THE REPUBLIC OF UGANDA

ECOSYSTEM BASED ADAPTATION IN MOUNTAIN ELGON ECOSYSTEM

Vulnerability Impact Assessment (VIA) for the Mt Elgon Ecosystem

December 2013

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Acknowledgements

This Vulnerability Impact Assessment (VIA) report is a result of contributions from a wide range of experts, partners and stakeholders. The VIA 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 under the coordination of Mr. Paul Nteza. The report has been written by a consortium of experts from National Forestry Resources Research Institute (NaFORRI) which included Dr. David Hafashimana, Dr. James Epila-Otara, Mr. Jude Sekatuba, Mr. Mthalib Balikitenda Katumba (RIP) and Dr. Samson Gwali; and Dr. Daniel Waiswa from the School of Forestry, Environmental and Geographical Sciences (SFEGS) of Makerere University. The team of experts was assisted by the following staff from NaFORRI: Mr. Fred Kalanzi, Mr. Kenneth Eryau, Mr. Samuel Ongerep, Ms. Susan Nansereko and Mr. Moses Mbalule. Administrative support from NaFORRI and SFEGS to the consortium is gratefully 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

Prof. Ephraim Kamuntu
MINISTER OF WATER AND ENVIRONMENT, REPUBLIC OF UGANDA

Executive Summary

1. Uganda is already experiencing climate change related hazards like erratic rains, drought, famine, floods and landslides together with their associated impacts on natural resources that form the basis of people's livelihoods. With current average temperatures expected to increase by between 0.7^{0}C and 1. 5^{0}C by 2020, the frequency and severity of these hazards will increase, and this will inevitably have serious socio-economic consequences and/or implications with regard to food security, health, and economic development. Uganda's mountain regions have been noted to be particularly vulnerable to climate change impacts in spite of the heavy dependence of human populations on the goods and services provided by these ecosystems. The EBA project is implementing activities in the Mt. Elgon region of eastern Uganda (in the districts of Kapchorwa, Kween, Bulambuli and Sironko) which has been identified as particularly vulnerable to climate change impacts. The project was conceived out of the realization that climate change impacts are already affecting the functioning and integrity of mountain ecosystems in particular. The overall objectives of the EBA project are twofold: a) to strengthen the capacities of Uganda to enhance ecosystem resilience for promoting EBA options and (b) to reduce the vulnerability of communities, with particular emphasis on mountain ecosystems and associated floodplains in adjacent lowlands.

2. This VIA was designed as a planning tool for the UNDP-EbA Project Management Unit and its stakeholders. The VIA is meant to generate supporting and baseline information, analyses and maps to enable the detailed design, monitoring and evaluation of the project's strategy and implementation plan for promoting ecosystem based adaptation to climate change in the Mt. Elgon region. The exact geographical and administrative area to which the VIA is applicable was delineated in a participatory process involving a number of stakeholders from the four EBA project districts. The VIA was conducted while taking into account the three slope categories: up-slope, mid-slope and down-slope. These slope categories were classified by altitude as follows: up-slope (>1,625 m asl), mid-slope (1,164 -1,625 m asl) and down-slope (398 -1,164 m asl).

3. The assessment indicates that farmlands in the region have continuously increased in spatial coverage; partly due to the conversion of other land uses to agriculture. Agricultural production is oriented towards food crops (millet, sorghum, groundnuts, cassava, sweet potatoes, beans and Irish potatoes), cash crops (cotton and coffee), fruits (passion fruits), and an assortment of vegetables (e. g. tomatoes, onions and cabbages). On the upper slopes are areas of intensive farming characterized by lush gardens of coffee, bananas, Irish potatoes and beans. In contrast, the lowlands are characterised by crops such as maize, groundnuts, sorghum, millet, cotton, soya beans, sweet potatoes, sunflower and rice. The Benet Resettlement Area in Kween is quite intensively cultivated, dominated by a patchwork of maize, Irish potatoes, beans, barley, wheat, assorted vegetables and scattered stands of eucalyptus.

4. There is increased encroachment on natural forests leading to significant loss of tree cover as a result of the high increase in human population. Natural forests, therefore, only remain in the upslope areas where they fall within the Mt. Elgon National Park. The upslope areas have more tree cover than lowlands because oxen ploughs are used on the lowlands fields requiring big open areas while oxen cannot be used on the upper slopes due to the rocky nature of the land and terrain of the slopes. Middle slope and down slope locations depict the highest deforestation arising out of increasing human population and rising demand for tree resources and agricultural land. Generally, forest cover in the region has significantly reduced over the last decade, a trend largely attributed to expansion of farmlands into previously forested areas.

5. Several wetlands (rivers and swamps) are found within the region. In Kapchorwa and Kween districts, 75% of the wetlands are found in the plains of Ngenge sub-county and 25% in Mt. Elgon National Park. Except for areas that are inaccessible due to terrain, the river catchments are utilized for several socio-economic activities including agriculture, small scale industries, tourism, settlements and wildlife conservation. These wetlands provide local people with an array of ecosystem services, such as herbal medicines, food (yams, maize, sugarcane,

bananas, vegetables and fish, especially catfish and lungfish), fresh water for domestic use and watering animals, water cycling thus modifying local weather (temperature), building poles, fibre and firewood. Some of the activities practiced in the river and swamp systems in the area include cultivation along river banks, sand mining, re-channeling of water movement to gardens (canal irrigation). Most wetlands in the region, such as those in Ngenge sub-county, are under significant degradation and are almost depleted due to 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 degraded by cultivation of especially maize, bananas, coffee and other horticultural crops (cabbages, onions, tomatoes, Irish potatoes) up to river banks leading to soil erosion and siltation. Indeed, crop farming in wetlands was identified by communities as the major cause of siltation of River Atari and flooding of River Ngenge. Grazers and farmers, particularly in Kawowo sub-county, compete for the limited water from the wetlands during drought and this is a major source of wrangles. Other drivers of wetland degradation are livestock rearing, unsustainable fishing, removal of craft materials and extraction of herbal medicines.

6. Temperature variation in the Elgon region is influenced by altitude. For example, the low lying sub-counties of Bunambutye, Bwikhonge and Ngenge experience higher temperatures compared to areas at higher elevation, such as Benet, Bulaago and Bumasifwa. Likewise, rainfall also varies with altitude, the upper slopes receiving relatively more rain than lower lying areas. Historically, these two elements of weather and climate have shown a general upward trend. Data for the period 1961 – 2000 indicates that temperatures in the region increased by 0. 2^{0}C. However, with regards to rainfall, the pattern is not as clear as that for temperature although overall, mean annual rainfall has increased. The Mt. Elgon region is, therefore, affected by a range of climate related hazards such as strong winds, lightning, soil erosion, crop pests and diseases, flooding, landslides, drought, famine, and human diseases.

7. Although the importance of these hazards is context specific, there was consensus (during community consultations) about the significance of landslides, flooding, soil erosion and drought or intense dry season to the communities in this region. In this assessment, drought severity indices ranged from 0. 50 to 0. 99, indicating that the Mt. Elgon area experiences prolonged dry periods, rather than drought in the strict sense of the word. Indeed, experiences of prolonged dry periods due to effects of dry winds from the semi-arid areas were recurrently reported by communities in low-lying parts of Bulambuli and Kween districts bordering the Karamoja sub-region. Prolonged dry spells in the four districts of Kween, Kapchorwa, Bulambuli and Sironko occur in the areas close to semi-arid Karamoja and Teso sub-regions. These result in poor crop yields, shortage of water for domestic use, decline of livestock forage, and in worst case scenarios famine, which impact on people's livelihoods

8. Mt. Elgon region is also very susceptible to landslides due to the steep slopes and excessive rain coupled with other anthropogenic factors such as deforestation. Landslides significantly impact on the lives of affected communities and compromise their main sources of livelihoods. The most vulnerable sub-counties include 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. In these areas, the strategies adopted by individuals, households or communities to cope with landslides include tree planting based on the assumption that what has happened in the past is likely to repeat itself in familiar pattern.

9. Flooding is, in many instances, catalyzed by silting of rivers, reclamation of swamps and blockage of drainage channels. In the Mt. Elgon region, floods usually occur in low-lying locations in situations of above normal rains or as a result of rivers bursting their banks. Flooding is a localized event that occurs fairly regularly in flood-prone locations. Apart from destruction of homes and other household property, the impacts of flooding are more adverse in the health and agricultural sectors. Flooding in this region 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.

10. The Elgon ecosystem is exposed to several types of soil loss including sheet (surface flow across a wide section of land), rill (shallow and narrow tunnels), gulley (deep and wide tunnels) and landslide/ mudslide. There is close association between slope category and extent of soil erosion. 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. Given that most people depend on agricultural production for food and income, soil erosion is one of the factors contributing to poverty and food insecurity in Mt. Elgon region.

11. Several climate predictions derived from global circulation models (GCMS) are available that predict future scenarios based on these parameters. One such model is the 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], temperatures in the region are predicted to by 0.5-0.6^{0}C for the next 20 to 50 years while rainfall will increase by 18.7 mm over the next 20 years. In terms of seasonality, the present drier months of June, July and August are expected to receive even lesser rainfall (with reductions of up to 6 mm in the 2020 - 2039 prediction and 10.9 mm in the 2040 - 2059 model).

12. Food is one of the major provisioning services in the Mt. Elgon ecosystem which is sustained by smallholder resource-poor farmers. Considering that agriculture in the region is predominantly rain-fed, which increases sensitivity of crop yields to climatic variations, the ecosystem's capacity to provide food is very vulnerable to the impacts of climate change and extreme climatic events. Although the current scenario depicts food production in the Mt. Elgon region as adequate, continuous cultivation of arable land coupled with higher temperatures in the future is expected to have an impact on crop yield per unit area. Optimistically, the changing climatic conditions, especially the reduction in rainfall during the months of June – August, may favour introduction of new food crops that may reinforce food security. Nonetheless, the rising temperature and increased variation in rainfall together with increasing intensity and frequency of climate hazards such as floods and droughts will subject soils to significant risk of climate induced degradation.

13. The availability of several water sources makes the Mt. Elgon ecosystem a vital water tower. The major source of water is rain, which provides the main recharging means of the various rivers, streams and swamps in the region. Currently, fresh water supply relies on both surface and ground water sources. Surface water sources, the most common supply of the fresh water used by communities in the region, tend to be susceptible to extended dry spells. Future supply of fresh water is projected to be affected by climate related events such as erosion, floods and landslides. Therefore, future provision of clean water is projected to deteriorate in the region thereby escalating demand. Correspondingly, the quantity of clean fresh water will be effectively reduced by contamination from unprotected water catchments and poor sanitation, amidst increased rainfall intensity. In low-lying parts of the ecosystem, fresh water availability is projected to be compromised by increased temperatures and higher rates of evaporation during prolonged dry spells causing more widespread water stress, drying up, wells and springs and thus shortage of fresh water.

14. Soil erosion poses severe limitations to sustainable agriculture. Erosion control depends mainly on the structural aspects of ecosystems, especially vegetation cover and root systems. Given the terrain, land cover types, intense rainfall and nature of soils, erosion in most parts of the region will likely increase as current vegetation cover is converted to cropland or deforested land. Soil erosion will be exacerbated by the probable increase in water runoff due to the increased rainfall amounts expected in future. Although the projected increase in temperature may not have serious effects on soil loss in the future, it is expected to enhance soil erodibility thereby accelerating the impact of increased rainfall on soil erosion.

15. Flooding, as a climate related hazard in the Mt. Elgon region, is currently prevalent along major drainage systems and in low-lying plains where flood waters accumulate from places at higher elevation. Flooding, however, is not an entirely localized occurrence but is inextricably linked to off-site land use processes upstream. The Elgon ecosystem's capacity to regulate flooding in future will be of incremental importance considering that increasingly large numbers of people are affected by floods. With both peak rainy seasons registering higher rainfall in March – April and October – November, susceptibility to flooding is expected to increase during such months unless flood regulation measures are enhanced. According to the future climate change scenarios, a significant increase in stream flow has been predicted for the

region in the coming decades as a consequence of increased rainfall amounts. Land-use changes like the conversion of forested areas to agricultural land are anticipated to lead to further elimination of natural flood retention capacities in upstream areas. Naturally forested areas are anticipated to shrink by 38% by 2032, implying a serious decline in flood regulation services. The extent of flooding is likely to increase further as a result of anthropogenic changes in the catchment's areas through human settlement and other forms of interference with natural drainage. This is exacerbated by the absence of buffer zones along most rivers and streams as result of replacement of natural vegetation with annual croplands and grazing land.

16. In this report, specific interventions to combat the climate related hazards and expected impacts in the Mt. Elgon region have been suggested. These include relocation of people, soil stabilization (through tree planting, grass bunds, avoided deforestation), farm/land use planning, awareness raising and capacity building, establishment of early warning systems, 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.

List of acronyms

BCFD	British Colonial Forest Department
BugiZARDI	Buginyanya Zonal Agricultural Research and Development Institute
CBD	Conversion on Biological Diversity
CIGI	Centre for International Governance Innovation
CRiSTAL	Community-Based Risk Screening Tool – Adaptations and Livelihoods
CSO	Civil Society Organisations
CVCA	Climate Vulnerability and Capacity Analysis
EBA	Ecosystem Based Adaptation
FHH	Food for the Hungry
GEF	Global Environment Facility
GHG	Green House Gases
GIS	Geographical Information System
GoU	Government Of Uganda
GPS	Global Positioning Systems
HDI	Human Development Index
HHD	Household Density
IPCC	Intergovernmental Panel on Climate change
IUCN	International Union for Conservation of Nature
KACODA	Kapchorwa Community Development Association
LLS	Livelihoods and Landscape Strategy
Masl	Metres Above Sea Level
MERECEP	Mt. Elgon Regional Ecosystem Conservation Programme
MWE	Ministry of Water And Environment
NAADS	National Agricultural and Advisory Services
NaFORRI	National Forestry Resources Research Institute
NDP	National Development Plan
NEMA	National Environment Management Authority
NGO	Non-Governmental Organisation
NUSAF	Northern Uganda Social Action Fund
OPM	Office of the Prime Minister
SFEGS	School of Forestry, Environmental and Geographical Sciences
SLF	Sustainable Livelihood Framework
TACC	Territorial Approaches to Climate Change
UBOS	Uganda Bureau of Statistics
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
VIA	Vulnerability Impact Assessment
WFP	World Food Program

CHAPTER ONE

BACKGROUND

1.1 Introduction

Climate change is one of the greatest challenges facing humankind today. It poses serious threats to socio-economic development, biodiversity and ecosystem services. While the impacts of climate change are already being experienced globally, the least developed countries, including those in Africa are the least prepared to deal with these impacts. Undoubtedly, Uganda is one of the countries identified to be the most vulnerable to climate change[1]. For example, many parts of Uganda are already experiencing climate change related hazards like erratic rain, drought, famine, floods and landslides together with their associated impacts on natural resources that form the basis of people's livelihoods. With current average temperatures expected to increase by between 0.7^{0}C and 1.5^{0}C by 2020[2], the frequency and severity of these hazards will increase, and this will inevitably have serious socio-economic consequences and/or implications with regard to food security, health, and economic development. Resource – poor communities, households and individuals with least resources have the least capacity to adapt to the impacts related to these hazards and are therefore the most vulnerable[3].

Vulnerability varies with geographical location, cultural outlook, human activities, rainfall, geology, altitude and gradient of the landscapes. Uganda's mountain regions have been noted to be particularly vulnerable to climate change impacts in spite of the heavy dependence of human populations on the goods and services provided by these ecosystems. Indeed, because of this very inherent vulnerability, Mt. Elgon region that straddles the common boundary between Uganda and Kenya has attracted special attention. Apart from being one of the most important biodiversity areas and a water tower for both Uganda and Kenya, Mt. Elgon serves as a catchment area for the drainage systems of three lakes: Victoria, Turkana and Kyoga. In the past, the natural vegetation on Mt. Elgon served as the plumbing system that led rainwater cascading down the slopes to Rivers Suam/Turkwel, Lwakhakha, Sipi, Malaba, Sio-Malakisi, Nzoia, Soloko and others.

With a human population of about two million and annual population growth rate of upto 4%, the multiple functions of Mt. Elgon ecosystem are under increasing threat from human activity. Nearly 80% of the largely resource-poor residents depend directly on land through low-input subsistence agriculture or the direct extraction of natural resources. The enormous pressure on land leads to encroachment on protected areas and cultivation of ecologically fragile areas e.g. steep slopes, swamps and riverbanks. The resultant conflicts over natural resource entitlements have further jeopardized the multi-functionality of this ecosystem. Increasing environmental challenges e.g. soil erosion, declining soil fertility, land/mud slides, etc., are testimony to this deterioration. The effects of climate change are feared to compound this dismal situation even further.

In the recent past, several strategies have been devised to reduce the rate and magnitude of climate change and enable communities to adapt to its impacts. Such undertakings require the right measures to reduce the negative effects of climate change (or enhance the exploitation of the positive ones) by making the appropriate adjustments and changes[4]. This is important in not only reducing present day impacts, but also increasing resilience to future impacts. Besides, adaptation and mitigation actions can complement each other and when combined, can significantly reduce the risks of climate change. Currently, one encompassing initiative is the Ecosystem-based Adaptation (EBA) Project which specifically seeks to respond holistically to the impacts of climate change on mountain ecosystems.

1.2 Ecosystem Based Adaptation Project

In Uganda, the EBA project was conceived out of the realization that climate change impacts are already

1 CIGI (2007). International Risk Report: The Center for International Governance (CIGI)
2 GoU (2009). National Development Plan 2010/11 – 2014/15. Government of Uganda, Kampala.
3 IPCC (2001). Third assessment report, Annex B: Glossary of terms.

4 Parry M.L., Canziani O.F., Palutikof J.P., van der Linden P.J. and Hanson C.E., (Eds.), (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I. Cambridge University Press, Cambridge, UK, 976pp).

affecting the functioning and integrity of mountain ecosystems in particular, exacerbated by additional stresses imposed on the ecosystems through unsustainable land-use practices. The project is a partnership between the Government of Uganda, UNEP, UNDP and IUCN. Project activities are currently being implemented in the Mt. Elgon region of eastern Uganda (in the districts of Kapchorwa, Kween, Bulambuli and Sironko) which has been identified as particularly vulnerable to climate change impacts. The activities involve testing and piloting appropriate tools, methodologies as well as learning lessons, capturing experiences and practices in EBA that can be replicated in other parts of Uganda, particularly in the hilly and mountainous areas and the flood plains that are often affected by the flooding and/or land/ mudslides from the mountainous/hilly areas.

The overall objectives of the EBA project are twofold:

a) to strengthen the capacities of Uganda to enhance ecosystem resilience for promoting EBA options, and

(b) to reduce the vulnerability of communities, with particular emphasis on mountain ecosystems and associated floodplains in adjacent lowlands.

1.3 The Vulnerability Impact Assessment

One of the key outputs of the EBA Project is a Climate Change Vulnerability Impact Assessment (VIA) in the Mt. Elgon ecosystem. This assessment is intended to articulate past and forecast future climate variability in the Mt. Elgon ecosystem and thereafter, recommend strategic priorities for monitoring and management of adaptation options. As a planning tool for the Project Management Unit and stakeholders, the VIA is meant to generate supporting and baseline information, analyses and maps to enable the detailed design, monitoring and evaluation of the project's strategy and implementation plan for promoting ecosystem based adaptation to climate change in the Mt. Elgon region.

The specific objectives were to: i) conduct a VIA for Mt. Elgon with a focus on the links between ecosystems and people to enable EBA; ii) produce maps of vulnerability to the most relevant types of climate change impacts of local communities and the ecosystem services that support them in the Mt. Elgon region; iii) produce maps of current and future ecosystem service supply for the Mt. Elgon region; and iv) provide GIS data sets suitable for national and district project stakeholders to explore options for locations suitable for EBA activities[5].

5 See Annex 1 – for a detailed Terms of Reference which guided the production of this report.

CHAPTER TWO

APPROACHES AND METHODS

2.1 Introduction

This chapter describes the spatial-temporal scope of this VIA and delineates the focus of the assessment to specific elements within local livelihood, infrastructure and ecosystem services. Methods which were utilised for the circumscription of geographical boundaries and time frame for this VIA are outlined as well as the adaptation targets (livelihood, infrastructure and ecosystem services) that formed the focus of the recommendations for ecosystem based adaptation to the impacts of climate change.

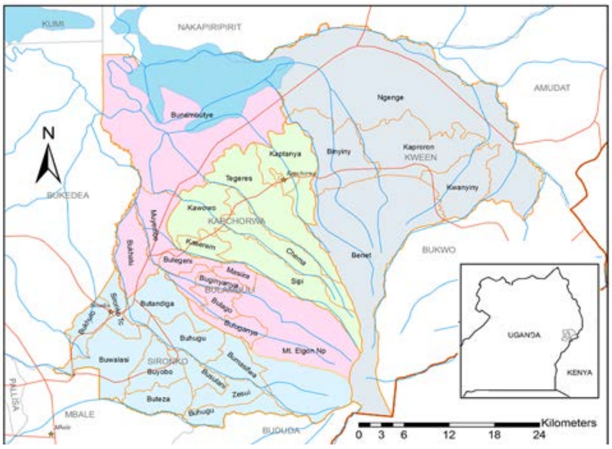
2.2 Vulnerability Impact Assessment (VIA)

2.2.1 Scope and focus of the VIA

The scope and focus of the VIA were defined at the initial stages of the assessment through a consultative process with local communities and other stakeholders of the EBA project[6]. The aim was to reach a consensus on the geographical boundaries and time frame for the VIA as well as local livelihoods, infrastructure and ecosystem services available to the people of the Mt. Elgon region. Based upon this, the VIA's scope is as described in section 2.2.1a-c. In addition, a specific set of direct and/or proxy indicators (Annex 3) and climate variables (such as rainfall and temperature) that were used for determining vulnerability to the impacts of climate change were identified through secondary sources and expert opinion. The indicators and climate variables together with the overall change in land use as observed from satellite imagery over a ten year period formed the basis for modelling the vulnerability to the impacts of climate change.

(a) Geographical boundaries

The Mt. Elgon ecosystem spans a wide geographical area and many administrative units. The exact geographical and administrative area to which the VIA is applicable was therefore delineated in a participatory process involving a number of stakeholders from the four EBA project districts. Previous studies[7,8] were used to provide a preliminary account of the geophysical and socio-economic environment in the Mt. Elgon region. During the stakeholder consultations, consensus was built on the practicable boundaries for the VIA process, and the likelihood of significant spill-over effects to and from neighbouring districts, as well as the need for considering such localities in the assessment. Since the purpose of the VIA process was to produce supporting and baseline information, and analyses as well as maps to enable promotion of ecosystem based adaptation (EBA) to climate change in the EBA project districts, it was agreed during the stakeholder consultations that the VIA covers the four project districts of Kween, Kapchorwa, Sironko and Bulambuli (Figure 2.1).



Source: Mt Elgon VIA 2013

Figure 2.1. Administrative boundaries of Kween, Kapchorwa, Bulambuli and Sironko districts.

Table 2.1 gives a summarised characterization of this geographical territory in terms of the location of the districts, size, elevation and administrative units.

6 See Annex 4 for a full list of stakeholders consulted.

7 MERECP, 2007 Final Report: Activities Undertaken between June 2006 and March 2007. UNDP, Kampala.

8 Mugagga, F., Buyinza, M. and Kakembo V. (2010). Livelihood Diversification Strategies and Soil Erosion on Mt. Elgon, Eastern Uganda: A Socio-Economic Perspective. Environmental Research Journal 4: 272-280.

Table 2.1. Characterization of the project districts

District	Characteristics			
	Location	Area (Km²)	Elevation (m asl)	Administrative units (# of sub-counties)
Kween	01°25'N 34°31'E	791	1,900	12
Kapchorwa	01°24'N 34°27'E	1,738	1,800	15
Bulambuli	01°22'N 34°09'E	809	1,526	18
Sironko	01°14'N 34°15'E	462	1,420	22

The four districts experience several spill over effects from neighbouring locations which influence local livelihood and environmental circumstances. Heavy runoff in the mountains results in siltation and flooding in low-lying areas of Bukedea district (Kolir and Malera) and parts of Teso region. Local communities also report the presence of alien plant species hitherto associated with lowland areas invading the highland areas. On the other hand, due to proximity to Karamoja (Figure 2.1), social and environmental processes in the northern parts of Kween and Bulambuli have been significantly affected by cattle rustlers. The stakeholders also reported cases of damage to crops and property by strong dry winds that sweep across the region from the northern and north-eastern direction. Due to logistical and time constraints, the processes that result in various spill-over effects (so-called leakages) are only discussed in this report based on secondary sources in order to enhance understanding of their linkages to and implications on the project area and neighbouring regions. Particular sites for study were guided by further consultations at district and sub-county levels.

