of these ecosystems. Although maintaining such ecosystems is essential for ensuring

future supply of vital ecosystem services (e.g. food, fresh water, medicines etc.) they are under growing threat due population increase and climate change. Climatic hazards, especially flooding, extended dry spells, landslides and soil erosion are increasing in many parts of the region. Vulnerability to these hazards largely depends on elevation and population density. These hazards not only make life more difficult, but actually threaten people's very existence. Future climate conditions are no consolation either as increases in rainfall and temperatures can only make the situation worse.

Some interventions to address the climate related hazards and expected impacts in the Mt. Elgon region have been suggested. These include soil stabilization (through tree planting, grass bunds, avoided deforestation), farm/land use planning, awareness raising and capacity building, establishment of early warning systems, relocating people from hotspot areas, irrigation, water conservation (water harvesting), sinking of boreholes, gravity flow schemes, protected springs, drought resistant crop varieties, post harvest management (e.g. food storage), de-silting of rivers, riverbank protection (e.g. planting grass, trees), enhancing enforcement and governance systems through use of bylaws, demarcation, mapping and gazettement of wetlands, agroforestry (hedgerows, alley cropping), tree planting, reforestation/afforestation, conservation tillage, organic manuring, contour banding, mulching and use of cover crops.

Annex 1: Glossary of Terms

Ecosystem-based Adaptation

Ecosystem-based Adaptation is defined as ''the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" .Ecosystem-based adaptation uses sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate variability/change. The approach contributes to reducing vulnerability and increasing resilience to both climate and non-climate risks and provides multiple benefits to society and the environment.

Climate change

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as: "any change in the statistical properties of the climate system over time, whether due to natural variability or as a result of human activity". These changes are often recorded over long periods of time. Furthermore, climate change can also refer to ''the observed and projected increases in average global temperature as well as associated impacts (e.g. changes in the timing or amount of precipitation. ''

Exposure

Exposure is defined as the nature and degree to which a system is exposed to significant climatic variations. Exposure is location-specific so the presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by climatic/physical events and which,

thereby, are subject to potential future harm, loss, or damage.

Sensitivity

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct or indirect. For example, a community reliant on rain-fed agriculture in a given locality is more sensitive to changing rainfall patterns than one where mining is the dominant economic activity.

Adaptive capacity

Adaptive capacity is defined as ''the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.'' One of the most important factors shaping the adaptive capacity is access to and control over resources including human, physical, natural, social and financial resources.

Vulnerability to climate change

Vulnerability to climate change has been defined as ''the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity"[11]. In the context of this study, the systems being referred to are primarily vulnerable communities and natural ecosystems. Human communities and natural ecosystems are not homogeneous. For instance, particular households, individuals, plant species within a given locality may have differing degrees of vulnerability.

Hazard

A hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. In the context of this study; hazards, may refer both to shocks such as floods (rapid onset), and to stresses like drought or changing rainfall patterns (slow onset). It is important to distinguish between the hazard (e.g. flood) and the effects of the hazard (e.g. death of livestock.) Some effects, such as food shortages, may be the result of a combination of hazards, shocks and stresses.

Resilience

Resilience can be defined as ''the ability of a system [human or natural] to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change. In this study, resilience encompasses both resistance to change and the ability to recover from disturbances as in long-term perspective both mechanisms contribute to retention of the structure and ways of functioning of the system.

Adaptation to Climate Change

Adaptation is defined as ''an adjustment in natural or human systems in response to

actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation is viewed as a process focused on reducing vulnerability, which usually involves building adaptive capacity, particularly of the most vulnerable people. In some cases, it also involves reducing exposure or sensitivity to climate change impacts. In fact, adaptation is more than reducing vulnerability; it is about making sure that development initiatives do not inadvertently increase vulnerability.

Ecosystem
Ecosystem is defined as all organisms and the abiotic environment found in a defined spatial area. It is also a functional unit of interacting animals, plants, micro-organisms and their physical environment, e.g. a forest, mountain, lake, wetland etc.

Ecosystem services
Ecosystem services are benefits people obtain from ecosystems such as food, fuel, fresh water, regulation of soil erosion, landslides, floods, disease outbreaks, and non-material/tangible benefits like recreational and spiritual benefits of natural areas.

Erosivity
Is the power of runoff to erode soil. Erosivity is a factor of rainfall and soil type.