Due to the mountainous nature of the Mt. Elgon region, the VIA was conducted while taking into account the three slope categories: up-slope, mid-slope and down-slope.[9] From Figure 2.2, these slope categories were classified by altitude as follows: up-slope (>1,625 m asl), mid-slope (1,164-1,625 m asl) and down-slope (398-1,164 m asl). This categorisation cuts across all the target districts. Given marked differences in the ecosystems at each slope category, impacts of climate change tend to vary across the slope gradient.

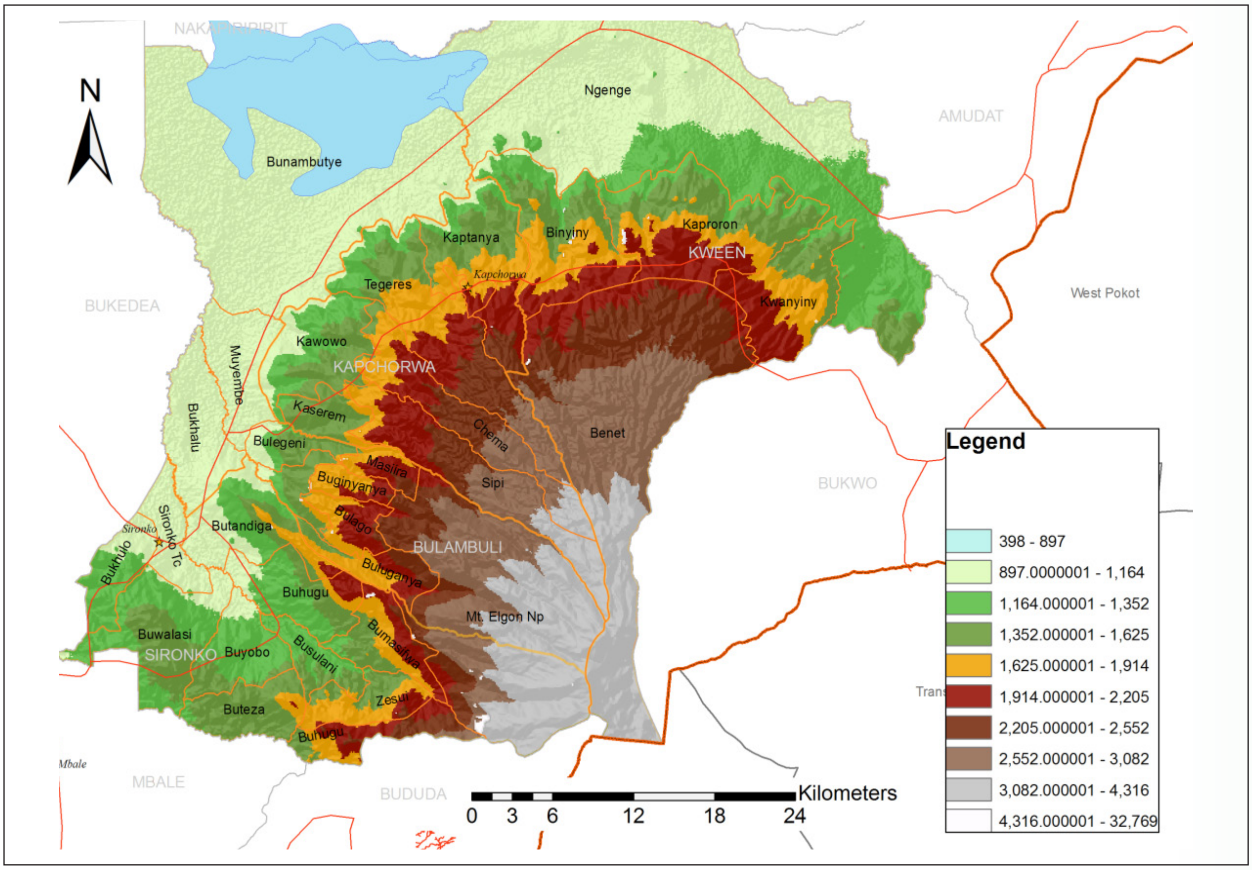


Figure 2.2. Altitudinal zonation for Mt. Elgon region with clearly discernible slope categories.

Source: Mt Elgon VIA 2013

9 These slope categories have been described in UNDP-EBA Consultancy Report "Provision of services in supporting information for Ecosystem-based Adaptation in Mt. Elgon Ecosystem Project", Kampala, Uganda. November 2011, Pp. 14-17.

(b) Time frame

Consensus on the appropriate timeframe of the VIA was reached through review of archives, expert opinions and community consultations. The focus here was to identify temporal dimensions within which analysis of historical events as well as projected future scenarios in the Mt. Elgon ecosystem is practical. Information on past trends was drawn from key informants and review of archives. The capacity of key informants to recall past historical events was noted to diminish when referring to periods beyond the 1960s backwards.

Most historical analyses therefore have been confined to a 50-year period extending from early 1960s to date. The projection of future scenarios bases on 40 years as this provides the opportunity to align interventions with national development planning frameworks, especially Uganda's vision 2040.

(c) Adaptation targets (livelihoods, infrastructure and ecosystems services)

Reducing current vulnerabilities and increasing adaptive capacities requires an understanding of how livelihoods are achieved and sustained, since the assets and capabilities that comprise people's livelihoods often shape vulnerability and the ability to reduce it. A preliminary list of important aspects of local livelihood, infrastructure and ecosystem services to be assessed for their vulnerability to climate change (adaptation targets) was derived from project documents and previous consultancy reports. The Sustainable Livelihood Framework (SLF) provided the basis for analysing the components of local livelihood systems that are connected to ecosystem services and that are likely to be amenable to Ecosystem-based Adaptation. In all aspects, the analysis sought to understand the composite elements, their relative importance to people's lives, and the extent to which each is resilient or vulnerable to climate-related changes.

(i) Livelihoods

Figure 2.3 shows components of livelihood adaptation targets. Based on the five livelihood assets, the adaptation targets in physical capital include housing, sanitation, land availability, energy and livestock. Natural assets include crops and their productivity, soil fertility, tree cover and water quality. Financial assets on the other hand, comprise of household incomes, access to credit and marketing systems. Human capital considers human health, food security, literacy and labour availability, while social capital resources were the existing community institutions and degree of egalitarianism in the communities.

PHYSICAL	NATURAL	FINANCIAL	HUMAN	SOCIAL
▪ Housing ▪ Sanitation ▪ Land ▪ Energy ▪ Livestock	▪ Crops ▪ Soils ▪ Tree Cover ▪ Water Quality	▪ Income ▪ Markets	▪ Health ▪ Food Security ▪ Labor	▪ Equity ▪ Community Institutions

Figure 2.3. Livelihood adaptation targets

(ii) Infrastructure

Various infrastructure are vital in enabling communities to adapt to climate change. Infrastructure adaptation is necessary to reduce the risks and impacts of extreme weather events. Understanding of the vulnerability of infrastructure to climate stresses was considered vital for this study. With consultation of stakeholders, the key infrastructural elements that were considered as most likely to be impacted upon by climate change were identified (Figure 2.4). The relative importance of these infrastructure elements was explored together with their vulnerability or resilience to climate change.

ENERGY	SHELTER	TRANSPORT	SANITATION
▪ Hydro Power ▪ Animal Power	▪ Residential Houses ▪ Community Halls	▪ Roads ▪ Bridges	▪ Protected Springs ▪ Gravity Flow Schemes ▪ Dams

Figure 2.4. Infrastructural adaptation targets

(iii) Ecosystem services

The range of ecosystem services in the Mt. Elgon region and their relative importance to people's livelihood were derived from stakeholder consultations and revolved around key provisioning, regulatory, supporting and cultural services as outlined in Figure 2.5.

PROVISIONING	REGULATING	SUPPORTING	CULTURAL
▪ Firewood ▪ Food ▪ Fresh Water ▪ Medicines ▪ Timber	▪ Air Quality ▪ Climate ▪ Pests & Dis-eases ▪ Erosion ▪ Flood ▪ Landslide	▪ Pollination ▪ Soil Fertility ▪ Rain	▪ Traditional Rituals ▪ Tourism

Figure 2.5. Ecosystem service adaptation targets

2.3 Mapping supply of ecosystem services and vulnerability to the impacts of climate change

Vulnerability to the impacts of climate change was analysed and mapped in ArcGis utilising data from online sources as well as the IGAD EumetCast eStation in Nairobi. The models were constructed using ArcGis Model Builder. Two reference points were also utilised to project landuse change i.e. LandSat Imagery for 2001 and 2011 – a period of 10 years was used to model the present situation. Normalised Different Vegetation Indices (NDVI) were very crucial for modelling various aspects of climate change impact and these were downloaded from IGAD EumetCast eStation at a spatial resolution of 1 km x 1 km. A detailed description of the methods used to model specific impacts or risk scenarios is provided in the respective sections of this report.

CHAPTER THREE

ECOSYSTEMS AND PEOPLE

3.1 Ecosystems of Mt. Elgon Region

The Mt. Elgon region consists of a wide range of ecosystems which offer a variety of ecosystem services upon which local communities heavily depend.These ecosystem services, as shown in Figure 3.1, are categorized as provisioning (e.g. food, fibre, water, medicine), regulating (e.g. erosion regulation, flood regulation, landslide regulation), supporting (pollination, soil fertility) and cultural (e.g. recreation, cultural heritage) services. In this report, ecosystems are therefore considered as discrete areas where ecosystem services are derived. Thus, for sustainable supply of ecosystem services, it is important to identify the ecosystems that supply these services. The major ecosystems identified by local communities in the Mt. Elgon region are farmlands, rivers and streams, forests/trees, pasturelands, swamps and mountains/hills. Figure 3.1 illustrates the multifaceted linkages between these ecosystems, ecosystem services and ecosystem beneficiaries in Mt. Elgon region. Data and information obtained from expert consultations, ground-truthing and local community (people's) narratives are collectively used to describe the spatial distribution, salient characteristics of four priority ecosystems together with their linkages to the local communities in sections 3.1.1 – 3.1.4 below.

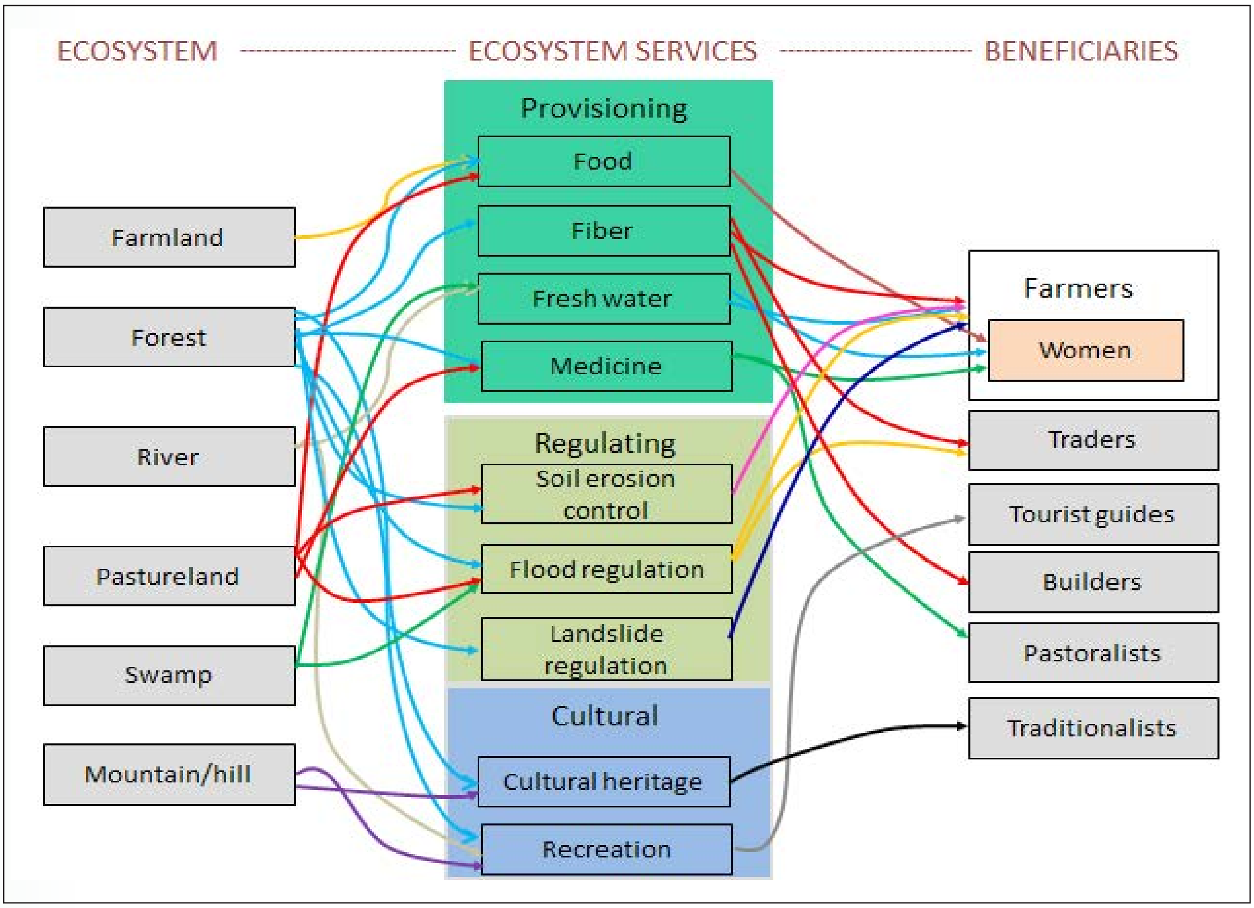


Figure 3.1. Diagrammatic nexus of key ecosystems, ecosystem services and beneficiaries *Source: Mt Elgon VIA 2013*

3.1.1 Farmland

Farmland is an important ecosystem because of its direct linkage to agriculture, which is the main stay for local peoples' livelihoods. Like many parts within the East African highlands, the farmlands of the Mt. Elgon region have great potential for agricultural production (Table 3.1). The favourable climate and fertile soils attracted farmers to the region many centuries ago. Historically, the Bagisu have been cultivators much as their livelihood also depends considerably on utilization of forest and grassland resources. The Sabiny, on the other hand, were more of nomadic pastoralists who supplemented their livelihoods by hunting, gathering and settled farming. Small-holder subsistence farmlands thus represent the largest land use system in the Mt. Elgon region. Stretching from the fringes of the degraded tropical forest on the upper slopes, farmlands extend downwards across the mid slope, gradually transiting into the lowland grasslands and woodlands to the northern and north-eastern fringes of Mt. Elgon (Figure 3.2). Characteristically, the farmlands on the lower slopes of Mt. Elgon are predominantly dry cropland and pasture, while those of the middle slopes can be characterised as cropland/woodland mosaic.

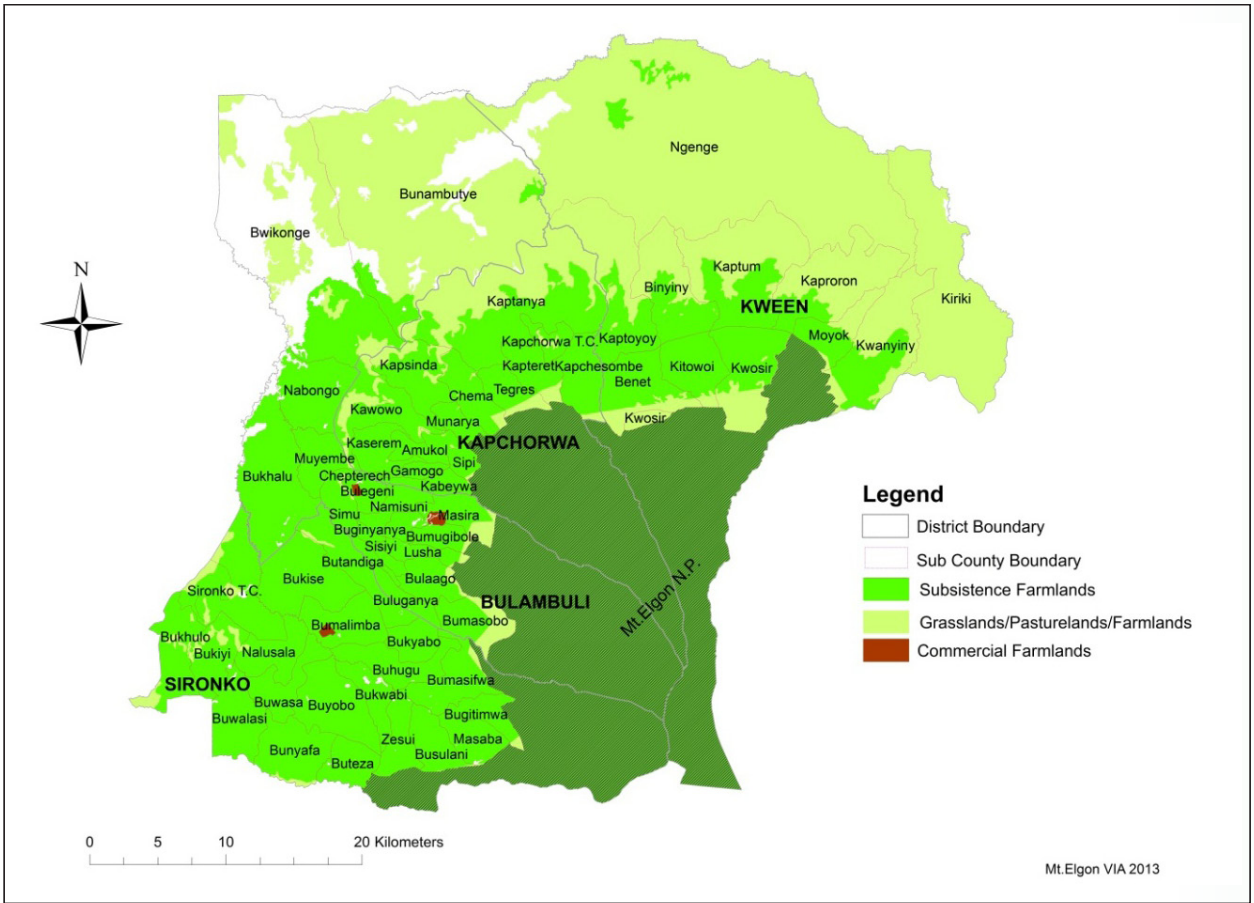


Figure 3.2. Farmland coverage in Bulambuli, Sironko, Kapchorwa and Kween districts

Farmlands in Mt. Elgon region have continuously increased in spatial coverage (Figure 3.3), partly due to the conversion of other land uses to agriculture (refer to Figure 4.3 in Chapter 4). Marginal and fragile natural areas such as riverbanks, swamps and steep slopes are increasingly being brought under cultivation due to the increase in human population and resultant demand for food.

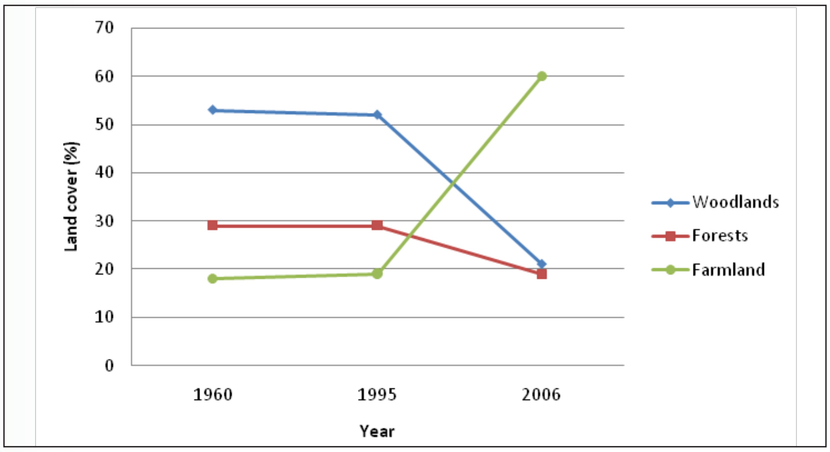


Figure 3.3. Land use trends in Mt. Elgon region between 1960 and 2006

Source: Muggaga (2011)[10]

The nature of farmlands in Mt. Elgon is, therefore, to a large extent influenced by the farming practices characteristic of particular locations. The large open areas of the lowlands (e.g. Bunambutye and Ngenge) encourage the use of ox ploughs for cultivation, in contrast to the fragmented, rugged and rocky fields of up slope areas (e.g. Bulaago, Tegeres and Benet) where animal draught is not possible (see Plate 3.1).

Current livelihood systems are primarily dependent on intensive agricultural production as evident from the vast patchwork of crop gardens that characterize much of the landscape. Agricultural production is oriented towards food crops (millet, sorghum, groundnuts, cassava, sweet potatoes, beans and Irish potatoes), cash crops (cotton and coffee), fruits (passion fruits), and an assortment of vegetables (e.g. tomatoes, onions and cabbages). Production is for both subsistence and commerce.

Plate 3.1. *Vast areas of the Mt. Elgon ecosystem are increasingly being brought into farmland. A view of the deforested Benet area that was formerly part of the Mt. Elgon Nation Park.*

10 Mugagga F (2011) Land Use Change, Landslide Occurrence and Livelihood Strategies on Mt. Elgon Slopes, Eastern Uganda. PhD Thesis, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Farmlands on the upper slopes are areas of intensive farming characterised by lush gardens of coffee, bananas, Irish potatoes and beans (Plate 3.2). Some landscapes (e.g. Benet Resettlement Area in Kween district) are quite intensively cultivated, dominated by a patchwork of maize, Irish potatoes, beans, barley, wheat, assorted vegetables and scattered stands of eucalyptus. In contrast, the lowlands are characterised by crops such as maize (Plate 3.3), groundnuts, sorghum, millet, cotton, soya beans, sweet potatoes, sunflower and rice. Arabica coffee gardens situated on the lower slopes are characterised by relatively high density of shade trees like *Cordia africana* and *Albizia coriaria* which contrasts markedly with those on the upper slopes.

Plate 3.2. *Gardens of Irish potatoes in Benet.In the background is highly degraded land that was previously forested part of Mt. Elgon National Park.*

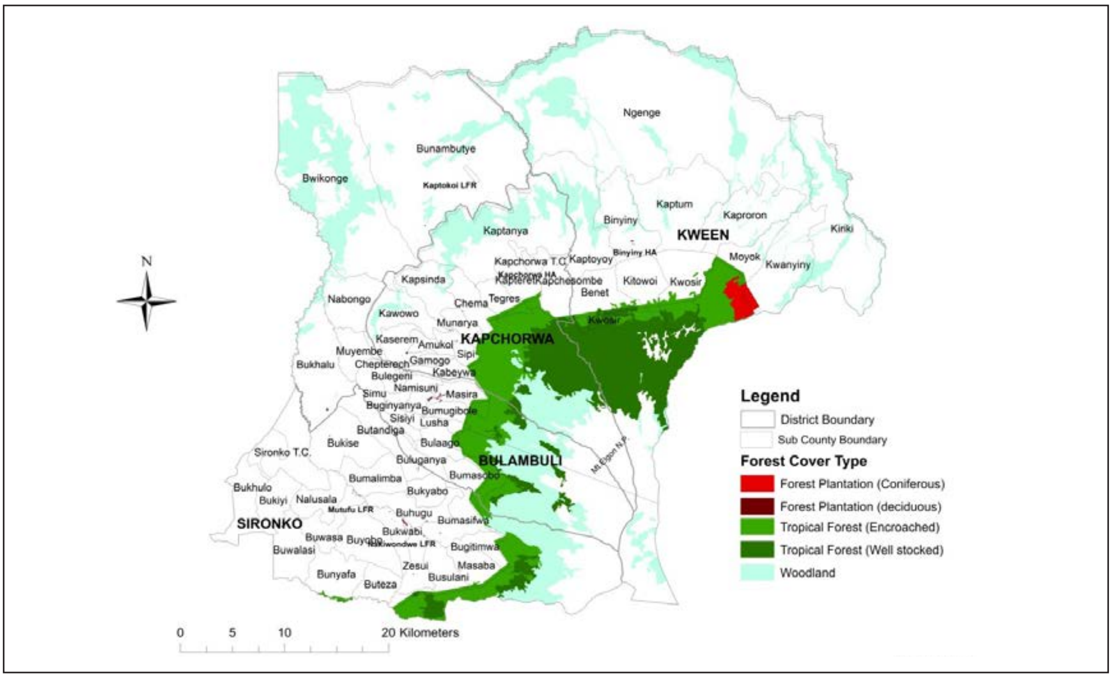


Figure 3.4. Forest and woodland cover in the Mt. Elgon region

Source: Mt Elgon VIA 2013

Plate 3.3. *Maize gardens on the lower slopes of Mt. Elgon, Bulambuli district*

In the low-lying wetland areas of Ngenge, Bunambutye and Muyembe sub-counties, rice is fast emerging as a cash crop. Coffee and bananas are predominant in Sironko, Bulambuli and parts of Kapchorwa (in Tingey, Sipi and Tangwen sub-counties) while barley, maize, wheat and Irish potatoes dominate in Kween district.

In the face of changing climatic conditions and increased degradation of the Mt. Elgon area, farming communities struggle to meet their subsistence food requirements. In addition, farmers have to cater for their cash requirements, such as school fees, medical care and clothing. The area, however, has great potential for agricultural production to meet subsistence and market needs of the people (Table 3.1). Although the traditional cash crops are coffee and cotton, every crop has become a cash crop. Farmers sell their crop products to middlemen who bring their trucks to farms and village trading centres. The tarmacking of the Mbale-Kapchorwa road dramatically increased access to markets and contributed to increased “cash crop” production. Extensive cultivation of maize, sorghum, cassava, rice and millet, including livestock production, are currently practiced in the plains and swamps of Ngenge and Bunambutye sub-counties. Despite a shortage of grazing land, livestock rearing is seen by many as the most reliable and lucrative activity[11].

Table 3.1. Acreage and production of major agricultural crops of Kapchorwa and Sironko districts

Crop	Area (ha)		Production (MT)			
	Kapchorwa	Sironko	Uganda	Kapchorwa	Sironko	Uganda
Maize	6,074	5,645	1,014,260	49,904	18,649	2,361,956
Sweet potatoes	89	634	440,256	156	850	1,818,769
Rice	-	180	75,086	-	25	190,736
Cassava	413	2,213	871,388	920	9,238	2,894,311
Bananas	3,299	6,118	806,627	26,892	29,066	4,017,986
Beans	960	5,192	617,521	322	2,128	929,278
Irish potatoes	639	57	32,758	1,913	263	154,435

(Source: MAAIF, Uganda Census of Agriculture, 2009)

11 Himmelfarb D. (2005). Moving people, moving boundaries: The socio-economic effects of protectionist conservation, involuntary resettlement and tenure insecurity on the edge of Mt. Elgon National Park, Uganda. University of Georgia.

3.1.2 Forests

In the Mt. Elgon region, forests can be divided into natural forests and woodlots (Figure 3.4). In addition, farmers integrate trees with crops on farm. The high increase in human population has, however, resulted into encroachment on natural forests leading to significant loss of tree cover. As a result, natural forests only remain in the upslope areas where they fall within the Mt. Elgon National Park. In the higher altitudes, the vegetation structure of the forest changes from Montane to grassland, bamboo (Box 3.1) then heath and moorland. These high altitude forests are dominated by camphor, *Aningeria adolfi-friederici*, *Podocarpus latifolius*, *Olea hochestetteri* and *Prunus africana*[12].

Mixed bamboo occurs at about 2,500-3,000 m asl followed by an open woodland dominated by *Hagenia abyssinica* and African rosewood, forming the heath zone which occurs at 3,000-3,500 m asl and then the Afro-alpine region which stretches from 3,500 m to 4,321 m asl, dominated by *Senecio elgonensis*[13]. Bamboo is one of the most important resources from the forest zone (Box 3.1). A series of accusation and counter accusation between local communities and park authorities coupled with shifting boundaries of the park has meant more encroachment on the park and conversion of originally forested land to agriculture and settlement. In most areas, what remains outside the national park, are remnants of natural forests and natural vegetation. Most of the natural forests have been cleared to open up more land for agriculture as a result of high population pressure (Table 3.2).

Table 3.2. Current status of forest reserves in Sironko, Bulambuli, Kapchorwa and Kween districts

District	Current status of forest reserves
Sironko	▪ **Mutufu:** forest reserve 21 ha, half of it is Eucalyptus, half maize. ▪ **Nakiwondwe in Budadiri:** 21 ha, established to provide building poles. Planted with Eucalyptus. District Natural Resource and Production Department manages this forest reserve. ▪ **Namatale:** Only a small portion is found within Sironko district, the rest falling in Mbale district.
Bulambuli	▪ Kaptokwoi: 85 ha., bushland.
Kapchorwa	▪ **Town council forest:** (not forest any more), leasehold, 5 acres, open with houses, under NFA management, peri-urban. ▪ **Kapchorwa central forest reserve:** Not a forest any more. Houses and schools have been built. Few eucalyptus, 5 ha.
Kween	▪ **Binyiny:** This forest was totally encroached and turned into agricultural land. It is undergoing replanting. Beekeeping by the veterinary department is the main activity. The reserve is used by the community for firewood. Meetings to make agreements for intercropping maize with trees have been arranged.

(Source: Soini, 2007[14])

Box 3.1. Bamboo: the most important non-timber forest product from Mt. Elgon region

Bamboo (Arundinaria alpina) is locally utilized for making handcrafts (baskets, beehives, granaries, mats, stretchers, trays and toys) and furniture (beds, chairs, tables, shelves and lamp sheds), construction (granaries, fences, ceilings, house gutters and wall panels[Plate 3.4]), food (bamboo shoots), energy (firewood and charcoal). Other uses include stakes (Plate 3.5), tube-containers, drinking vessels, stands, medicines, fodder, musical instruments, cooking utensils and walking sticks. Basketry using bamboo is prevalent among households close to the park. Use of bamboo shoots for food is by far the most recognised, especially among the Bagisu. During the harvesting season, which peaks around November, the local communities are allowed by the park authorities into some zoned parts of the forest to harvest bamboo shoots. Involvement in the collection of bamboo shoots and utilisation of bamboo for various products is more prominent towards the upslope areas adjacent to the park. This is because bamboo is located far away from the forest edge and a lot of time is spent while traversing the forest to extract the products. Promotion of bamboo growing on-farm could develop a larger market for its products while at the same time improving the livelihoods of local people especially women involved in the craft industry.

Focus Group Discussions, Benet Resettlement Area and Bugitimwa Sub-county, May 2013

12 Hamilton A.C., Perrott R.A. (1981). A study of altitudinal zonation in the montane forest belt of Mt. Elgon, Kenya/Uganda. **Plant Ecology** 45: 107-125.

13 Hamilton A.C., Perrott R.A. (1981). A study of altitudinal zonation in the montane forest belt of Mt. Elgon, Kenya/Uganda. Plant Ecology 45: 107-125.

14 Soini E. (2007). Land tenure and land management in the districts around Mt. Elgon: An assessment presented to Mt. Elgon Regional Ecosystem Conservation Programme (MERECP). ICRAF Working Paper No. 49. Nairobi, Kenya: World Agroforestry Centre.

Plate 3.4. *Bamboo obtained from Mt. Elgon National Park can be used for protecting house walls from being washed by rain*

Plate 3.5. *Bamboo can be used in staking beans*

Timber, poles and firewood are the main products extracted from forests. These products are mainly extracted from woodlots and trees on farm although communities adjacent to the national park still illegally extract poles and firewood from the park.

On-farm tree cover in Mt. Elgon region can be explained by farming practices, farmland characteristics and tradition. The upslope areas have more tree cover than lowlands because oxen ploughs are used on the lowland fields requiring big open areas while oxen cannot be used on the upper slopes due to the rocky nature of the land and terrain of the slopes. Also, some of the crops grown on the upper slopes (mainly coffee and banana) require shade, thus encouraging tree planting. Woodlot sizes vary from 0.01 to 1 ha[15] . The tree species that dominate in the woodlots is *Eucalyptus* spp due to its fast growing nature. This tree species is preferred due to its potential to meet the high demands for timber, fuelwood (Box 3.2) and poles in the region. Other tree species found scattered on the farms include *Pine* spp., *Sesbania sesban, Casuarina equesitifolia*, *Albizia* spp, *Grevillea robusta* and *Tectona grandis*.

Box 3.2. Firewood: the case of forest and tree resources scarcity

Many upslope residents living near the national park collect firewood from the forest/park, especially for areas where on farm wood resources are almost exhausted e.g. Benet Resettlement Area. Off farm sources are as far as 4 km away across steep terrain. Currently, Mt. Elgon National Park officials are very strict, which has further compounded residents' access to firewood resources. Elsewhere, on-farm trees and woodlots provide much of the firewood used at home and sold on local markets. Firewood from on-farm trees includes species like Eucalyptus spp., Sesbania sesban and Grevillea robusta.

The firewood situation in the midslope areas was described by local communities as "so scarce that some people resort to use of maize cobs for cooking". Although prices vary from place to place, firewood is considered to be expensive. Presently, a bundle of firewood is sold at 1,000 shillings in Bulaago, up from 500 shillings a decade ago. In Bugitimwa sub-county, three (3) small pieces of firewood cost 1,000 shillings, up from 200 shillings or even free access a decade ago. In Kaptum sub-county, one (1) bundle of firewood, which can last a household for two days, costs 5,000 shillings, up from 1,500 shillings around 2002. It is estimated that a household of ten people uses firewood worth 3,000 shillings daily. Trees outside forest have, therefore, become of increasing importance, as they are often the main tree resource for the majority of the rural populations[16]. Free grazing livestock in the lowlands also pose a threat to tree growing, or at least complicates it.

Focus Group Discussions conducted in the study area, May 2013

3.1.3 Rivers and streams

The Mt. Elgon ecosystem serves as a catchment area for the drainage systems of Lakes Victoria, Turkana and Kyoga through several rivers, springs and streams originating from the National Park and the caldera at the top of the mountain (see Plate 3.6). The rivers assume a radial pattern, covering the entire mountain (Figure 3.5) and flow all year round. These rivers include Suam/Turkwell, Nzoia, Lwakhakha, Sipi, Malaba, Sio-Malakisi, Soloko (Sironko), Atari, Manafwa, Namatale and Ngenge. Other minor rivers include Bukwo, Cheberen, Simu, Sasa, Kere, Yembek, Sirimityo, Chebonet, Cheptui, Cheseber, Kaptakwoi, Yemdyony, Chepyakaniat, Sundet, Kere, Siti (Kapkwata), Nyalit, Amanang, Kelim (Greek or Kiriki), Nauyo, Nambale, Makhuba, Passa, Nabuyonga, Lwere, Muyembe, Ukho, Kajeri, Guragado, Dingana, Sasa, Sisi, Namuserere. These rivers provide food, water, recreational services and act as buffers during periods of low precipitation and/or long dry season.

Except for areas that are inaccessible due to terrain, the river catchments are utilized for several socio-economic activities including agriculture, small scale industries, tourism, settlements and wildlife conservation. However, in spite of the above mentioned utilitarian values, all river catchments are threatened by encroachment and unsustainable land use practices. Outside the protected area (Mt. Elgon NP), local economic activities around the rivers leave no buffer zones. Some of these activities include cultivation along river banks, sand mining and re-channeling of water movement to gardens. Cultivation of river banks is especially apparent along the lower courses of the rivers.

15 NEMA (2004). State of Environment Report. Kapchorwa district local Government. National Environment Management Authority, Kampala, Uganda.

16 Soini E. (2007). Land tenure and land management in the districts around Mt. Elgon: An assessment presented to Mt. Elgon Regional Ecosystem Conservation Programme (MERECP). ICRAF Working Paper No. 49. Nairobi, Kenya: World Agroforestry Centre.

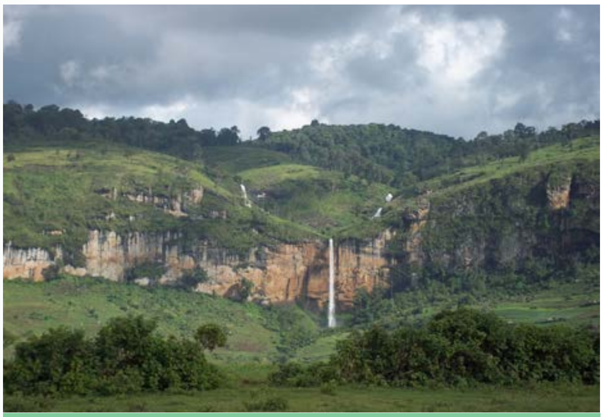


Plate 3.6. *Many rivers cascade from the top of Mt. Elgon to the lowlands, making the mountain truly a water tower of the region*

Although the law requires preservation of 100 metres on both sides of gazetted rivers such as Sironko, Namatale, Sipi, Ngenge, Atari, Kere and Bukwo, this has not been adhered to and has therefore not been practiced on the ground[17].

Much of the vegetation that could have regulated flooding has therefore been cleared, leading to erosion of river banks and siltation. For example, the upstream inaccessible, vegetated section of River Sipi is well protected compared to its lower degraded sections. The banks of rivers Atari, Sironko, Namatale, Ngenge, Kaptakwoi and Muyembe have been degraded by cultivation of maize, bananas, coffee and other horticultural crops (cabbages, onions, tomatoes, Irish potatoes) leading to soil erosion and siltation. In Tegeres sub-county, river banks are threatened by cultivation of bananas and coffee[18].

The supply of fresh and clean water in Mt. Elgon region, especially to the downstream communities such as Ngenge, Bunambutye, Muyembe and Bwikonge (Figure 3.5 and Plate 3.7) is in jeopardy and there is need to develop both adaptation and mitigation strategies. The German Agency for Technical cooperation (GIZ) has facilitated the construction of automatic flood monitoring hydro stations (early warning systems) on some rivers, such as Sipi (Kapchorwa district) and Solonko (Sironko district) to monitor water levels and provide alerts on thresholds that would result in floods[19]

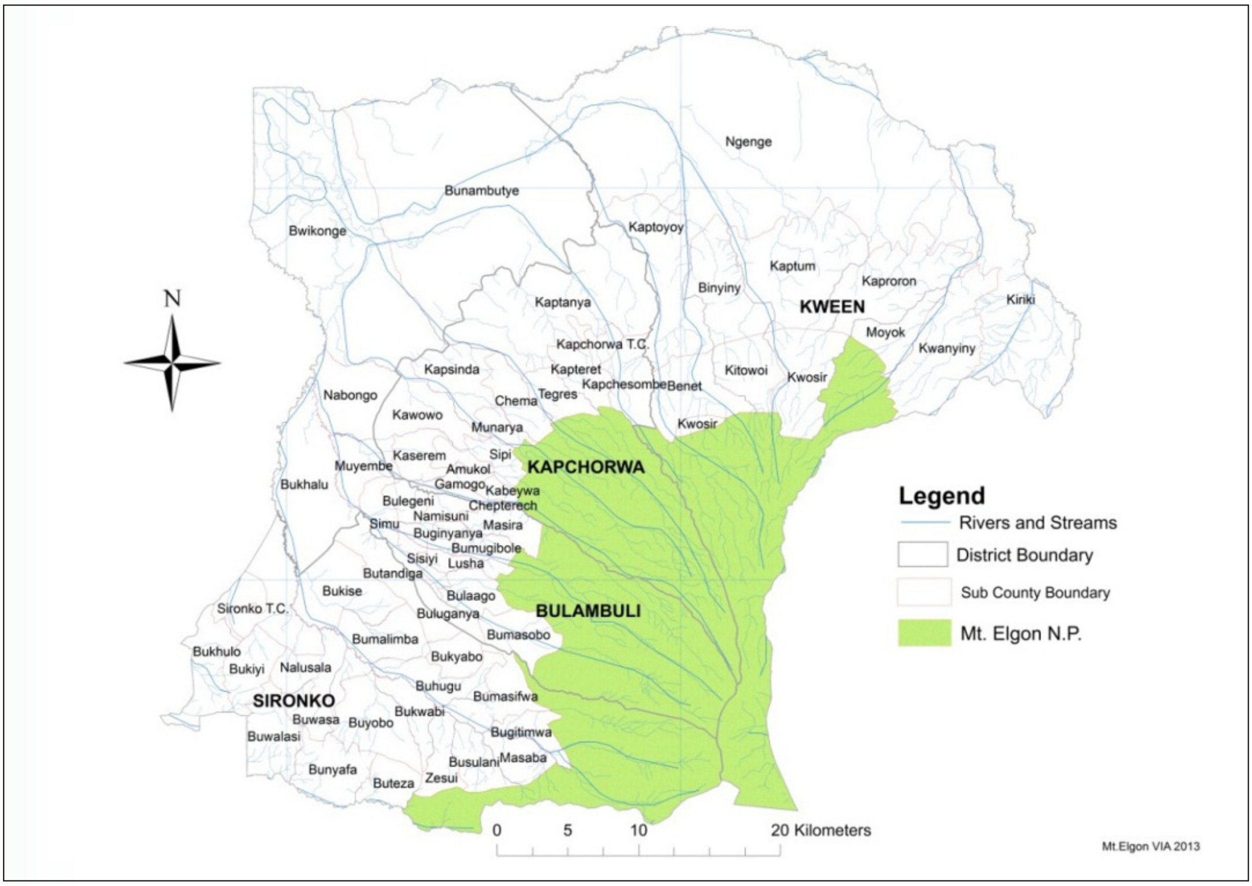


Figure 3.5. Drainage pattern (rivers and streams) in Sironko, Bulambuli, Kapchorwa and Kween districts

17 Aryamanya-Mugisha (2011). 20 years of wetlands conservation in Uganda – have Uganda's wetlands become wastelands again? Paper presented at the World Wetlands Day, 2nd February 2011 – Theme: Wetlands for Forests, Uganda Museum, Kampala.

18 Kapchorwa DSOER (2004). Kapchorwa District State of the Environment Report, Kapchorwa, Uganda.

19 Ministry of Water and Environment, Water and Environment Sector Performance Report, 2012.

Plate 3.7 *Cultivation along the bank of downstream R. Sisiyi, resulting in erosion and dirty water*

3.1.4 Swamps/wetlands

The wetlands in Mt. Elgon region can be classified as riverine, bogs and marshes, the latter being common in the caldera at the top of Mt. Elgon National Park. In total, there are about 4,051 hectares of wetlands, with 1,042 hectares in Kapchorwa/Kween and 3,009 hectares in Sironko/Bulambuli districts[20]

In Kapchorwa and Kween districts, 75% of the wetlands are found in the plains of Ngenge sub-county and 25% in Mt. Elgon National Park Most wetlands in Kapchorwa and Kween are seasonal though some wetlands in parts of Greek (Kiriki) and Tabuk (Cheywakaniet) are permanent. Many of the wetlands in Mt. Elgon region are privately and/or customarily owned, apart from those that fall within the protected areas of Mt. Elgon National Park[21]. In the park, wetlands are totally inaccessible for product extraction and basically serve as water catchment for lower areas. All these wetlands drain into three major river systems namely: Suam to the east, Greek (Kiriki) bordering Moroto district and Sironko (Solonko) flowing west towardsLake Kyoga.

The most common vegetation in wetlands in Kapchorwa and Kween districts are grasses (e.g. *Echinochloa* sp., *Cyperus articulata*, *Typha* spp., *Setaria* spp.), sedges and trees (e.g. *Acacia* and *Syzgium* species). Papyrus (*Cyperus papyrus*) is found only in the permanent wetlands of Tabuk and Kiriki. The wetlands in Sironko and Bulambuli districts form part of the Bisina/Opeta wetland system (Ramsar site since 2006), which covers an area of 123,141 ha[22]. The animals found in the lowland wetlands include snakes, frogs, monitor lizards, monkeys, baboons, antelopes, buffaloes, leopards, lions and water bucks. Birds that are present mainly on the lowland wetlands include ducks, cranes, pelicans, ibis, herons, ostriches, guinea fowls and many other small birds[23]

Wetlands are important for biodiversity conservation, maintenance of water regimes, climate modification, water supply and as sources of fish.These wetlands therefore provide local people with an array of ecosystem services, such as herbal medicines, food (yams, maize, sugarcane, bananas, vegetables and fish, especially catfish and lungfish), fresh water for domestic use and watering animals, water recycling thus modifying local weather (temperature), building poles, fibre and firewood. In the Ngenge wetlands, for example, several fishes such as catfish, lungfish and some haplochromis – like fish are found. In the highlands though, fishes, especially the Mirror carp species, are only found in artificial ponds managed by communities.

Most wetlands in the region are under significant degradation, e.g. Ngenge wetlands which are almost depleted due to agriculture (growing of vegetables, paddy rice, yams and sugarcanes) especially during the dry season. Indeed, crop farming in wetlands was identified by communities as the major cause of siltation of River Atari[24] and flooding of River Ngenge. Other drivers of wetland degradation are livestock rearing, unsustainable fishing, removal of craft materials and extraction of herbal medicines. Grazers and farmers particularly in Kawowo sub-county compete for the limited water from the wetlands during drought and this is a major source of wrangles. Serious loss of biodiversity in these wetlands is also caused by bush burning during the dry season.

20 Drichi P. (2003). National Biomass Study 1996-2002. Technical Report No.16. Forest Department, Ministry of Water Lands and Environment, Kampala, Uganda.

21 Kapchorwa DSOER (2004). Kapchorwa District State of the Environment Report, Kapchorwa, Uganda.

22 Byaruhanga et al. (2001). Important Bird Areas in Uganda. Nature Uganda, Kampala, Uganda.

23 Kapchorwa DSOER (2004). Kapchorwa District State of the Environment Report, Kapchorwa, Uganda.

24 Kutegeka S., Nakangu B. and Bagyenda R. (2011)Local responses to the impacts of climate risks on maize, beans and coffee production in Uganda . A case study of Kacheera sub county in Rakai district and Kawowo sub-county in Kapchorwa district. International Union for Conservation of Nature (IUCN), Uganda Country Office

CHAPTER FOUR

VULNERABILITY OF LOCAL COMMUNITIES AND ECOSYSTEM SERVICES

4.1. Trends in land use and climatic conditions

4.1.1 Land use changes

The prevailing conditions in a landscape are the product of a combination of natural and man-made processes. Climate has a significant bearing on the natural processes, although it also influences the manner in which humans interact with the environment. Natural environments respond differently even when exposed to the same manifestation of climate change. Human interaction with the environment, as well, is strongly influenced by the manner in which physical environments respond to changes in climate. Within particular localities, climate processes affect different sectors (e.g. agriculture, food security, income, water and sanitation, health, transport, housing, education etc.) differently. Given that agricultural activity in the Mt. Elgon region is strongly weather-dependent, changes in climate tend to have significant effects not only on its nature, but also its contribution to people's livelihood. Land use trends in the Mt. Elgon region were analysed through a combination of satellite imagery and participatory methodologies.