Soil erodibility
Refers to the inherent susceptibility of soil particles or aggregates to become detached or transported by erosive agents such as rainfall, runoff, wind or frost.

Soil erosion
Is defined as the washing away of top soil by either running water (runoff) or strong winds

Impact
The consequences of hazards on natural and human systems, and can include crop damage, income losses and reduced soil fertility.

Flood
Is an overflow of an expanse of water that submerges land. A flood may as well mean high amounts of water flowing in streams, rivers and other water bodies to burst their banks thereby submerging the surrounding areas. Floods are due to excessive rainfall.

Drought
Is unusual dryness of soil, resulting in crop failure and shortage of water for other uses, caused by significantly lower rainfall than average over a prolonged period.

Landslide
Can simply mean the mass movement of soil mainly on steep slopes caused by its saturation from excessive rain.

Annex 2: Details of climate hazards and options for Ecosystem-Based Adaptation

Hazard	Affected areas	Impacts	Specific interventions
Landslides	• **Sironko:**Bumasifwa, Busulani, Buhugu, Butandiga, Bukiyi, Buwasa, Buwalasi, Buteza, Bunyafa, Bukwabi; • **Bulambuli:**Masira, Buginyanya, Bulegeni, Buluganya, Sisiyi, Simu, Bulago • **Kapchorwa:**Sipi, Chema, Kaptanya, Kapsinda, Kawowo • **Kween:** Kaptoyoy, Binyiny, Kaptum, Kitowoi	• Population displacement • Loss of fertile land • Deaths • Loss of property • Famine • Poverty	• Relocation of people • Soil stabilization measures (e.g. tree planting, grass bunds, avoided deforestation). • Farmland use planning. • Awareness raising and capacity building. • Establishment of early warning systems.
Drought (severe dry spells)	• **Sironko:**Bukhulo, Sironko TC • **Bulambuli:**Bukhalu, Nabongo, Muyembe, Bwikonge, Bunambutye • **Kapchorwa:**Kawowo • **Kween:**Ngenge, Kiriki, Kaproron	• Reduced crop yield • Famine • Income poverty • Water scarcity • Shortage of pasture • Increase in crop pests	• Irrigation • Water conservation (water harvesting, • Sinking of boreholes • Gravity flow schemes • Protected springs • Drought resistant crop varieties • Post harvest management (e.g. food storage)
Flooding	• R. Sironko, R. Namatala, R. Simu, R. Sisi, R. Ngenge, R. Cheborom, R. Kiriki, R. Tabok, R. Sipi, R. Muyembe	• Damage of crops • Water borne diseases • Destruction of transport infrastructure • Siltation of rivers • Damage to property (e.g. homes, livestock).	• De-silting of rivers • Riverbank protection (e.g. planting grass, trees) • Enhancing enforcement and governance systems through use of bylaws • Early warning systems • Demarcation, mapping and gazettement of wetlands. • Sensitization and public awareness • Farm and land use planning.
Soil erosion	Due to the topography of the region, soil erosion is common but the following are the highly prone areas: • **Sironko:**Butandiga, Bukyabo, Buhugu, Bumalimba, Bumasifwa, Bugitimwa, Bukwabi, Buyobo, Zesui, Busulani, Buteza, Bunyafa, Buwalasi, Buwasa, Buyobo, Bukiyi, Bukhulo, Nalusala • **Bulambuli:**Bulegeni, Namisuni, Masira, Simu,Buginyanya, Sisiyi, Bumugibole, Lusha, Bulaago, Buluganya. • **Kapchorwa:**Kaptanya, Kapchorwa T.C., Kapteret, Tegeres, Chema, Kapsinda, Kawowo, Munarya, Kaserem, Amukol, Sipi, Kabeywa, Gamogo, Chepterech. • **Kween:**Kaptoyoy, Binyiny, Kaptum, Kaproron, Kirik, Kwanyiny.	• Reduced crop yields • Silting of rivers • Food insecurity • Income poverty • Formation gullies • Destruction of roads • Contamination of water sources • Increased costs of agricultural production.	• Agroforestry (hedgerows, alley cropping) • Tree planting, reforestation/afforestation • Conservation tillage • Organic manuring • Terracing • Contour banding • Mulching • Use of cover crops • Soil and water conservation structures • Sensitization and awareness creation • Farm planning.

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