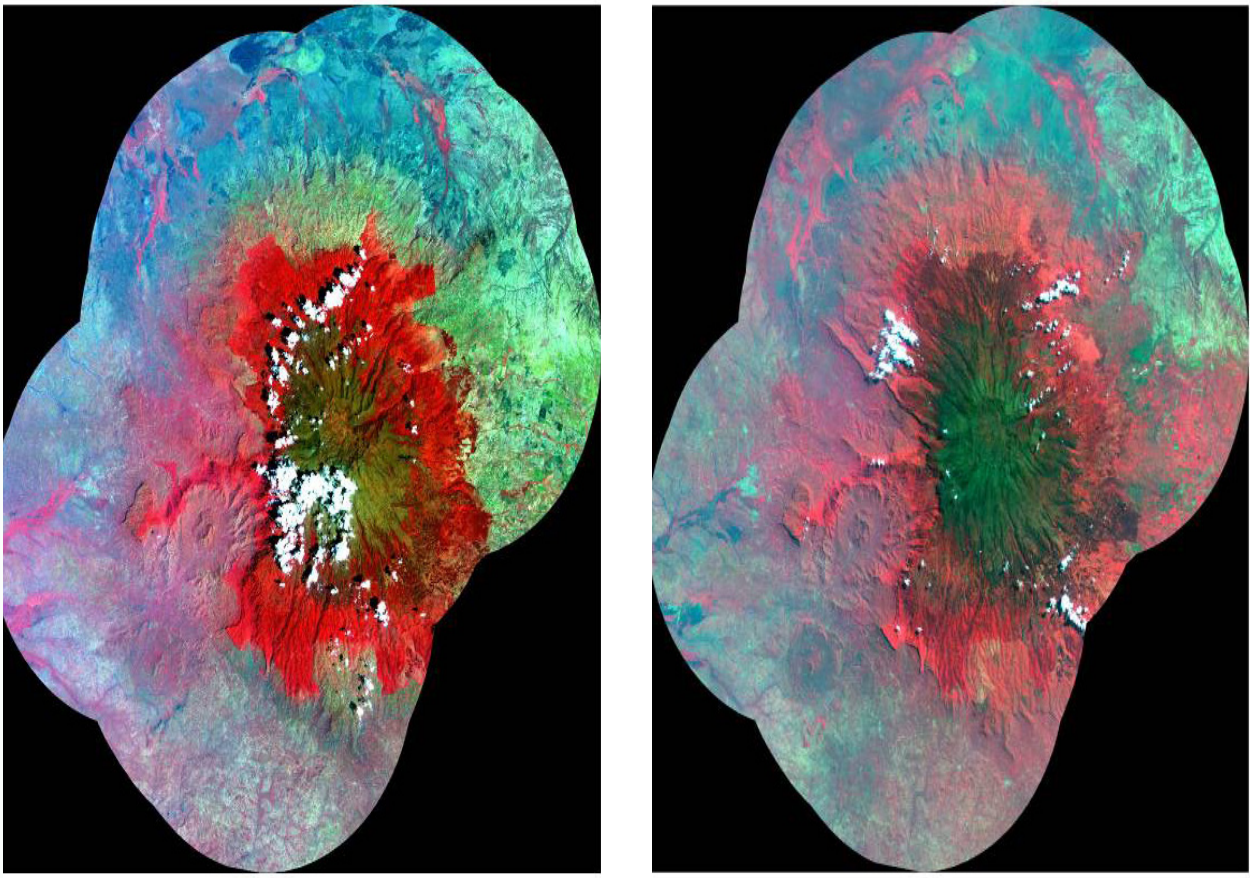


Figure 4.1. LandSat imagery of Mt. Elgon land cover in 2001 (left) and 2011 (right)

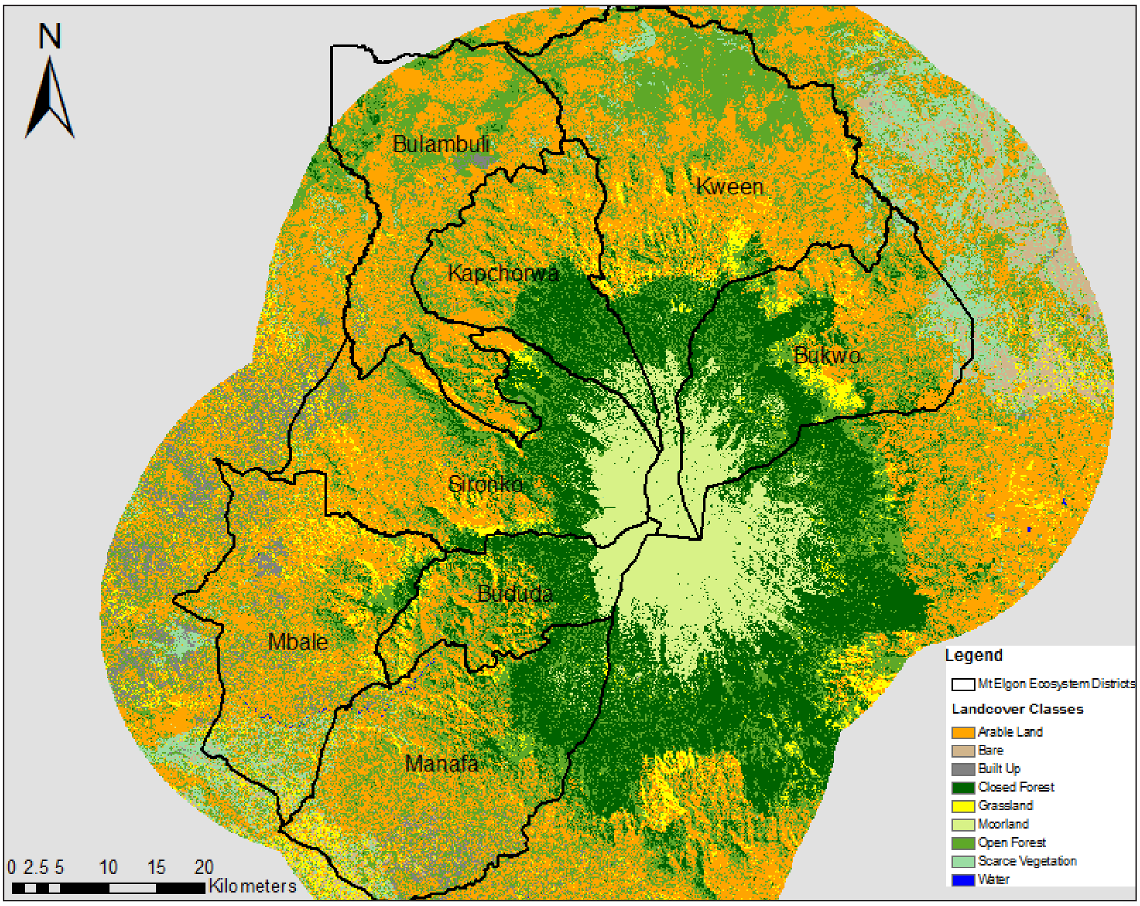


Figure 4.2. Mt. Elgon ecosystem land cover in 2001 re-classified from LandSat Imagery *Source: Mt Elgon VIA 2013*

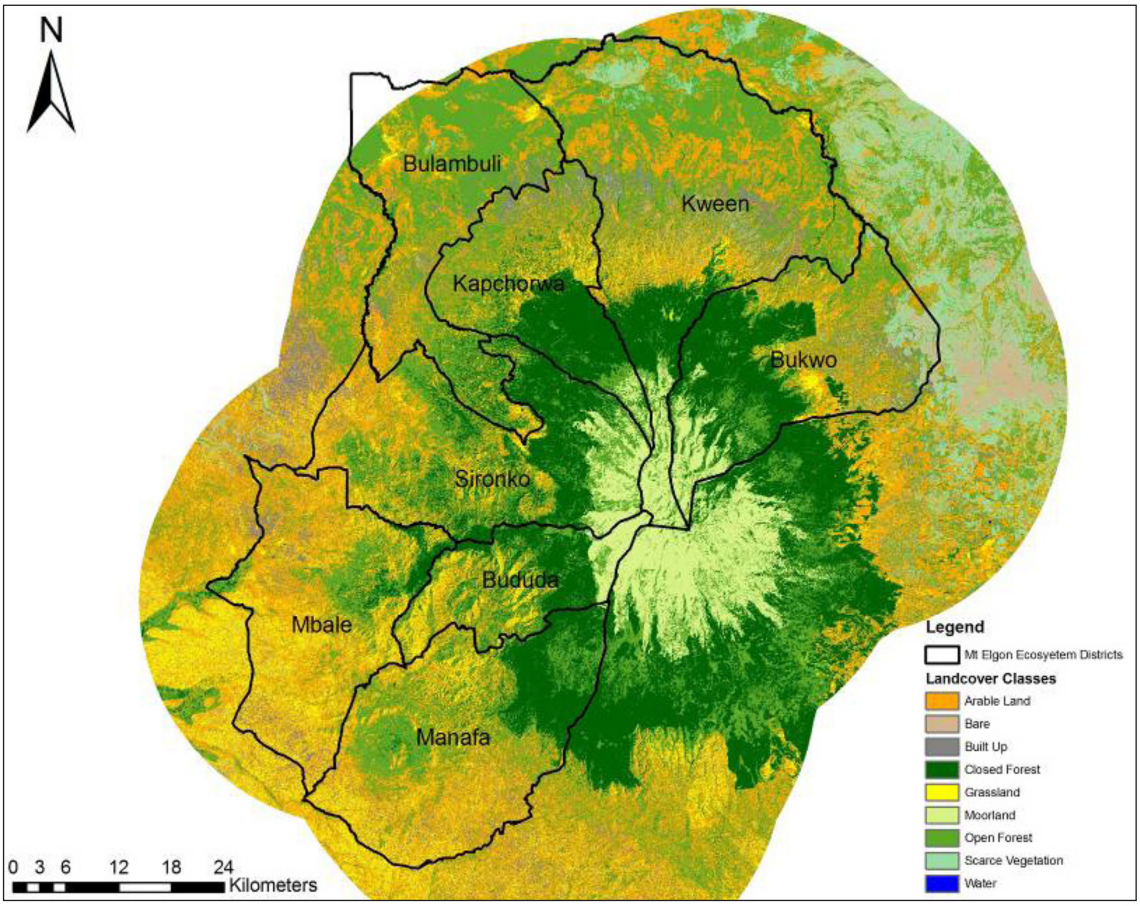


Figure 4.3. Mt. Elgon ecosystem land cover in 2001 re-classified from LandSat Imagery *Source: Mt Elgon VIA 2013*

Generally, forest cover in the region has significantly reduced over the last decade, a trend largely attributed to expansion of farmlands into previously forested areas. This trend is closely associated with vast deforestation, wetland degradation and loss of biodiversity (Figures 4.1 - 4.5). Middle slope and down slope locations depict the highest deforestation arising out of increasing human population and rising demand for tree resources and agricultural land. The upslope areas have experienced less degradation as the human activity there has been compounded by the steep terrain and climatic conditions there.

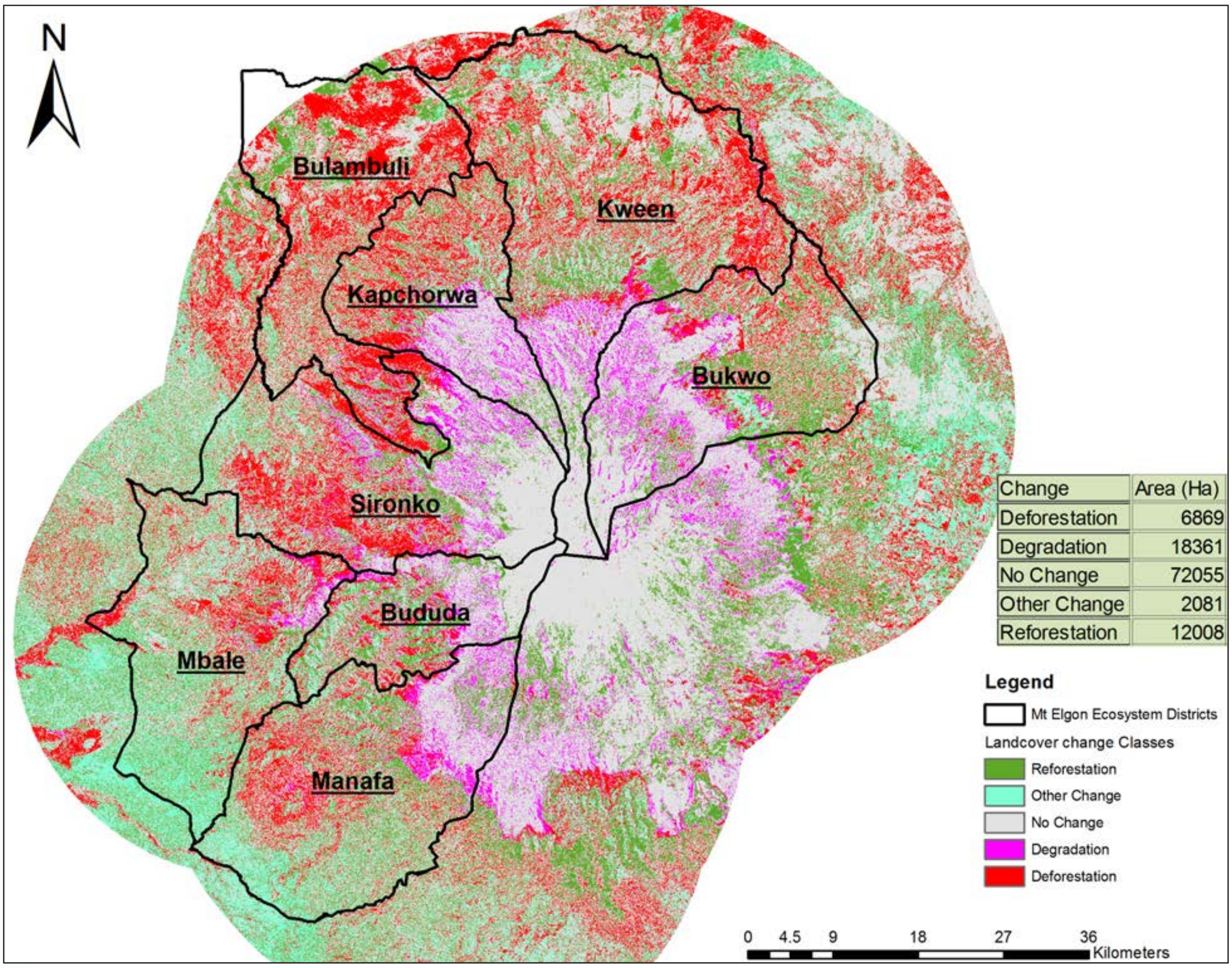


Figure 4.4.Mt. Elgon ecosystemland cover change between 2001 and 2011

Source: Mt Elgon VIA 2013

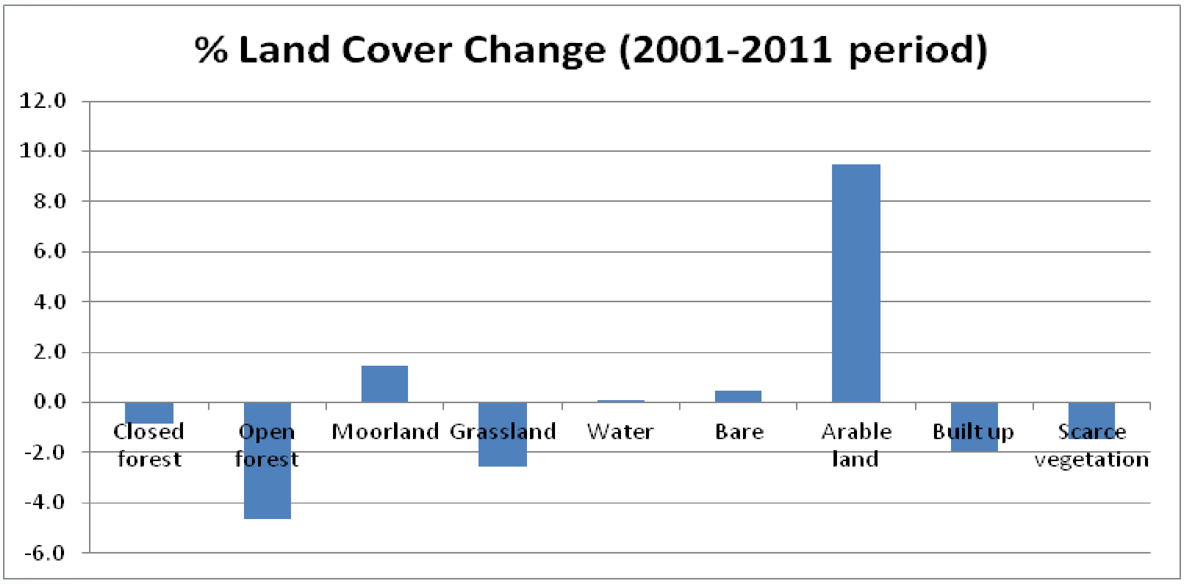


Figure 4.5. Graphical trends in land cover proportions (%) in Mt. Elgon region (2001– 2011)

4.1.2 Climate changes

Temperatures in the Mt. Elgon region are influenced by altitude. As shown in Figure 4.6, higher altitude areas are much cooler than low altitude areas. However, even within the low-lying plains, there are observable differences in temperatures. For example, the sub counties of Bunambutye, Bwikhonge and Ngenge are susceptible to higher temperatures compared to other low-lying areas. Even in upslope locations, conditions are warmer than in past years.

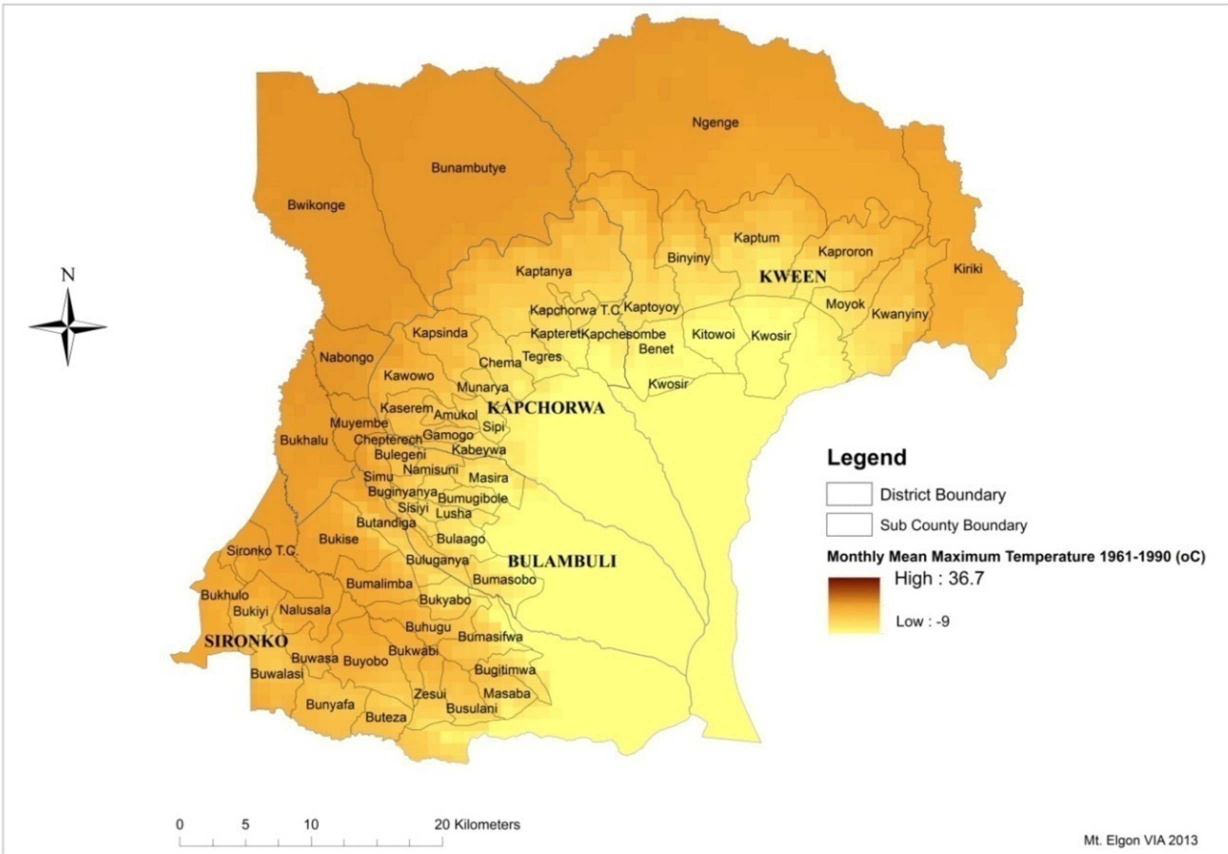


Figure 4.6. Mean monthly maximum temperatures oftarget districts (1961-1990)

Rainfall also varies with altitude, the upper slopes receiving relatively more rain than lower lying areas (Figure 4.7). Like most parts of Uganda, rainfall in the Elgon region is bimodal, with the first and second rains occurring in March - May and August–October respectively (Figure 4.8). Noticeably, bimodality is not very marked as some rain still occurs between the two peaks. Mount Elgon experiences intense dry spells from December to February. However, during discussions with local communities, perceptions of rainfall patterns were as described in Box 4.1.

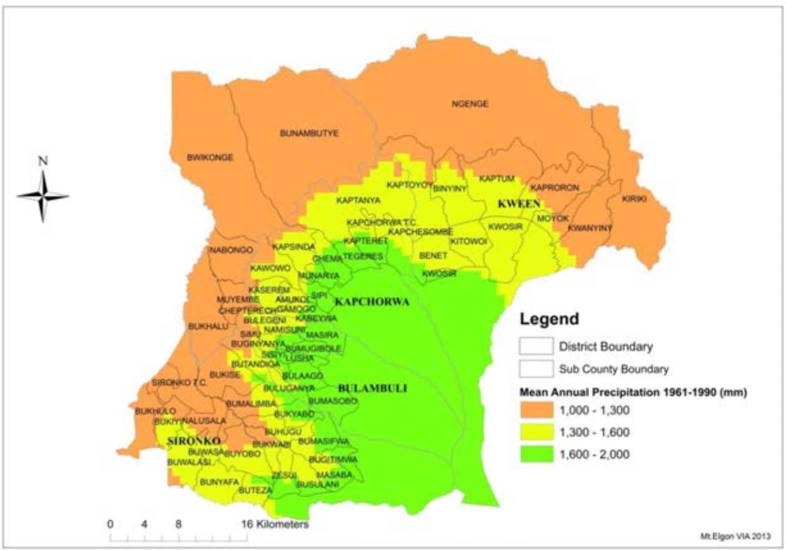


Figure 4.7. Mean annual precipitation for target districts (1961-1990).

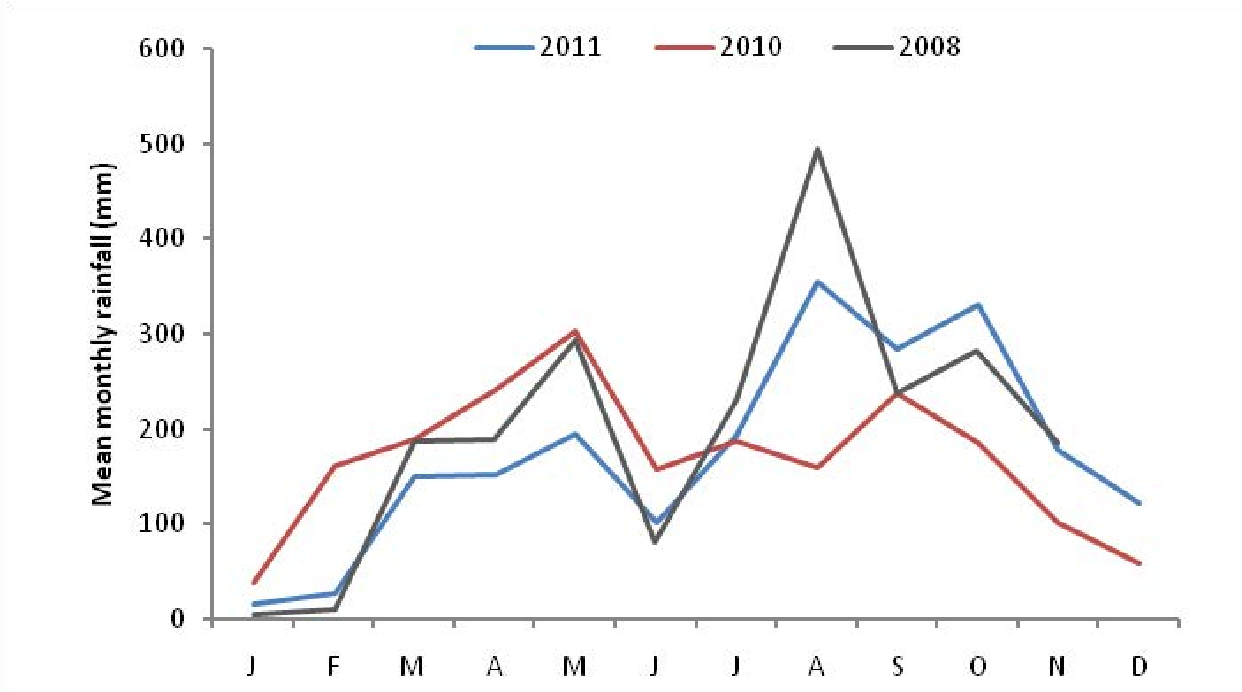


Figure 4.8. Mean annual rainfall patterns at Buginyaya weather station for 2008, 2010 and 2011.

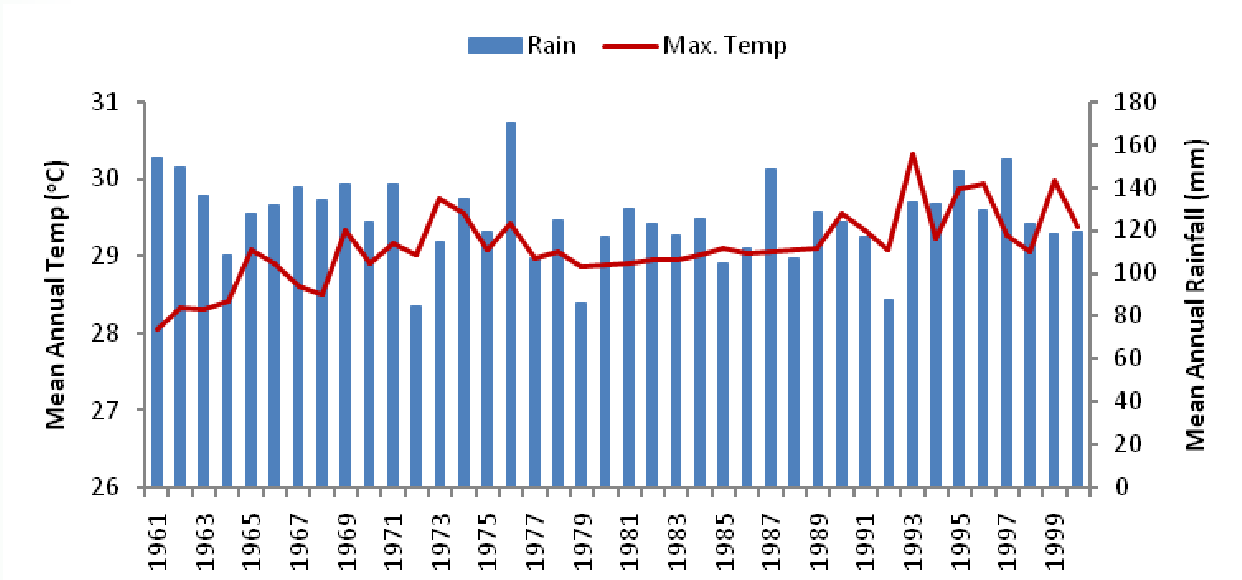


Figure 4.9. Mean annual temperature and precipitation (1961 – 2000) for Mt. Elgon region (extracted from Tororo weather station).

Box 4.1 Community perspectives about changing rainfall patterns

The local communities report a drastic change in pattern, timing and amount of rain. Rains are quite erratic, sometimes beginning as early as February. During some years, such as 2012, there was rainfall throughout the year. The amount of rainfall is also reported to have increased during the last 1 or 2 years. This increase in the amount of rainfall has had negative effects on crop performance (especially beans and maize) as well as other farm enterprises (e.g. beekeeping). In down slope areas, local communities report significant changes in rainy seasons since the 1990s. Much more rains have been received in recent years. During this year (2013), the rains have been notably heavier compared to previous years.

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On a long term basis, the rainfall pattern is not discernible compared to the clear trend for temperature (Figure 4.9). Estimates based on the same data from Tororo weather station for the period 1961– 2000 indicate that temperatures in the region increased by 0.2^{o} C. But local perceptions indicate increase in temperature, especially during the dry spell, only in the last 2 to 3 years (Box 4.1).

The climatic patterns described above coupled with land use change cause various climate-related perturbations and hazards. Discussions with local communities in the region revealed that the area is affected by a range of climate related hazards such as strong winds, lightning, soil erosion, crop pests and diseases, flooding, landslides, drought, famine, and human diseases. Although the importance of these hazards is context specific, there was consensus about the significance of landslides, flooding, soil erosion and drought or intense dry season to the communities in this region.Therefore, these four hazards form the central focus of this assessment.

4.2 Vulnerability to climatic hazards and perturbations

4.2.1 Drought

Drought is a temporary reduction in water or moisture below the normal or expected amount for a specified period.[25] Perceptions of drought, however, vary because reduction in rainfall may range from a few weeks to several years and its effects depend on the situation in a particular area. In the Mt.Elgon region, rainfall shortages last for up to four months (Figure 4.7). Therefore, drought in this region may actually be considered as prolonged dry spells. These are often associated with elevation, wind circulation and vegetation cover, given the influence these have on rainfall and temperature regimes.

Satellite data processed into Normalized Difference Vegetation Indices (NDVI) can be used to indicate deficiencies in rainfall and portray drought patterns both timely and spatially, thus serving as an indicator of drought patterns. The NDVI, which is a dimensionless variable, is a measure or estimate of the amount of radiation being absorbed by plants. The amount of radiation absorbed is directly related to evapotranspiration, which is constrained by the amount of water in the soil. And for relatively low rainfall amounts, the amount of water in the soil is constrained by rainfall[26]. Hence NDVI correlates with rainfall.

The NDVI can be used to measure and monitor plant growth, vegetation cover, and biomass production. Box 4.2 describes the procedure through which satellite data was processed into Normalized Difference Vegetation Indices (NDVI) and used to indicate deficiencies in rainfall and portray drought patterns in the Mt. Elgon region.

Box 4.2. Method for deriving the drought severity model (Figure 4.10)

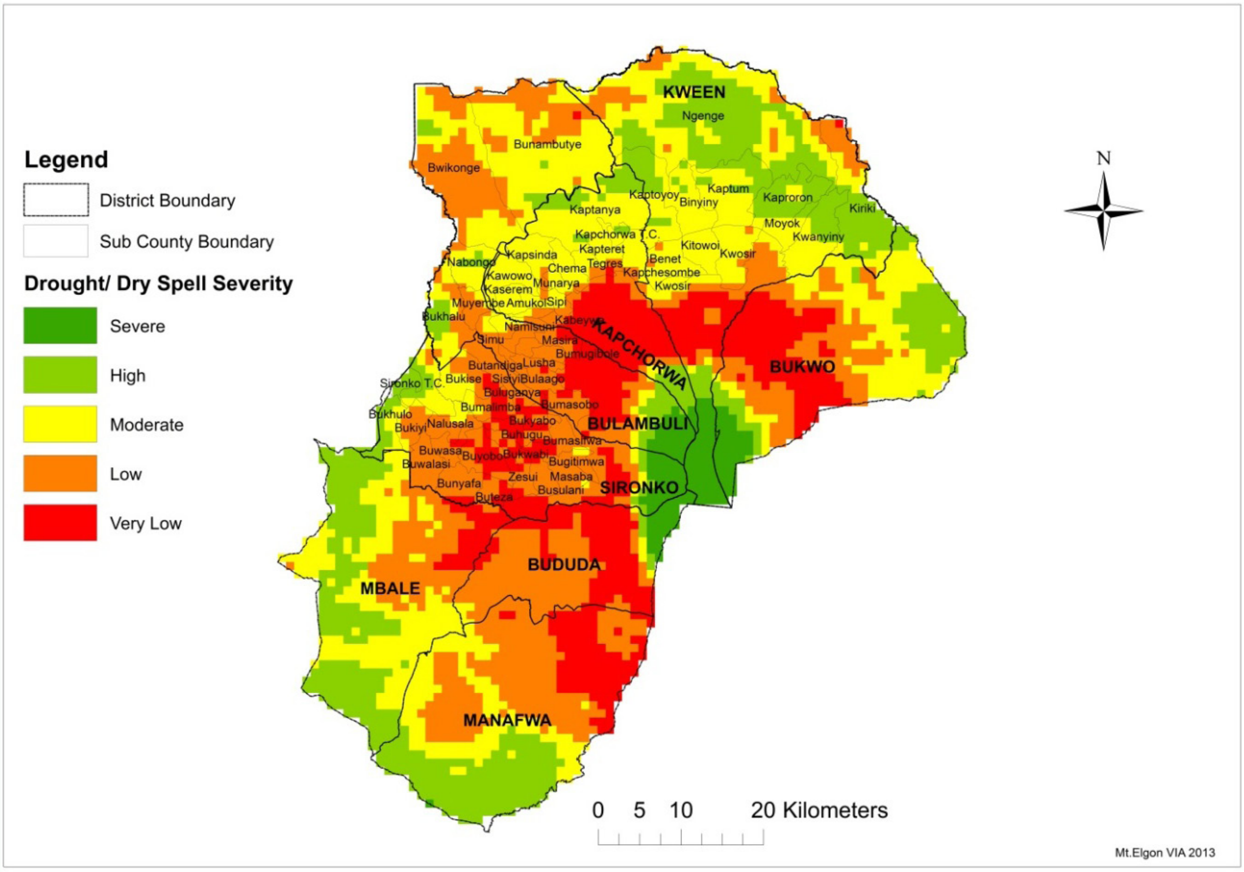
The drought severity map (Figure 4.9) was based on NDVI for 10 years (2003-2012). Earth satellite vegetation data from SPOT (Satelite Pour l'Observation de la Terre) were downloaded from the Inter-Governmental Authority on Drought (IGAD) EumetCast e-station in Nairobi at a spatial resolution of 1 km x 1 km and processed using spatial analysis in ArcGIS 10.2. Raster digital NDVI values were converted to real NDVI values using Raster calculator in ArcMap. Monthly/seasonal NDVI were then calculated using cell statistics. Drought severity indices were computed based on maximum NDVI (MNDVI) as the deviation of current MNDVI values from their corresponding long-term mean MNDVI values for every pixel for the last 10 years (2003-2012). The final drought susceptibility map was classified using the natural breaks method into five classes:

Classes	Values
Severe	0.50 – 0.68
High	0.68 – 0.76
Moderate	0.76 – 0.80
Low	0.80 – 0.84
Very low	0.84 – 0.92

Figure 4.10.Drought severity in Mt. Elgon region based on

25 IIRR (2008). Drought Cycle Management: A Toolkit for the Drylands of the Greater Horn. International Institute of Rural Reconstruction, Nairobi, Kenya. 253pp.

26 Rowland, J., Nadeau, A., Brock, J., Klaver, R. and Moore, D. (1996) Vegetation Index for Characterizing Drought Patterns. Raster Imagery in Geographic Information Systems. Santa Fe, New Mexico, Onward Press, pp. 247-254



Normalized Different Vegetation Index (NDVI) for 2003-2012

The computed Drought Severity Indices for the Mt. Elgon region ranged between 0.50 and 0.92. According to Alley (1984)[27], values between +0.49 and 0.49 can be interpreted as conditions of near normality. Values of 0.50 to 0.99 (within the range obtained in the present assessment) indicate conditions of incipient wet spells. Higher values than 1.0 indicated increasingly wet conditions. Since drought severity indices for this region were greater than 0.4 but less than 1.0, it can be concluded that the Mt. Elgon area experiences prolonged dry periods with incipient wet spells. Therefore, while drought severity has been classified from very low to moderate in the present study, it must be understood that the level of severity indicated falls outside what can be generally understood as drought under certain contexts.

In Figure 4.10, 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.[28] 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.

From the drought severity map (Figure 4.10), prolonged dry spells in the four districts of Kween, Kapchorwa, Bulambuli and Sironko occur in the areas close to semi-arid Karamoja and Teso sub-regions. Indeed, experiences of prolonged dry spells due to effects of dry winds from the semi-arid areas were recurrently reported by communities in low-lying parts of Bulambuli and Kween districts bordering Karamoja sub-region. Communities located along the middle slopes are also relatively more prone to prolonged dry spells compared to their upslope counterparts. The sub-counties most prone to such dry spells are outlined in Annex 4(a) and include: Ngenge, Kiriki and Kaproron in Kween district; Kawowo in Kapchorwa district; and Bukhalu, Nabongo, Muyembe, Bwikonge and Bunambutye in Bulambuli district.

27 Alley M. W. (1984). The Palmer Drought Severity Index: Limitations and Assumptions. Journal of Climate and Applied Meteorology, Vol.23.

28 Gu Y., Hunt E., Wardlow B., Basara JB., Brown JF and Verdin JP (2008). Evaluation of MODIS NDVI and NDWI for vegetation drought monitoring using Oklahoma Mesonet soil moisture data. Geophysical Research Letters Volume 35, L22401. Doi: 10.1029/2008GL035772.

Vulnerability to drought in Mt. Elgon is high due to heavy reliance on climate-dependant resources such as rain-fed agriculture. Prolonged dry spells with incipient rainfall thus result in water scarcity leading to water stress and unfavourable conditions for plant growth. This results in poor crop yields, unavailability of water for domestic use, shortage of livestock forage, and in worst case scenarios famine, which impact on people's livelihoods. Crop failure due to drought has been recorded to cause losses of up to 80% of farm production[29] . Food insecurity, especially in the lower and mid-slope areas, renders the people more vulnerable to malnutrition and disease. Areas prone to prolonged dry spells (Figure 4.10) face recurrent food insecurity due to poor crop yields. Climate change models indicate that an increase of 2^{0}C could have a significant negative impact on crops such as coffee.[30]

The communities' capacity to adapt to long dry spells depends on access to resources that enable adequate response to threats and exposures from drought. In agriculture for instance, an immediate response to extended drought is irrigation of crops using existing rivers and streams for increased farm production, while livestock keepers resort to unconventional animal feed e.g. use of dry grass, maize stover and banana stems (Plate 4.1).

Plate 4.1. *Maize stover stacked and kept for use as animal feed during dry spell*

However, adaptive capacity is compounded by financial limitations and lack of technical knowledge. There are high poverty levels that limit efforts to contain extended periods of low rainfall. To enhance adaptive capacity to extended dry spells, it is imperative that communities have access to functional boreholes, protected springs, clean water points, irrigation systems and water storage, health care and sanitation.

4.2.2 Landslides

A landslide refers to mass movement of soil mainly on steep slopes caused by its saturation from excessive rain.[31] Several studies have attributed increased frequency of landslides to land use changes[32 33 34]

29 AATF/NARO (2010) Enhancing maize productivity in Uganda through the WEMA Project. Policy Brief. www.aatf-africa.org/userfiles/WEMA-UG-policy-brief 1.pdf

30 MFPED, 2004

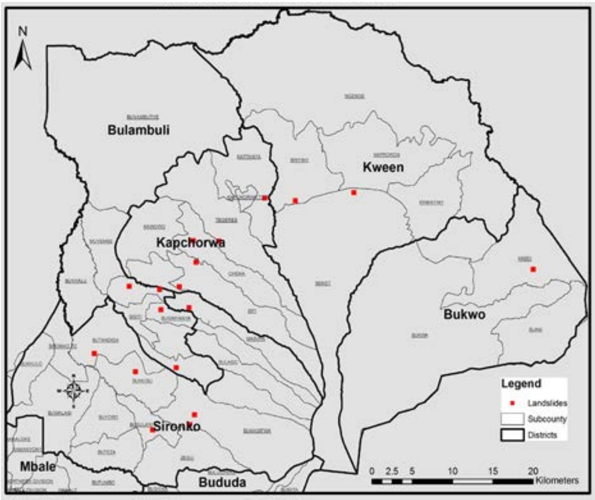
31 Cruden D. M. (1991). A simple definition of a landslide. Bulletin of the International Association of Engineering Geology 43 (1): 27-29.

32 Meusburger, K., Alewell, C. (2009). The influence of temporal change on the validity of landslide susceptibility maps. Natural Hazards and Earth System Sciences 9, 1495–1507.

33 Wasowski, J., Lamanna, C., Casarano, D. (2010). Influence of land use change and precipitation patterns on landslide activity in the Daunia pennines, Italy. Quarterly Journal of Engineering Geology & Hydrogeology 43, 387–401.

34 Mugagga, F., Kakembo, V. and Buyinza, M. (2012). Land use change on slopes of Mt. Elgon and the implication for the landslides. Catena (90) 39-46.

In Mt. Elgon National Park, landslides have been observed to occur even on the densely forested slopes[35] This implies that other causal factors such as geology, slope shape, slope undercutting, soil texture and heavy rainfall are quite important[36] . Past landslide occurrences in the Mt. Elgon region have tended to concentrate in the mid and upslope areas (Figure 4.11).



Source: Mt Elgon VIA 2013

Figure 4.11. Location of previous incidents of landslides in the Mt. Elgon region

In order to understand the spatial distribution of landslides, mapping was undertaken by combining several parameters in ArcGIS model builder (Figure 4.12). Box 4.3 describes the procedure used to derive the landslide hazard map for the Mt. Elgon region.

It can be deduced from Figure 4.13 that mid slope and upslope areas are more vulnerable to landslides. Steep concave slopes, oriented to the north-east and especially where deforestation and cultivation have taken place, are more exposed to landslides[40 41] The most vulnerable sub-counties are indicated in Annex 4(a) and include 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.

Box 4.3. Method for deriving the landslide hazard map (Figure 4.13)

Landslide hazard mapping was done by considering slope, soil type, land cover and rainfall intensity. NASA Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data were downloaded from ftp://e0srp01u.ecs.nasa.gov/srtm/version2/SRTM3/ and Mt. Elgon region extracted using the mask tool in ArcGIS. Slope risk was derived based on slope steepness computed in degrees and re-classified into five classes using manual breaks as follows:

Classes	Values
Flat	0 – 2
Very gentle to flat	2 – 5
Gentle	5 – 15
Steep	15 – 30
Very steep	> 30

Land cover data were downloaded from http://ionia1.esrin.esa.int/ based on ENVISAT's Medium Resolution Imaging Spectrometer (MERIS) level 1B format at a resolution of 300 m x 300 m.Landcover risk was derived by extracting the Mt. Elgon region from the GlobCover Geo file and reclassified the landcover codes into landcover classes. Soil risk was determined from data downloaded from the Harmonized World Soil Database version 1.2[37] .Rainfall risk was derived from historical mean annual rainfall data (1961-1990) downloaded from WorldClim – Global Climate Database[38] .The relative importance of the risk factors was determined using Saaty's pairwise comparison method[39] to arrive at the following weights: Slope (0.42), Rainfall (0.33), Soil types (0.17) and Land cover (0.08). These were input into ArcGIS Model Builder to derive the potential landslide risk index, which was then overlaid on the map of the region to produce a landslide hazard map. This procedure is schematically presented in Figure 4.11.

35 Mugagga F., KakemboV. and BuyinzaM. (2012). A characterisation of the physical properties of soil and the implications for landslide occurrence on the slopes of Mount Elgon, Eastern Uganda. Natural Hazards 60 (3): 1113-1131.

36 Knapen A, Kitutu MG, Poesen J, Breugelmans W, Deckers J, Muwanga A (2006). Landslides in a densely populated county at the foot slopes of Mt. Elgon Uganda, Characteristics and causal factors, Geomorphol. 73: 1-2: 149 – 165.

37 FAO/IIASA/ISRIC/ISS-CAS/JRC (2012). Harmonised World Soil Database version 1.2. FAO, Rome, Italy and IIASA, Laxenburg, Austria. (http://www.iiasa.ac.at/Research/LUC/luc07/External-World-soil-database/html/index.html?sb=1).

38 http://www.worldclim.org/bioclim

39 Saaty TL. (2008). Relative measurement and its generalisation in decision making: Why pairwise comparisons are central in Mathematics for the measurement of intangible factors – The analytical hierarchy / network process. RACSAM – Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales Serie A. Mathematicas. 102 (2): 251 – 318.

40 Knapen A, Kitutu MG, Poesen J, Breugelmans W, Deckers J, Muwanga A (2006). Landslides in a densely populated county at the foot slopes of Mt. Elgon Uganda, Characteristics and causal factors, Geomorphol. 73: 1-2: 149 – 165.

41 Mugagga, F., Kakembo, V. and Buyinza, M. (2012). Land use change on slopes of Mt. Elgon and the implication for the landslides. Catena (90) 39-46.

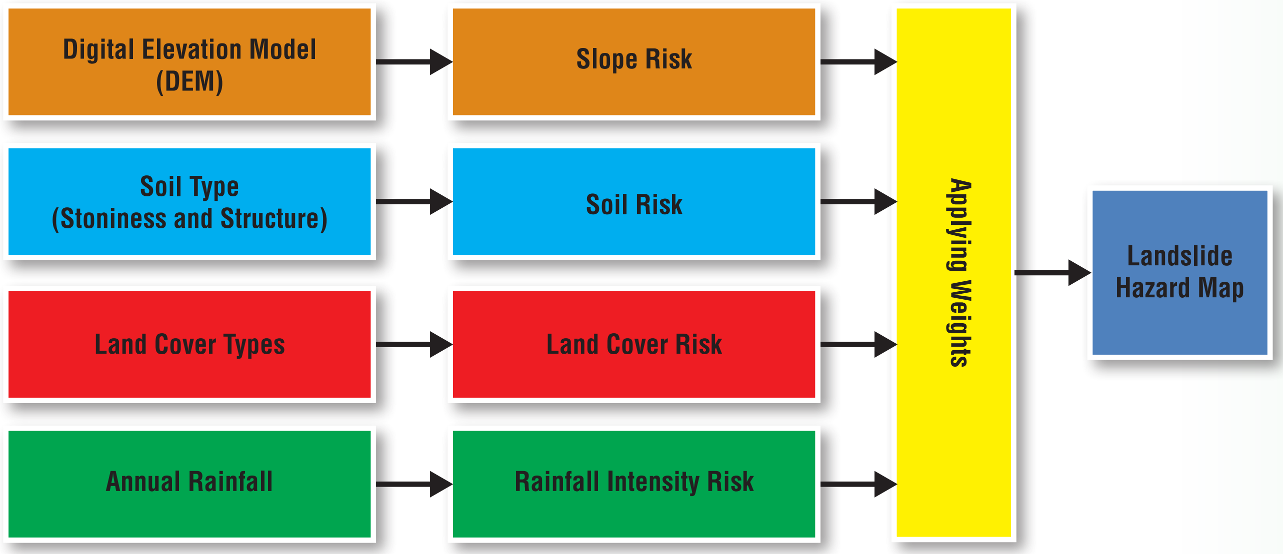


Figure 4.12. Method for deriving landslide susceptibility (hazard) map

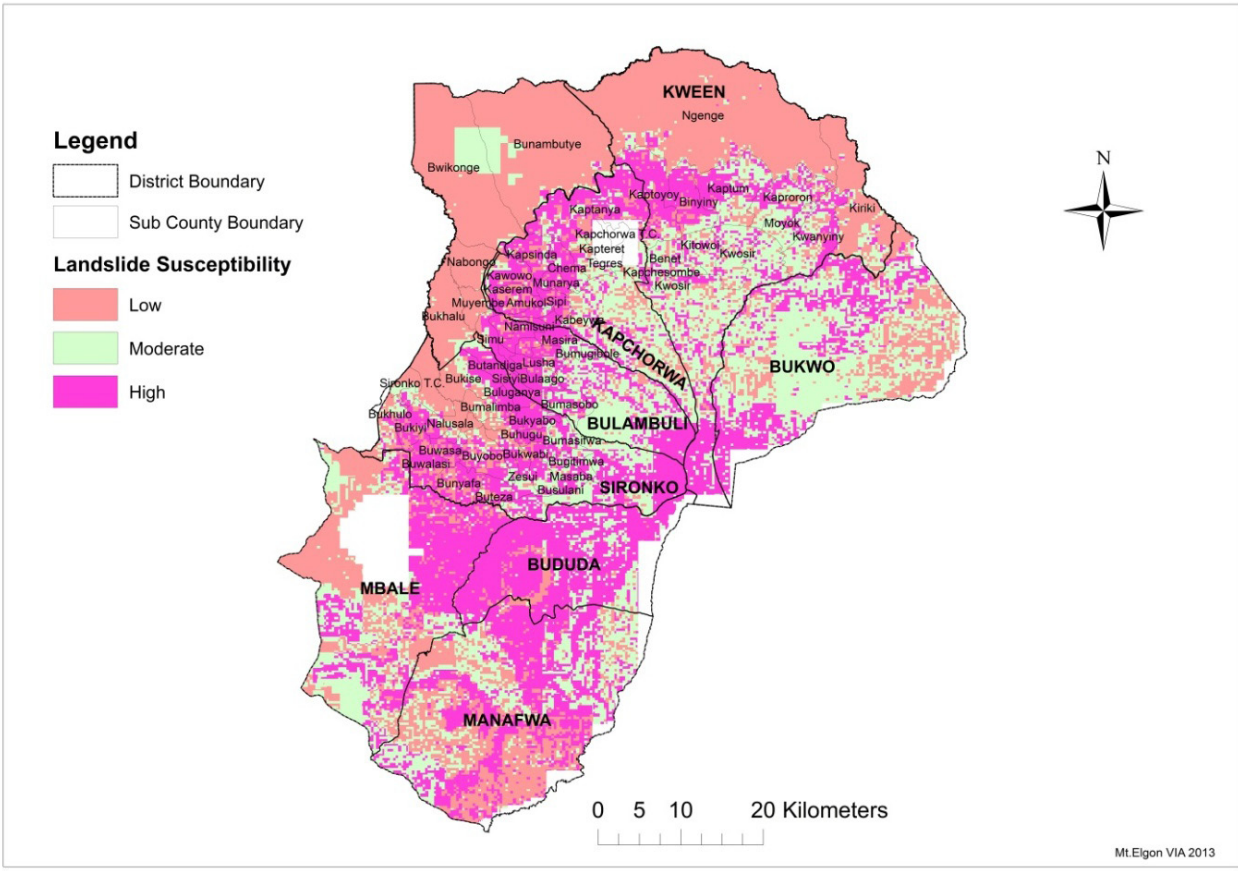


Figure 4.13. Landslide susceptibility(hazard) map for the Mt. Elgon region

Landslides significantly impact on the lives of affected communities and compromise their main sources of livelihoods.The impact of landslides in the Mt. Elgon region is further exacerbated by the dense human population. Destruction of human settlements automatically leads to displacement of people with its associated problems. Given that agriculture is the mainstay for people's livelihoods in this region, destruction of crops and livestock, as well as loss of fertile land due to landslides places people at the risk of famine. Damage to roads and other infrastructure can further marginalize and isolate the already affected communities. The ultimate outcome of these impacts is untold suffering and poverty. This is in addition to loss of human lives which may occur in the event of severe landslides. For example, in August 2011 landslides devastated 7 villages of Buluganya and 6 villages of Sisiyi sub-counties, killing over 27 people and injuring 33[42].

The strategies adopted by individuals, households or communities to cope with landslides are based on the assumption that what has happened in the past is likely to repeat itself in familiar pattern. Moreover, people's ability to cope depends on the resources and assets at their disposal. In this region, high poverty levels among communities limit their capacity to adapt to landslides. Children, elderly and disabled persons are particularly incapacitated in emergency situations such as landslides. Early warning systems are vital for timely detection of landslide occurrences. Sometimes, relocating settlements may be one of the measures to avoid the devastating impacts of landslides. In the short run, however, social networks e.g. families, friends, neighbours and community groups provide affected households with emotional and material support.

4.2.3 Flooding

A flood is an overflow of water that submerges land which is usually dry[43]. Floods usually occur in low-lying locations in situations of above normal rains or as a result of rivers bursting their banks. This phenomenon is, in many instances, catalysed by silting of rivers, reclamation of swamps and blockage of drainage channels. In the Mt. Elgon region, flooding is a localized event that occurs fairly regularly in flood-prone locations. In order to map the locations and extent of flooding in this region, a flood susceptibility model was developed following the methods described in Box 4.4.

Box 4.4. Method for deriving the flood susceptibility model (Figure 4.13)

Flood susceptibility was modelled through a combination of several map layers in ArcGis. The process is described below:

Creation of Soil LandUse Risk Map Layer

The landuse layer obtained from GlobCover data downloaded from http://ionia1.esrin.esa.int/ via EumetCast e-station was modified by adding flood risk soil factors for the respective land use type. The soils layer was modified by adding the hydrologic class for each soil unit. The modified landuse and soils layers were then modified to obtain a "soiluse" layer. A flood risk field was then created and populated with the following values:

Class	Values
3	>70
2	40-70
1	<40

The common boundaries in the "soiluse" layer were then dissolved using the values in the flood risk field and the result saved as the Soil_LandUse_Risk_Map layer.

Creation of Rainfall Risk Map Layer

NASA Tropical Rainfall Measuring Mission (TRMM) data were downloaded from ftp://trmmopen.gsfc.nasa.gov/pub/gis and processed to give a rainfall layer. The resulting rainfall layer was then converted into a GRID layer which was later reclassified into a rain risk field using the following rainfall range of values:

Rain risk	Value
3	>60 mm
2	25 – 60 mm
1	<25 mm

The reclassified GRID layer was then converted to a vector layer. The common boundaries were then dissolved using the values in the rain risk field and the result saved as Rainfall_Risk_Map Layer.

Creation of Slope Risk Map Layer

NASA Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data were downloaded from ftp://e0srp01u.ecs.nasa.gov/srtm/version2/SRTM3/ and processed into a DEM TIN layer which was then converted into a GRID slope layer. The GRID slope layer was then reclassified into a slope risk field using the slope ranges shown below:

Slope risk	Slope Range (%)	Slope Range (^{0})
6	< 0.1%	< 0.06^0
2	0.1% - 0.5%	0.06^0- 0.3^0
1	> 0.5%	> 0.3

In order for the flood risk model to be based solely on flood levels not on velocity, weights (as shown above), were assigned such that slopes of less than 0.1% were favoured. Under natural conditions, flood storage is more likely to occur on such flat slopes than ones with the higher values. The reclassified GRID slope layer was then converted to a vector layer. The common boundaries were then dissolved using the values in the slope risk field and the result saved as Slope_Risk_Map Layer.

42 Personal communication: Agnes Mukoya, Uganda Red Cross Official, Bulambuli district.

43 Ozga-Zielinska, M. (1989). Droughts and floods-their definition and modelling. New Directions for Surface Water Modelling. IAHS Publication No. 181, pp. 313-322.

Creation of Flood Risk Map Layer

The Soil_LandUse_Risk_Map layer was overlaid with the Rainfall_Risk_Map Layer and saved as Soil_LandUse_Rainfall_Risk Layer. This layer was then overlaid with the Slope_Risk_Map layer to give the Overall_Risk Layer. A new field (named Overall_Risk field) was therefore created and populated with the following expression: Overall_Risk = Soil_LandUse_Risk_Map layer + Rainfall_Risk_Map layer + Slope_Risk_Map layer. The boundaries of the Overall_Risk layer were then dissolved using the values in the Overall_Risk field. A new Risk_Level field was thereafter created and populated with values from the Overall_Risk field as shown below:

Risk_Level	Overall_Risk Range
3	> 9
2	7-9
1	< 7

Based on the Risk_Level classification, a Flood_Risk field was created and populated as follows:

Flood_Risk	Risk_Level Value
High	3
Medium	2
Low	1

The resulting Flood_Risk field was rasterised and saved as a Flood_Risk_Map Layer.

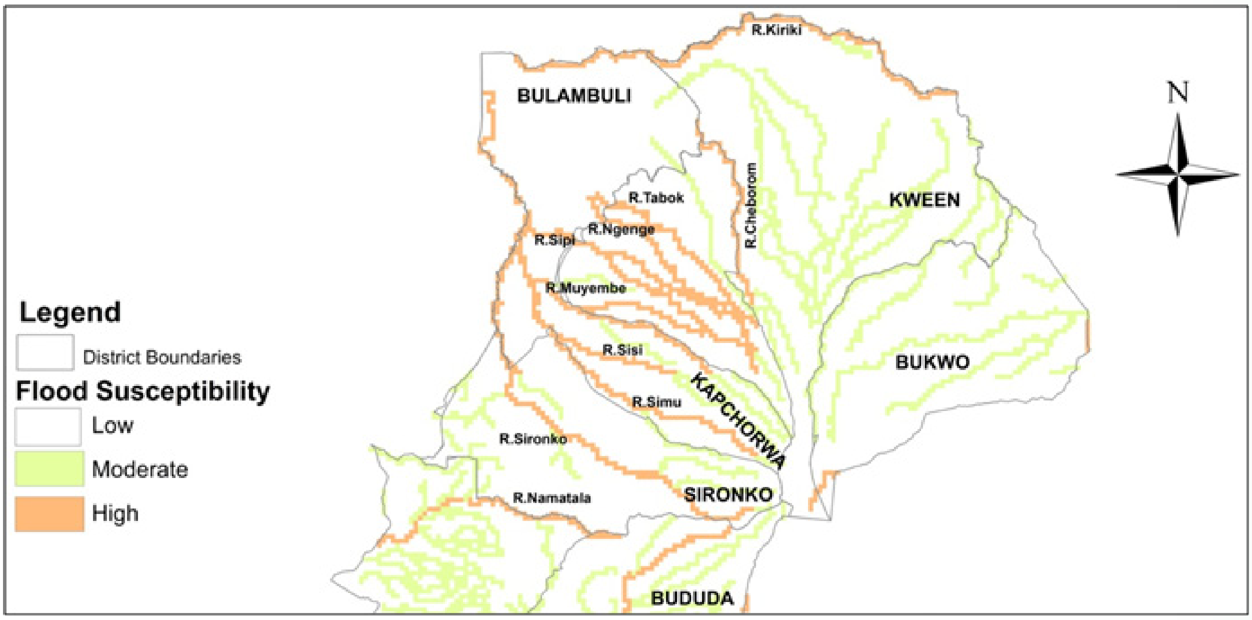


Figure 4.14. Flood prone areas in the Mt. Elgon region *Source: Mt Elgon VIA 2013*

Scientific and community observations for the last 10 to 15 years in Mt. Elgon region have reported increased rainfall resulting in flash floods[44]. Under current conditions, flooding in this region is closely associated with the drainage system (rivers and streams) in mid and upslope areas (Figure 4.14).This implies that locations along riverbanks are increasingly exposed to flooding. The courses of rivers Sironko, Namatala, Simu, Sisi, Ngenge, Cheborom, Kiriki, Tabok, Sipi and Muyembe are particularly prone to flooding. Specific locations with high flood incidence include Cheringir valley, Tuyobei, Kaibeyos, Sikwo, Seretyo, Kaimareng, Moroto, Sundet and Cheborom in Kween district; Mutyoro and Chebchebai streams in Kapchorwa district; Bukalu, Nabongo, Muyembe and Simu parishes in Bulambuli district; and Karawa, Buyi and Nakiwombe parishes in Sironko district.

Apart from destruction of homes and other household property, the impacts of flooding are more adverse in the health and agricultural sectors. Floods increase incidence of human diseases e.g. diarrhoea, typhoid and dysentery. In the event of flooding, water sources are contaminated making the water unsafe for domestic use. Flooding is perceived by communities as one of the climate-related hazards that the agricultural sector is particularly sensitive to. Maize and beans, which are major crops in this region, are seriously affected by flooding, directly impacting on people's livelihood. Crop failure due to flooding often translates into food shortage and increased poverty. Floods also constrain livestock production due to death of animals. And yet

44 Kansiime M.K, Wambugu S.K and Shisanya C.A. (2013). Perceived and actual rainfall trends and variability in Eastern Uganda: Implications for community preparedness and response. Journal of Natural Sciences Research, 3 (8): 179-194.

livestock are a major safety net from which households draw to overcome various setbacks. Moreover, since flooding usually results in destruction of roads and bridges (see Plate 4.2), access to and marketing of crop produce is hampered. Additional transportation costs are therefore passed on to farmers in form of lower farm gate prices, rendering farming less profitable.

Plate 4.2. Damage to infrastructure such as roads (above: main Mbale – Nakapiripirit road) is common during the rainy season.

Health and sanitation are among the elements of people's lives that are most sensitive to flooding. As such, availability of and accessibility to safe water, good sanitation and health services have direct implications on people's capacity to adapt to flood situations. Protected springs and boreholes are the major sources of safe water for communities and their capacity to withstand flooding will impact on large sections of the population (Table 4.1). Where the boreholes are dysfunctional e.g. in Kween district (Plate 4.3), households and communities' capacity to cope with flooding is compromised.

Box 4.5. Case study: Health and sanitation in Sironko district

According to the Sironko District Development Plan, malaria remains a major cause of illness accounting for 42.7% of outpatient attendance. There is a shortfall in the staffing of health facilities with only 41% of approved posts filled by trained health workers. In addition to understaffing, about 60% of these health facilities lack improved sanitation facilities. The situation is not any better in the communities. District hand washing coverage of 4% and pupil latrine stance ratio of 1:119 are indicative of a grim situation. An estimated 60% of the population is served by clean water, while sanitation coverage stands at 40% and 64% in rural and urban areas of the district respectively.

Source: Sironko District Development Plan 2010-2014

Table 4.1. Distribution of safe water sources in the study districts

Water sources	Number of water sources in district				
	Bulambuli	Kween	Sironko	Kapchorwa	Overall
Protected springs	233	126	383	272	1,014
Public stand posts	103	84	385	138	710
Deep hole	74	39	65	13	191
Yard taps for public use	60	2	59	33	154
Shallow wells	64	1	19	-	84
Rain water harvest tank	7	12	13	17	49
Kiosk	2	-	5	-	7
Valley tanks	-	-	1	-	1
Dams	-	-	1	-	1

Source: Directorate of Water Development, Kampala.

Availability and utility of health facilities has a strong bearing on the local communities' propensity to manage flood situations, at least in the short term. Access to health centres often requires drawing from financial reserves to cover transportation and medical expenses. Prescriptions are commonly obtained from private clinics as formal health facilities (Table 4.2) are usually inadequately stocked. Cash and/or access to credit systems are thus key determinants of people's capacity to survive in flood situations. Financially-constrained households resort to indigenous health strategies using herbal medicines whose effectiveness in curing flood-related water-borne diseases (e.g. cholera, typhoid and dysentery) is not yet proven.

Table 4.2. Distribution of health units in Kween district

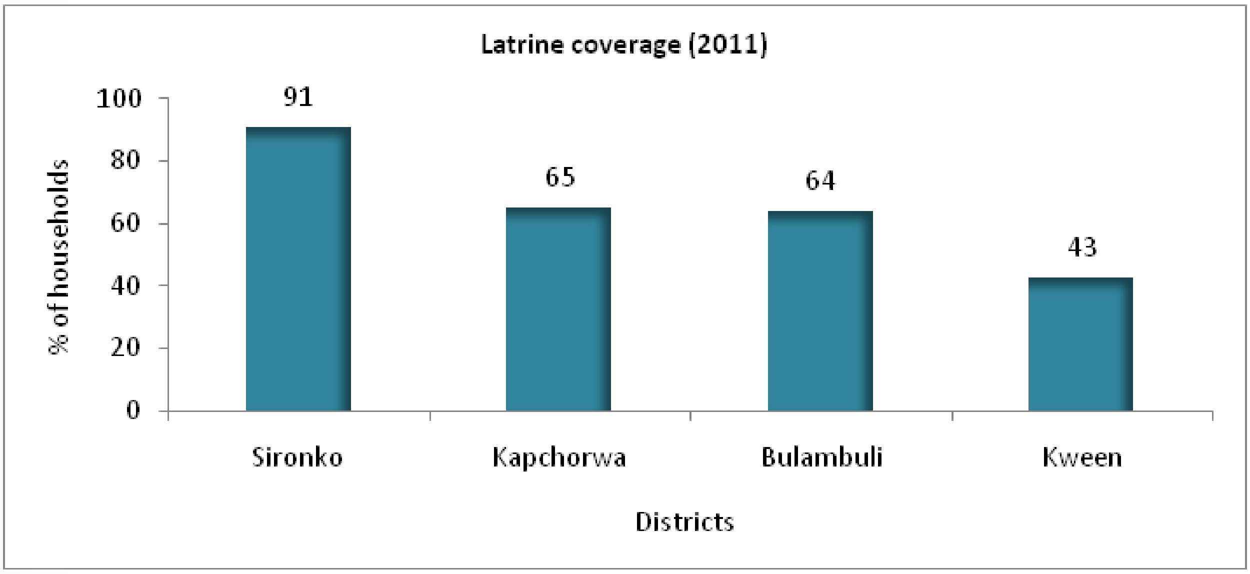
Sub county	Health Unit	Ownership	Level	No of beds
Binyiny	Atar	GoU	HC II	-
	Kapteror	NGO	HC II	-
	Binyiny	GoU	HC III	10
Kwosir	Benet	GoU	HCII	-
Benet	Terenboy	GoU	HCII	-
	Kongta	NGO	HCII	-
	Likil	NGO	HCII	-
	Chemwom	GoU	HCIII	4
	Mengya	NGO	HCII	4
Kaproron	Kaproron	GoU	HCIV	30
Kwanyiy	Kworus	GoU	HCII	-
	Kabelyo	NGO	HCII	2
	Kwanyiy	GoU	HCIII	4
Ngenge	Ngenge	GoU	HCIII	4
	Chepsikunya	GoU	HCII	-

Source: Kween District Development Plan 2010-2014

Adequate sanitation is indicative of reduced susceptibility of water sources to pollution due to flooding. In this assessment, latrine coverage is considered a key indicator of good sanitation. According to UBOS Statistical Abstracts 2012, latrine coverage is relatively high in Sironko (91%) and lowest in Kween (43%) (Figure 4.14). In this regard therefore, communities with lower latrine coverage (and thus low sanitation standards) depict low capacity to manage the effects of flooding.

In Mt. Elgon region, several attempts have been made as way of addressing the problem of floods. At household level, preventive measures include construction of canals around homesteads to protect houses from flood waters. Such canals are not effective though, in situations of severe flooding, as the flat terrain in most low-lying flood plains does not permit easy runoff. Interventions at community level are more long term and involve planting of trees along river banks, digging trenches (along riverbanks), de-silting rivers and planting Napier grass. The alternative response in the short term, however, is relocation of homesteads to safer areas. In communities located in the transition zone towards Karamoja, the trauma of past insecurity also renders migration a less acceptable option. Due to high population and poverty, however, few households can afford this option. In such situations, kinship and friendship networks, as elements of social capital, provide the only safety nets during flooding. As part of immediate response, affected individuals and households depend on contributions and sympathy of extended family and acquaintances. Where this reciprocal obligation is strong, community members are in better position to cope with the hazard (at least in the short term) than where they are deficient.

Plate 4.3. *Cases of disused boreholes, such as these are a common site, requiring the strengthening of institutions to maintain these infrastructures*



Source: UBOS Statistical Abstracts 2012

Figure 4.15.Household percentage latrine coverage in 2010/11

Social capital resources also form the basis upon which collective action is organised. Maintenance of communally beneficial infrastructure (e.g. bridges and roads) and natural resources (rivers and wetlands) is more likely to succeed when collectively done by entire communities within a landscape. Presently, linkages between communities sharing communal resources are limited. The divide between interests of upslope and down slope residents complicates collaborative arrangements even further. As such, interventions such as de-silting of rivers, digging trenches and planting trees along riverbanks, e.t.c. occur as part of exogenous adaptation strategies initiated by external agencies, rather than self-help undertakings from within the communities. In terms of capacity for long-term adaptation, this is a major limitation as home-grown strategies tend to be more sustainable than externally conceived interventions.

4.2.4 Soil erosion

Soil erosion is the detachment and transportation of soil particles by forces of water and/or wind[45]. Technically, soil erosion is one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization and soil acidity. Mt. Elgon ecosystem is exposed to several types of soil loss including sheet (surface flow across a wide section of land), rill (shallow and narrow tunnels), gulley (deep and wide tunnels) and landslide/mudslide[46]. This problem is influenced by factors such as rainfall intensity, wind speed, soil properties, slope angle, vegetation cover, population density and the capacity to invest in soil and water management practices[47]. Of these factors, population density is the leading cause of severe soil erosion as it forces farmers to cultivate steep, fragile slopes and river banks.[48] Loss of vegetation cover is another factor that has exacerbated the extent of soil erosion.

Box 4.5. Method for deriving the annual soil erosion model (Figure 4.16)

Soil erosion modeling and soil erodibility mapping were based on the Revised Universal Soil Loss Equation (RUSLE). The RUSLE is a revision of the Universal Soil Loss Equation (USLE), which was originally developed to predict erosion on croplands in the United States. With the revision, the equation can be employed in a variety of environments including rangeland, mine sites, construction sites, etc. The RUSLE is an empirical equation that predicts annual erosion (tons/acre/year) resulting from sheet and rill erosion in croplands. The RUSLE is factor-based, which means that a series of factors, each quantifying one or more processes and their interactions, are combined to yield an overall estimate of soil loss. It is the official tool used for conservation planning in the United States and many other countries have also adapted the equation. Although scientists at the United States Department of Agriculture plan to replace the model with the new Water Erosion Prediction Project (WEPP), the RUSLE is still very relevant and is particularly useful as a teaching tool. The equation is:

$$A = R * K * L * S * C * P$$

Where:

A = Annual soil loss (tons/acre) resulting from sheet and rill erosion. This is the predicted value resulting from the execution of the equation above.

R = Rainfall runoff erosivity factor. This factor measures the effect of rainfall on erosion. The R factor is a summation of the various properties of rainfall including intensity, duration, size, etc. It is computed using the rainfall energy and the maximum 30 minutes intensity (EI30).

K = Soil erodibility factor. The soil erodibility factor measures the resistance of the soil to detachment and transportation by raindrop impact and surface runoff. Soil erodibility is a function of the inherent soil properties, including organic matter content, particle size, permeability, etc.

L = Slope length factor. This factor accounts for the effects of slope length on the rate of erosion.

S = Slope steepness factor. This factor accounts for the effects of slope angle on erosion rates. All things being equal, higher slope values have greater erosion rates.

C = Cover management factor. Accounts for the influence of soil and cover management, such as tillage practices, cropping types, crop rotation, fallow, etc..., on soil erosion rates.

P = Erosion control factor. Accounts for the influence of support practices such as contouring, strip cropping, terracing, etc.

45 http://www.landfood.ubc.ca/soil200/soil_ngmt/soil_erosion.htm

46 Buyinza, M. and M. Nabalegwa, 2008. Socio-economic impacts of land degradation in the mid-hills of Uganda: A case study of Mt. Elgon catchments, Eastern Uganda. Environmental Research Journal, Vol. 2; 226 – 231

47 Bagoora, D. 1988. Soil erosion and mass wasting risk in the highland area of Uganda. Mountain Res. Dev. 8: 173 -182.

48 Soini E. 2007. Land tenure and land management in districts around Mt. Elgon. An assessment presented to Mt. Elgon Regional Conservation Programme. ICRAF Working Paper No. 49. World Agroforestry Centre, Nairobi, Kenya.

Erosion washes away top soil leading to nutrient depletion and decline in soil fertility. Declining soil fertility is a major hindrance to agricultural production as it results in reduced crop yields. To sustain agricultural production, farmers are compelled to apply fertilisers which greatly increases the cost of crop production. Given that most people depend on agricultural production for food and income, soil erosion is one of the factors contributing to poverty and food insecurity in Mt. Elgon region[49,50].

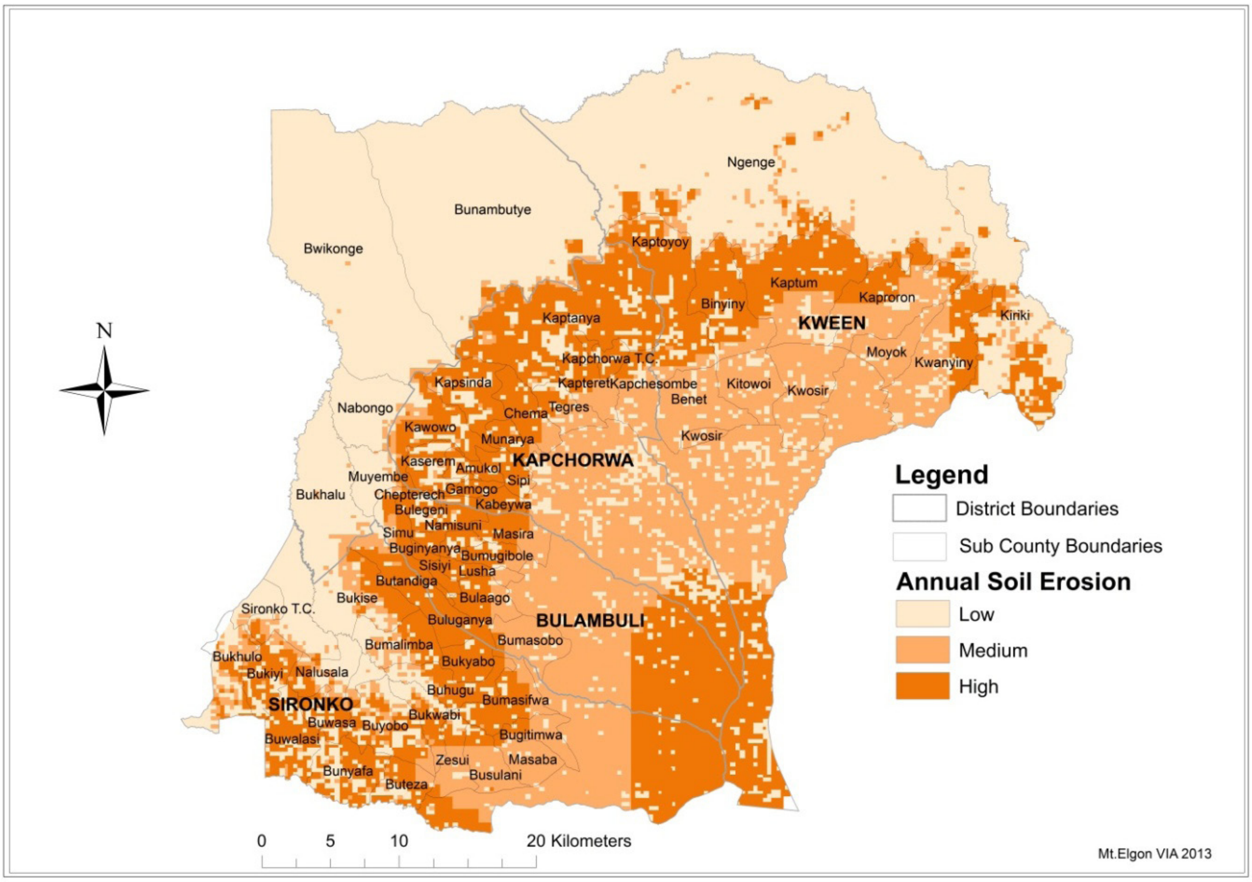


Figure 4.16. Soil erosion severity in the Mt. Elgon EBA project areas.

Besides the gradual decline in land productivity, soil erosion leads to formation of gullies and siltation of rivers and streams. Gullies are particularly destructive to roads and combine with the rough terrain to compound accessibility to remote areas. Siltation of rivers and streams on the other hand, leads to contamination of water sources due to increased impurity-load. In some instances, communities from upslope locations purchase organic manure from down slope areas where most of the fertile soils are deposited by erosion.

Mapping the locations and extent of soil erosion in this region followed the methods described in Box 4.5. There is close association between slope category and extent of soil erosion (Figure 4.16). Occurrence of soil erosion along the slopes of Mt. Elgon is also closely linked to rainfall run-off, slope length, slope steepness, soil type and cover management (vegetation). Areas most exposed to soil erosion in Mt. Elgon ecosystem are located along the middle and upper slopes. 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 (Figure 4.12 and Annex 4a).

Farmers' attempts to offset the problem of soil erosion involve a mix of preventive and corrective measures. Traditionally, farmers control soil erosion through terrace farming, planting of trees and perennial grass along terraces and river banks. Current practices for soil and water conservation in Mt. Elgon region include terracing, contouring, trenching, planting of trees (*Cordia* spp, *Sesbania* spp, *Calliandra* spp, *Albizia* spp etc.) and perennial grasses (Napier and elephant grasses), crop rotation, improved fallowing, mulching

49 Mugagga F., M. Buyinza and V. Kakembo. 2010. Livelihood diversification strategies and soil erosion on Mt. Elgon, Eastern Uganda. Environmental Research Journal. Vol. 40, Iss. 4.

50 Semalulu O., D. Kimaro, V. Kasenge3, M. Isabirye and P. Makhosi. 2012. Soil and nutrient losses in banana-based cropping systems of the Mt. Elgon hillsides of Uganda: economic implications. International Journal of Agricultural Sciences ISSN: 2167-0447 Vol.2 (9), pp. 256 – 262.

and cover cropping among others. Adoption of soil and water conservation practices is influenced by availability of farm tools, perceived fertility level of land parcels, location of land along the slopes, availability of extension services, financial and labour resources among others[51]. Soil productivity is enhanced by use of both organic and inorganic fertilisers. However, this practice is limited by small herd size and low incomes. Several civil society organisations[52] are working to enhance farmers' capacity to improve land management as a way of controlling soil erosion and its associated problems.

51 Barungi, D. H. Ng'ong'ola, A. Edriss, J. Mugisha, M. Waithaka and J. Tukahirwa. 2013. Factors influencing the adoption of soil erosion control technologies by farmers along the slopes of Mt. Elgon in Eastern Uganda. Journal of Sustainable Development; Vol. 6, No. 2.

52 Uganda Red Cross, Action Aid, Local Governments, Buginyanya Zonal Agricultural Research and Development Institute (BugiZARDI), National Agricultural Advisory Services (NAADS), IUCN, AT-Uganda, Northern Uganda Social Action Fund (NUSAF), UNDP-EBA, Uganda Women Concern Ministry, etc.

CHAPTER FIVE

CURRENT AND FUTURE SUPPLY OF ECOSYSTEM SERVICES

5.1 Introduction

The analysis up to this point has been restricted to past and current scenarios of climate change. Projections of future demand and supply of major ecosystem services in Mt. Elgon ecosystem depend on models that take into consideration the economic, social and environmental sustainability. Several climate predictions derived from global circulation models (GCMS) which have been used by the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report, are available that predict future scenarios based on these parameters. One such model is the Coupled Global Climate Model (CGCM3) of the Canadian Centre for Climate Modelling and Analysis[53,54].Climate change data for the Mt. Elgon region based on the CGCM3.1 model were downloaded from the World Bank Climate Change Knowledge Portal for Development Practitioners and Policy Makers (http://sdwebx.worldbank.org/climateportal/index.cfm) and used to generate Figure 5.1.

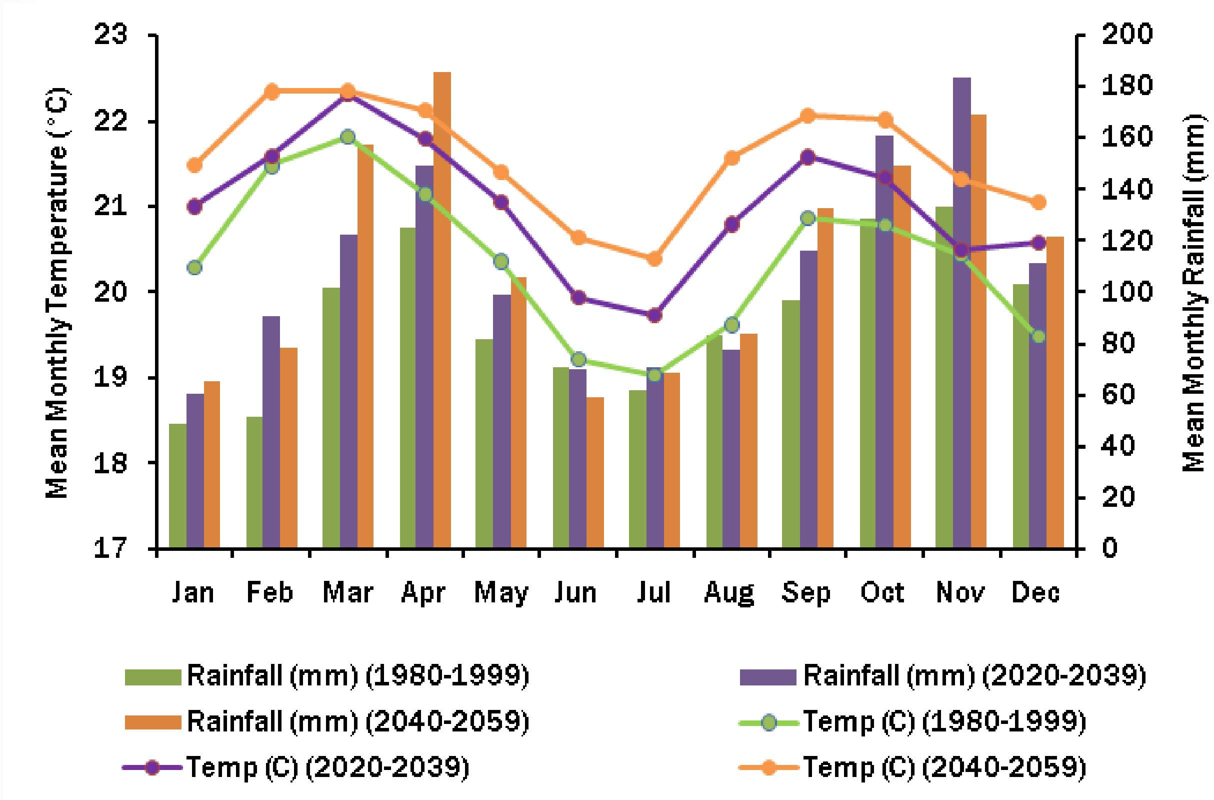


Figure 5.1. Global circulation model prediction of climate change in the Mt. Elgon region (2020-2039 and 2040-2059) based on mean historical climate record (1980-1999)

53 McFarlane, N.A., J. F. Scinocca, M. Lazare, R. Harvey, D. Verseghy, and J. Li(2005). The CCCma third generation atmospheric general circulation model. CCCma Internal Rep., 25 pp.

54 Scinocca, J. F., N. A. McFarlane, M. Lazare, J. Li, and D. Plummer (2008). The CCCma third generation AGCM and its extension into the middle atmosphere. Atmos. Chem. and Phys., 8, 7055-7074.

In Figure 5.1, data for the Mt. Elgon region are presented graphically to show the change in projected (future) climate (temperature and rainfall) for the periods 2020-2039 and 2040-2059. The monthly mean historical rainfall and temperature data have also been shown as a baseline for the projected climate scenarios. The graphical projections presented on Figure 5.1 are based on the B2 scenario of the model that 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. This scenario presupposes that government, the business sector, the media, and the public will pay increased attention to the environmental and social aspects of development. The model therefore shows an increase in temperature of 0.5-0.6^{0}C for the next 20 to 50 years. Rainfall will also increase by 18.7 mm over the next 20 years. In terms of seasonality, the present drier months of June, July and August are expected to receive even lesser rainfall (with reductions of up to 6 mm in the 2020-2039 prediction and 10.9 mm in the 2040-2059 model).

As already mentioned in chapter four, climate has a significant bearing on the natural processes as well as the manner in which humans interact with the environment and access ecosystem services. In addition, access to ecosystem services is strongly influenced by the manner in which physical environments respond to changes in climate. Given that agricultural activity in the Mt. Elgon region is strongly weather-dependent, changes in climate are likely to have significant effects not only on its nature, but also its contribution to people's livelihood. The following sections therefore discuss the future supply of ecosystem services in the context of the above observations, the B2 model scenario and in light of the future climate models (Figure 5.1).

5.2 Future supply of ecosystem services

5.2.1 Food provision

Food is one of the major provisioning ecosystem services in the Mt. Elgon ecosystem. The districts of the Mt. Elgon region are agricultural areas as is evident from the presence of extensive subsistence farmlands (Figure 3.2). Indeed, even at national level, subsistence agriculture provides over 78% of the food consumed in rural and urban areas[55]. Food production, however, is sustained by smallholder resource-poor farmers who comprise one of the categories most vulnerable to the impacts of climate change and extreme climatic events (e.g. floods, drought and hailstorms). The ecosystem's capacity to provide food is also vulnerable, considering that agriculture is predominantly rain-fed which increases sensitivity of crop yields to climatic variations.

Generally, the current scenario depicts food production in the Mt. Elgon ecosystem as sufficient. From the land degradation index map in Figure 5.2, it evident that most of the areas in the region are characterised as exhibiting very low to moderate land degradation which signifies that those areas still offer sufficient ecosystem services compared to the highly degraded areas. However, the available agricultural land is continuously cultivated due to land scarcity and communities attest to decreasing yield per unit area. In the short run, current food production can only be sustained by increased irrigation and fertilizer application. In the long run, however, because of ever increasing population, farmers may become more reliant on expansion of croplands at the expense of biodiversity. With future possibilities of converting natural habitats to agriculture being very limited due to their role in the climate regime, the supply of food in the Mt. Elgon ecosystem will become uncertain, in light of the higher temperatures and extending extremes in precipitation as predicted (Figure 5.1).

The future climate projections (Figure 5.1) point towards increased rainfall and temperature which would naturally support more food production. Optimistically, the changing climatic conditions, especially the reduction in rainfall during the months of June – August, may favour introduction of new food crops that may reinforce food security. Nonetheless, the rising temperature and increased variation in rainfall together with increasing intensity and frequency of climate hazards such as floods and droughts will subject soils to significant risk of climate induced degradation. This may ultimately impair crop productivity and render future food supply insufficient. Shifts in climate could also create conditions conducive for emergence of pests and diseases, resulting in reduced crop yields. The effects of climate change on food provision in the Mt. Elgon ecosystem gains more prominence when considering that cereals like maize, which is a widely popular staple are among the most affected (Box 5.1).

55 Mukwaya P., Bamutaze Y., Mugarura S., and Benson T. (2011).Rural – Urban Transformation in Uganda. Paper was prepared for the joint IFPRI and University of Ghana conference on "Understanding EconomicTransformation in Sub-Saharan Africa", held in Accra, Ghana, 10-11 May 2011.

Box 5.1 Maize: a case of future food supply in the Mt. Elgon region

Maize is the main cereal crop in the Mt. Elgon region where it also contributes considerably to household income. Thus, the projected climate scenario (Figure 5.1) could have a significant impact on maize production in the Mt. Elgon region. A significant increase in both temperatures and precipitation could have detrimental effects on maize yield,[56] thus causing food insecurity in the region. The overall impact on maize yield of a marginal increase in temperature simultaneous with a marginal increase in precipitation will be positive. However, the gain in maize yields begins to diminish as both parameters increase further[57]. An increase in mean precipitation naturally increases mean maize yields.

Conversely, in the case of Mt. Elgon region, increased rainfall will inevitably lead to increased floods down slope. Maize production in the down slope areas will be greatly hampered since it is susceptible to water logging. The maize plant, however, is quite adaptable to high temperatures compared to some crops such as beans58. Temperature increase will favour maize production more in the upslope areas which are currently experiencing cooler conditions. Nonetheless, high temperatures are highly associated with pests and disease outbreaks. This is because increased temperatures will reduce the latency period of many maize pathogens resulting into a higher number of generations per season. Already, the geographical distribution and predominance of Fusarium verticillioides has been linked to increasing temperatures within maize growing regions with the species likely to extend to currently cooler regions59. Higher average temperatures are also likely to expand the geographical distribution of insect-pests and their associated pathogens, with maize streak virus among the diseases likely to become more prevalent in the area[60].

These would be the expected results in case farmers continued to grow the same maize varieties in the same areas following the same agronomic principles. However, it is expected that research and plant breeding could mitigate many of the detrimental effects to enhance maize production and ensure food security in the region.

5.2.3 Fresh water provision

Fresh water supply is one of the major provisioning ecosystem services which make the Mt. Elgon ecosystem a vital water tower. As already noted in Chapter four, the supply of freshwater in various locations in Mt. Elgon ecosystem is generally high as exhibited by presence of wells, springs, bore holes, Gravity Flow Schemes (GFS), rivers, streams and wetlands. The peaks and natural forest of Mt. Elgon are important watersheds and /or catchments for the various fresh water sources.[61]

The functionality of different water sources (indicated in Table 5.1) is estimated at about 60% in Mt. Elgon ecosystem[9]. Water is mostly used for domestic purposes though water channelling for small scale crop irrigation in dry season is becoming increasingly common.

Table 5.1. Main sources of fresh water in Mt. Elgon ecosystem

District	Types of Water sources per district								Total
	Dam	Water Kiosk	Deep Bore Hole	Public Yard Tap	Public Stand Post	Rainwater Harvest Tank	Shallow well	Protected Spring	
Sironko	1	6	65	59	385	14	19	383	**932**
Bulambuli	-	2	74	64	115	5	64	277	**601**
Kapchorwa	-	-	8	33	138	17	-	277	**473**
Kween	-	-	39	2	84	12	1	126	**264**
Total	1	8	186	158	722	48	84	1,063	**2,270**

Source: Directorate of Water Development, Ministry of Water and Environment, 2013

56 Waha, K., Muller, C., Rolinski, S. (2013). Separate and combine effects of temperature and precipitation change on maize yields in sub-Saharan Africa for mid to late 21st century. Global and planetary change, 106: 1-12

57 Akpalu, W., Hassan, R.M.,Ringler, C. (2009).Climate Variability and MaizeYield in South Africa: Results from GME and MELE Methods, IFPRIDiscussion Paper No. 843 Washington, DC.

58 Jones, P.G., Thornton, P.K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global environmental change, 13: 51-59.

59 Torres, O. A., Palencia, E., Lopez de Pratdesaba, L., Grajeda, R., Fuentes, M., Speer, M. C., Merrill Jr, A.H., O'Donnell, K., Bacon, C.W., Glenn, A. E., and Riley, R. T. (2007). Estimated fumonisin exposure inGuatemala is greatest in consumers of lowland maize. J. Nutr. 137, 2723-2729.

60 Legrève, A. and Duveiller, E. (2010).Prevailing potential disease and pest epidemics under a changingclimate.In: Climate change and crop production (Reynolds, M.P. eds).CABI press, pp 263283.

61 Masiga M. (2012). Analysis of Adaptation and Mitigation Options. Territorial Approach to Climate Change in Mbale Region of Uganda Project.

The quality of water in Mt. Elgon ecosystem, however, is deteriorating due to increasing water pollution. The Uganda National Water Development Report (2005)[62] highlights key factors contributing to water quality deterioration as:

1. Soil erosion which is prevalent in Mt. Elgon ecosystem and is due to rampant forest degradation and/ poor agricultural practices that have led to increased sediment loads into the rivers, wetlands and streams. Increased sediment load in rivers and streams in Mt. Elgon ecosystem has led to water turbidity in some locations rendering water unfit for human consumption. Additionally, sand mining close to and/ or in water sources causes high turbulence and affects water quality.[63]

2. Drainage of wetlands for agriculture has greatly undermined the water buffering and filtration functions of wetland resources in Mt. Elgon ecosystem. This has contributed to the heavy solid loads observed in streams and rivers in this ecosystem as well as water-related conflicts as those between upslope and down slope communities and competition for water among cattle grazers in Kapchorwa district during the dry season[64].

3. Poor sanitation practices from including siting and construction of pit latrines are major contaminants of both surface and ground water sources in Mt. Elgon ecosystem. On-site pit latrines have contributed to increased spread of water borne diseases like diarrhoea, typhoid etc in this ecosystem.

Similar to most parts of Uganda, future provision of clean water is projected to deteriorate and the demand for fresh water to increase in the Mt. Elgon region[65,66]. A significant portion of the projected increase in fresh water demand will be towards the domestic and agricultural sectors. With rapidly growing human population, more pressure is expected on fresh water resources in this region. Correspondingly, the amount of clean fresh water will be effectively reduced by contamination from unprotected water catchments and poor sanitation, amidst increased rainfall intensity.

In low-lying parts of the ecosystem, fresh water availability may be compromised further by increased temperatures and higher rates of evaporation during prolonged dry spells causing more widespread water stress, drying up of wells and springs and thus shortage of fresh water[67]. Because of increased precipitation upstream, fresh water quality is likely to reduce due to flooding and increased sediment load into water sources from soil erosion. Increased precipitation will adversely affect surface water sources that are highly susceptible to contamination. However, increased precipitation may relieve water shortage through rainfall recharge. Groundwater recharge is a function of the amount and intensity of precipitation falling in a given area and is extremely sensitive to land use. Thus, inappropriate land management practices in Mt. Elgon ecosystem will affect ground water recharge given increased precipitation in the future.

Overall, Mt. Elgon ecosystem is endowed with fresh water resources to withstand the projected climate change without threatening the water resource base. However, the combination of climate-related drivers and non-climate stressors is projected to increase water stress in particular locations. Thus, future supply of fresh water in Mt. Elgon ecosystem is bound to decline given a number of causal factors. These include:

i) increasing population which will require more land resources thereby encroaching on river and stream banks, exacerbating siltation and ultimately affecting fresh water quality;
ii) increasing rates of deforestation likely to affect fresh water availability; and
iii) increasing use of agro-chemicals (herbicides, pesticides and fertilizers) to compensate for declining land productivity.

5.2.4 Soil Erosion Regulation

Soil erosion is a widespread form of soil degradation and poses severe limitations to sustainable agriculture. Erosion is influenced by the extent to which the soil is protected from the energy of the rainfall or surface runoff by the vegetative cover[68]. As such, natural ecosystems play a vital role in ameliorating increases in surface runoff by retaining soils. The ecosystem service

62 Uganda National Water Development Report – 2005. National Water Development Report: Uganda Prepared for the 2nd UN World Water Development Report "Water, a shared responsibility".

63 World Bank (2011) Background Report to Water Resources Country Assistant Strategy for Uganda, World Bank Country Office, Kampala, Uganda.

64 Kutegeka S., Nakangu B. and Bagyenda R. (2011). Local responses to the impacts of climate risks on maize, beans and coffee production in Uganda . A case study of Kacheera sub county in Rakai district and Kawowo sub-county in Kapchorwa district. International Union for Conservation of Nature (IUCN), Uganda Country Office.

65 Caffrey P., Finan T.,Trzaska S., Miller D., Laker-Ojok R., and Huston S. (2013). Uganda Climate Change Vulnerability Assessment Report. USAID African and Latin American Resilience to Climate Change (ARCC) United States Agency for International Development by Tetra Tech ARD, Arlington, VA.

66 Michael Jacobsen, Michael Webster ,Kalanithy Vairavamoorthy (eds.) (2012). The Future of Water in African Cities: Why Waste Water? Washington DC 20433 , International Bank for Reconstruction and Development / International Development Association or The World Bank.

67 Mbogga, M. (2013) Climate Profiles and Climate Change Vulnerability Assessment for the Mbale Region of Uganda May 2013. Shortened version of full report by TACC-UNDP.

68 FAO.2013. Natural Resources Management and Environment Department (http://www.fao.org/docrep/t0848e/t0848e-12.htm).

of erosion control depends mainly on the structural aspects of ecosystems, especially vegetation cover and root systems[69]. Areas requiring this service are those experiencing temporary or permanent reduction in the capacity of land to provide ecosystem goods and services (Figure 5.2).

Given the terrain, land cover types, intense rainfall and nature of soils, erosion in most parts of the Mt. Elgon ecosystem is generally high, especially in areas with high and very high land degradation (Figure 5.2). In addition, as population increases, more land is expected to be cleared for farming practices even on marginal steep slopes. Man-made accelerated erosion will likely increase as current vegetation cover is converted to cropland or deforested land[70]. As a result, soil erosion will be exacerbated by the probable increase in water runoff due to the increased rainfall amounts expected in future (Figure 5.1). Unless significant interventions are instituted, future projection is that soil erosion regulation functions of the Mt. Elgon ecosystem are to continue declining.

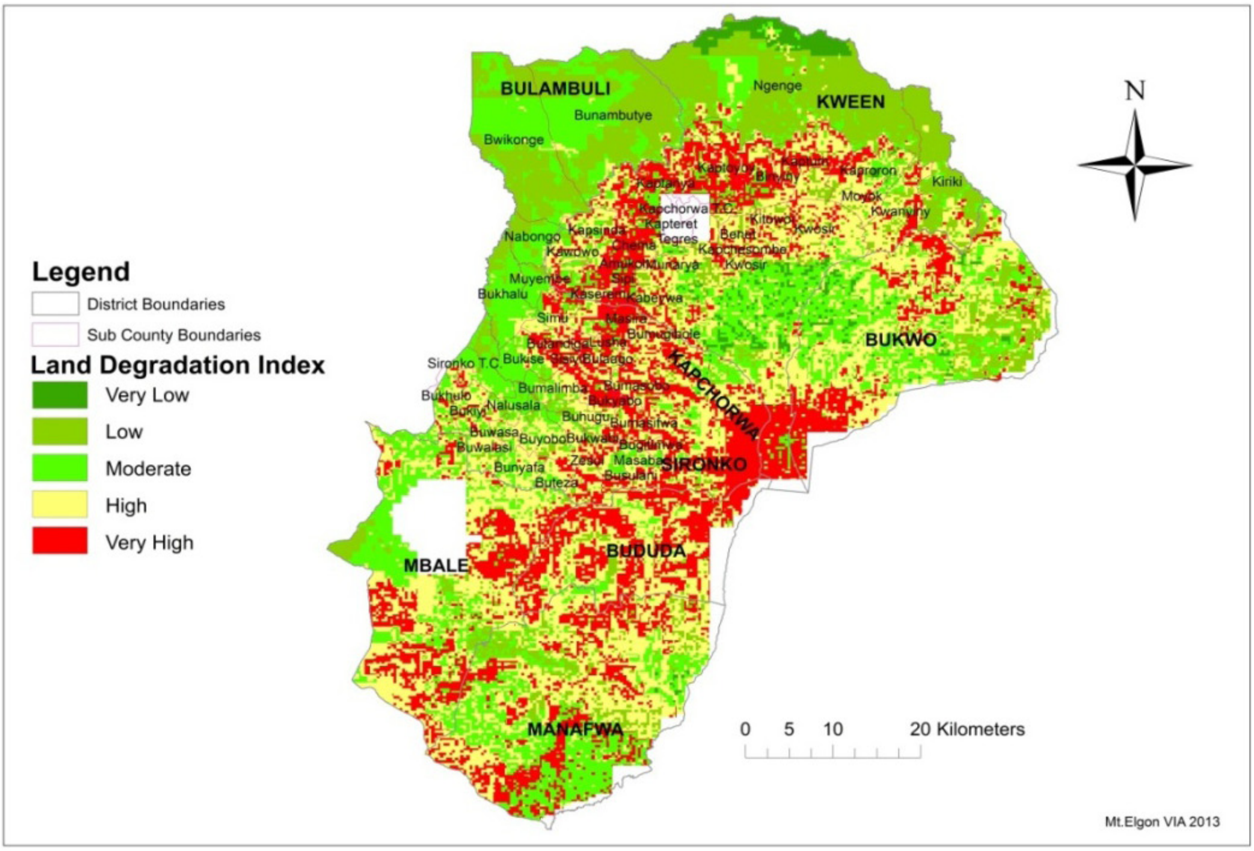


Figure 5.2. Current Land Degradation in the Mt. Elgon region

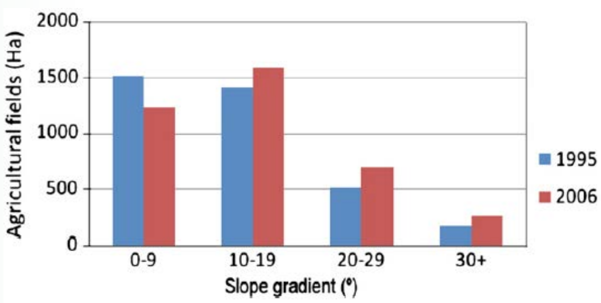


Figure 5.3. Expansion of agricultural fields onto critically steep slopes

(Source: F. Mugagga 2012)

Basing on the rainfall and temperature projections between 2020-2039 and 2040-2059, Mt. Elgon will have mean annual rainfall of between 60 mm and 200 mm and mean annual temperature of between 20°C and 23°C. Such conditions imply that soils in the ecosystem are likely to be subjected to slight chemical weathering[71]. Conclusions can then be drawn that increase in temperature per se, may not have serious effects on soil loss in the projected future other than producing a layer of potentially erodible disaggregated particles. It is the projected increase in amounts of rainfall that is likely to be the key factor which will subject this layer to soil erosion.

69 de Groot, R., M. A. Wilson, and R. M. Boumans. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41:393–408.

70 Zheng F., Tang., Zhang. and He X. (2002). Vegetation Destruction and Restoration Effects on Soil Erosion Process on the Loess Plateau. Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, Northwestern Sci-Tech University of Agriculture and Forestry, Yangling, Shaanxi, China (http://tucson.ars.ag.gov/isco/isco12/VolumeII/VegetationDestructionandRestoration.pdf)

71 Peltier, L. 1950. The geographic cycle in periglacial regions as it is related to climatic geomorphology. Ann. Assoc. Amer. Geog. 49, 214-36.

5.5 Flood Regulation

Flooding is one of the main climate hazards in the Mt. Elgon region. It is currently prevalent along major drainage systems and in low-lying plains where flood waters accumulate from places at higher elevation (Figure 5.4). Flooding, however, is not an entirely localised occurrence but is inextricably linked to off-site land use processes upstream. The situation is aggravated by unsustainable farming practices (especially over-cropping of marginally productive land) and deforestation on the upper parts of the watershed[72]. As such, people in the lower catchments are often taken unawares when floods occur following heavy rainfall in upper catchments, while the lower plains receive relatively low amounts. Changing climate conditions and land use in upper slope catchments are expected to determine the extent to which the Mt. Elgon ecosystem will be able to regulate flooding.

Figure 5.4. Flooded maize gardens in Muyembe, Bulambuli district. Farmers in lower catchments are often taken unaware by floods following heavy rainfall in upper catchments.

The Mt. Elgon ecosystem's capacity to regulate flooding in future will be of incremental importance considering that increasingly large numbers of people are affected by floods. This is due to increasing settlement in or close to wetlands to ease accessing them for a living[73]. Flood situations in Mt. Elgon ecosystem are characteristically defined by prolonged or high intensity rainfall in areas which experience short but heavy thundershowers. Based on future climate projections, the Mt. Elgon region is expected to receive more rainfall (18.7 mm) in the next 20 – 50 years compared to current levels. With both peak rainy seasons registering higher rainfall in March – April and October – November, susceptibility to flooding is expected to increase during such months unless flood regulation measures are enhanced. According to the future climate change scenarios, a significant increase in stream flow has been predicted for the region in the coming decades as a consequence of increased rainfall amounts.

One of the major components of the ecosystems that contribute to enhancement of flood regulation is

72 Githui F., (2008). Assessing the impacts of environmental change on the hydrology of the Nzoia catchment, in the Lake Victoria Basin. PhD Thesis submitted to the Department of Hydrology and Hydraulic Engineering Faculty of Engineering, Vrije Universiteit, Brussel, Pleinlaan 2 1050 Brussels.

73 IUCN (2011) Local responses to the impacts of climate risks on maize, beans and coffee production in Uganda: A Case study of Kacheera subcounty in Rakai district and Kawowo sub-county in Kapchorwa district. International Union for the Conservation of Nature (IUCN), Uganda Country Office, Kampala.

maintenance of land cover such as forests. Forested mountain areas are important not only as water sources, but also for their capacity to absorb and moderate the consequences of flooding and increased water flows[74]. Based on models of forest cover change in Mt. Elgon region, deforestation is predicted to increase, following trends that have been exhibited in the past (Figure 5.5). Land-use changes like the conversion of forested areas to agricultural land are anticipated to lead to further elimination of natural flood retention capacities in upstream areas. Naturally forested areas were anticipated to shrink by 38% between 1995 and 2032[75], implying a decline in flood regulation services from the Mt. Elgon ecosystem.

The extent of flooding is likely to increase further as a result of anthropogenic changes in the catchment's areas through human settlement and other forms of interference with natural drainage. Expansion of agricultural fields onto steeper slopes is expected to continue, along with its associated effects on the quantity and rate of surface runoff, and the rates of erosion and sediment transport. Deposition of sediments by flowing water reduces the capacity of rivers and streams to carry flood water. In effect, the increase in precipitation will accelerate problems of soil erosion and siltation in Mt. Elgon region, causing more rivers and streams to overflow their banks. This is exacerbated by the absence of buffer zones along most rivers and streams as result of replacement of natural vegetation with annual croplands and grazing land[76].

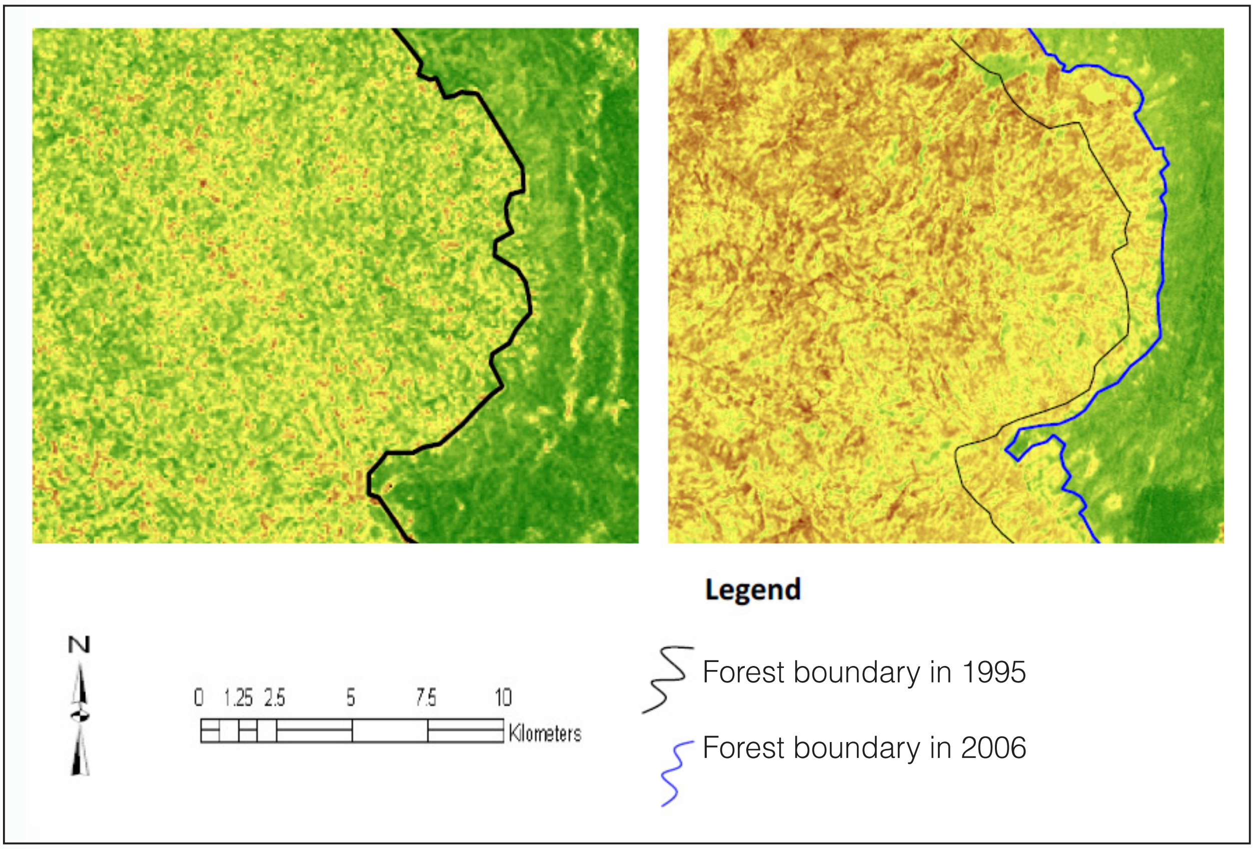


Figure 5.5. Illustration of the extent of forest encroachment between 1960 and 2006 *Source: Mugagga (2011).*

Some efforts by local governments and civil society agencies aimed at putting in place flood control strategies e.g. tree planting and riverbank management along major rivers like Atari and Sipi are already ongoing. It is likely that as the problem of flooding becomes more recurrent, such interventions will be accorded higher priority. A combination of on-site and off-site activities needs to be guided by hydrological delineation of river catchments within the Mt. Elgon ecosystem (Figure 5.6, Table 5.2).

74 (SwedBio, factsheet).

75 UNEP (2004). Global environment outlook scenario framework. Background paper for UNEP's third global environment outlook report (GEO-3). Nairobi: United Nations Environment Programme.

76 IUCN (2011) Local responses to the impacts of climate risks on maize, beans and coffee production in Uganda: A Case study of Kacheera subcounty in Rakai district and Kawowo sub-county in Kapchorwa district. International Union for the Conservation of Nature (IUCN), Uganda Country Office, Kampala.

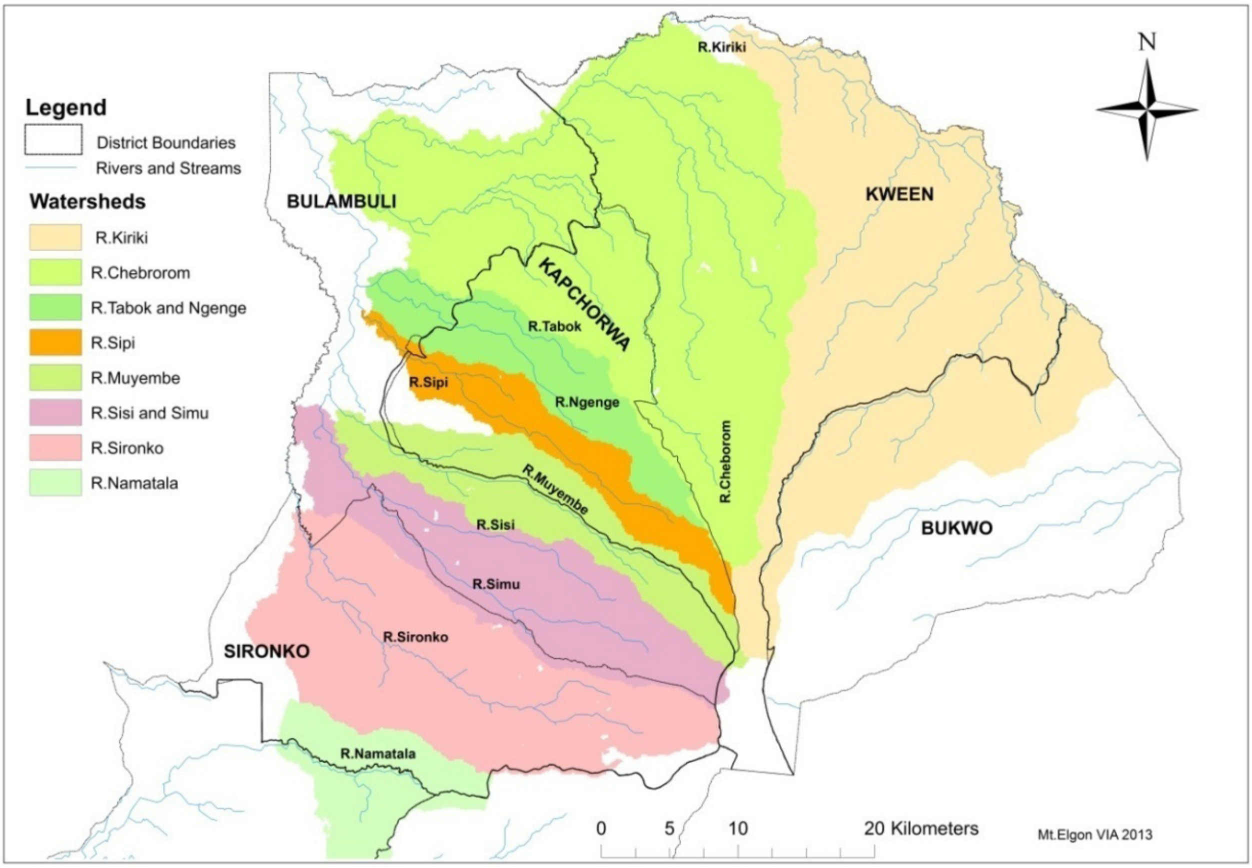


Figure 5.6. Delineation of major watersheds in the Mt. Elgon region

Table 5.2. Area, altitude and slope characteristics of major watersheds

Watersheds	Area (Ha)	Lowest point(m asl)	Highest point (m asl)	Average(slope (%)
Kiriki	92,475	1,091	4,107	11.2
Chebrorom	66,896	1,047	3,458	11.0
Tabok and Ngenge	11,322	1,054	3,165	13.2
Sipi	9,255	1,055	3,611	16.5
Muyembe	14,787	1,068	4,172	19.5
Sisi and Simu	20,343	1,066	4,183	22.4
Sironko	31,404	1,091	4,265	19.1
Namatala	10,035	1,191	2,353	20.3

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Links between ecosystems and people

Ecosystem services play a central role to the livelihood of communities in the Mt. Elgon region. Particularly important to local communities among the ecosystem services are food, fresh water, fibre, water purification, air quality, flood regulation, windbreakers, soil fertility and recreational values. Other important ecosystem services include soil erosion and landslide regulation, pollination and seed dispersal. Several categories of beneficiaries exist most prominent among which are farmers especially women, traders, tourist guides, traditionalists and herbalists.

The provision of ecosystem services depends on the condition and functioning of ecosystems. Thus, the status of given ecosystems is closely linked to the lives of people that depend on them for survival. Many ecosystems, including farmland, forests, streams, rivers, swamps, among others are under increasing threat of degradation or modification in the face of population increase and climate change.

Supply of regulatory services like soil erosion control is decreasing given unsustainable cropping practices that characterize the farming systems on Mt. Elgon. As a result, the supply of fresh clean water, especially to the downstream communities is threatened by soil erosion and siltation. Declining land productivity implies reduction in food supply alongside fast increasing human population. The resultant food gap has prompted expansion of agricultural frontiers to fragile parts of the ecosystem e.g. riverbanks, swamps and steep slopes. Inevitably, interference with slope stability has in recent years led to increased magnitude of various hazards e.g. soil erosion, landslides, siltation and flooding.

6.1.2 Vulnerability to climatic hazards

The main predisposing factors that determine people's exposure to climate-related hazards and perturbations are elevation and population density. Flooding, extended dry spells, landslides and soil erosion are considered the most pronounced climatic hazards in the region. Flooding is mainly associated with low lying areas and riverbanks. Locations most prone to flooding are situated along rivers and streams that often break their banks due increased rainfall upslope. Flooding mainly affects agriculture and transport through washing away of crop gardens and transport infrastructure e.g. roads, bridges and culverts.

Soil erosion on the other hand is more wide spread and sweeps across vast parts of the upper and middle slopes. Farmlands are predisposed to excessive water runoff as a result of increased exposure of soils due to continuous cultivation combining with increasingly torrential rainfall. Agriculture, food security, income, water and sanitation are the most sensitive and thus affected sectors as far as soil erosion is concerned. But agriculture being the mainstay of local livelihood, poor crop performance translates into both food and income insecurity.

Landslides are localised events that occur in highly prone areas. These are concentrated along the mid slope areas especially in Sironko and Bulambuli. Human settlement, agriculture, water and sanitation are usually most affected when landslides occur. Strong attachment to the region and shortage of land elsewhere are major reasons for people in landslide prone areas not readily relocating to safer places. Increasing precipitation due to climate change is expected to trigger increased frequency and magnitude of landslides especially in highly prone areas.

Drought as defined by global models as a very rare possibility in the Mt. Elgon region given the amount and duration of the rains. What is experienced in this region may therefore be referred to as extended dry spells rather than drought per se. This phenomenon is more pronounced in the low-lying areas especially in Kween and Bulambuli districts. Extended dry spells lead to poor agricultural performance and compromise food and income security of households and communities. They are closely linked to increased cultivation of wetlands where water stress is least felt during such periods. Water shortage during dry spells also worsens sanitation standards.

6.2 Recommendations

This assessment recommends a set of adaptation options for the project to promote as way of offsetting the various impacts of climate change. These options include climate-smart agricultural practices, fresh water management, livestock management, forestry management,agroforestry, wetlands management, sustainable energy options, infrastructure, social and public services, and institutional and regulatory reforms. Others are market and value addition, alternative income generating activities, knowledge systems, population control, collective action as well as farm and land use planning.

6.2.1 Climate-smart agricultural practices

Climate-smart agricultural interventions are recommended to address the problem of soil erosion that is projected to worsen with increased torrential rainfall due to climate change. Recommended interventions may be categorized into preventive and curative. Preventive measures include conservation tillage, fallow systems, terracing, contour banding, mulching, use of cover crops and farm planning. Use of organic manure, composting, use of legumes and crop rotations/diversification on the other hand, are recommended in replenishing fertility of degraded soils. Target areas for interventions in this category include vast parts of upslope and mid-slope Sironko and Kapchorwa, as well as scattered locations in upslope Bulambuli and Kween districts where soil erosion is prevalent.

The other climate-smart agricultural interventions seek to offset effects of anticipated extended dry spells on agriculture. These include introduction of improved crop varieties that withstand conditions of water stress. Conversely, micro irrigation schemes are recommended as the other solution to the same problem. While climate smart agricultural interventions are suitable for the entire region, areas that experience extended dry spells e.g. Ngenge, Kiriki, Kaproron (Kween), Bukhulo, Sironko TC (Sironko), and Bukhalu (Bulambuli) are considered suitable sites for this category of interventions so as to enhance the adaptive capacity of agricultural systems. Other interventions focus on development of integrated agricultural systems for nutrient management and pest and disease management.

6.2.2 Fresh water management

In fresh water management, rainwater harvesting, riverbank management, gravity flow schemes and protection of springs are recommended. Gravity flow schemes and protected springs are instrumental in addressing the high demand for water during extended dry spells. Drought prone areas e.g. Ngenge, Kiriki, Kaproron (Kween), Bukhulo, Sironko TC (Sironko), and Bukhalu (Bulambuli) tend to be hit hardest by water shortage and therefore need to be targeted. While rainwater may be harvested and stored for the same purpose, the use of this practice is especially recommended in upslope and middle slope locations given that it reduces on the volume of water runoff, subsequently lowering severity of soil erosion, siltation and flooding down slope. As measures of flood prevention to ensure clean water supply to down slope communities, this assessment recommends a combination of rainwater harvesting and riverbank management especially in areas outside MENP and relatively gentle middle slopes where riverbanks (such as those rivers Atari and Sipi,and Mutyoro and Chebchebai streams)lack sufficient buffer from livelihood activities (e.g. agriculture, sand mining, diversion of waters etc.).

Plate 6.1. *An example of a very active and functioning gravity flow scheme at Sipi, Kapchorwa district.*

6.2.3 Livestock management

Interventions recommended in livestock management include zero grazing; livestock breeding; livestock diversification; support supply of livestock pesticides and fodder bank management. Zero grazing and fodder bank management are recommended as strategies for enhancing fodder security especially during extended dry spells, in intensive livestock production systems typical of the upper and middle slopes. Degradation due to overgrazing and conflicts over access to wetlands by grazers stand to be minimized where intensive rather than open livestock production systems are predominant.

Other interventions in livestock management seek to increase resilience of livestock systems to novel challenges especially those related to emerging pests and diseases. Providing support to farmers to enable them better access to livestock pesticides is a short-term option, sustainability of which though may be questionable. Thus, it is recommendable that farmers diversifying their livestock enterprises to reduce on the risk of their entire stock being decimated by disease outbreak. Introduction of improved livestock breeds though long-term, may provide more guarantee for enhancing resilience of livestock production system in Mt. Elgon region in the face of climate change. Livestock diversification and pest-and-disease control interventions are relevant across the entire landscape.

6.2.4 Forestry management

Forestry management interventions recommended include Collaborative Forestry Management (CFM); avoided deforestation and reforestation/afforestation. Given the long gestation period of forestry interventions strategies like Collaborative Forestry Management (CFM) and avoided deforestation which build on management of already existing stands provide more promise in the short to medium term. Sub counties in close proximity to MENP are the most suited for CFM. Collaborative forest management reduces unsustainable extraction of forest resources and minimizes conflicts between conservation agencies and local communities. Avoided deforestation on the other hand is recommended to offset degradation arising from changing land uses on private lands and woodlands. Protecting existing pockets of woodlands in Kaptokoy, Kaptanya (Kapchorwa), Ngenge (Kween), Bwikonge and Bunambutye (Bulambuli) from conversion to agricultural land may be considered in this regard.

Given the enormous pressure arising from increase in human populations, efforts seeking to enable the Mt. Elgon system regain its previous tree cover may have to stretch beyond simple natural regeneration to include reforestation and afforestation. In this respect, a delicate mix of indigenous species and fast-growing exotic species is necessary in order to balance resource users' pressing needs for tree products and services; and long-term tree species diversity concerns.

6.2.5 Agroforestry

Recommendations in agroforestry include tree planting and management, home-gardens, live fencing; fodder banks; hedgerows; alley cropping; soil and water conservation as well as woodlots. Agroforestry systems are more resilient in the face of climate change due to the interactive synergies enjoyed by the various components of the system. Spatial technologies e.g. home-gardens, hedgerows, live fencing, alley cropping provide opportunities for introducing trees on smallholder farms without significantly compromising crop and livestock enterprises. This threat can be reduced further by employing appropriate tree management practices like tree pruning.

Plate 6.2. *Planting of woodlots such as these would greatly ameliorate the problem of soil erosion, landslides and lack of firewood*

The use of fodder banks and soil and water conservation techniques are recommended as measures for enhancing productivity of the livestock and crop enterprises respectively. As a whole, Agroforestry addresses salient impacts of soil erosion (e.g. low crop yields, food and income insecurity) and extended dry seasons (e.g. water stress on croplands and fodder shortage). Areas akin of these hazards are thus appropriate sites for promoting Agroforestry interventions that address such problems. The multi-facetted nature of Agroforestry also renders it applicable to a wide range of farming scenarios across the entire landscape. Besides associated livelihood benefits, enhancing productivity and resilience of farmlands can be expected to reduce encroachment on protected areas, yielding ecosystem benefits with time.

6.2.6 Wetlands management

Several interventions are suggested in wetland management e.g. sustainable wetland agriculture; demarcation, mapping and gazettement of wetland areas; restoration of degraded wetland areas through natural regeneration; enhancing the enforcement and governance systems through use of bylaws; and institution of wetland management plans. These primarily address flooding and drought. Sustainable wetland agriculture is proposed in recognition of the increasing conversion of wetlands into farmlands especially in the lowlands. As lasting solutions are sought, there is need to ensure in the short term, that cultivation at least, does not have adverse negative effect on the wetland systems. Practices e.g. bush burning and diversion of water channels, which are disruptive of wetland habitats need to be restricted. Ultimately, demarcation, mapping and gazettement of wetlands are considered a daunting but necessary undertaking for the restoration of degraded wetland. However, declaring boundaries per se may not suffice without streamlining and strengthening governance systems through which compliance is enforced.

6.2.7 Sustainable energy options

Several options are available in support of ensuring sustainable energy. Among these, the use of unconventional energy sources like biogas from manure waste; energy crops; micro hydroelectric power schemes and wind mills are recommended. It is noteworthy though that sustainability of these energy sources needs to be guaranteed before committing substantial capital investments into their development. Where possible, parallel complimentary schemes are recommended e.g. zero grazing to support biogas production, or at a slightly more ambitious scale, collaborative forest management to ensure protection of water catchments and enable hydro-electric power generation. The use of energy saving technologies e.g. Hydraform is also recommended as way of reducing dependency on fuel wood for brick burning to support the fast-growing construction industry. Promotion of energy saving cooking stoves is also recommended throughout the entire region as a strategy for reducing household fuel wood consumption.

6.2.8 Infrastructure, social and public services

Interventions recommended in this regard include development of infrastructure both for ensuring prior warning about occurrence of climatic extremes as well as those that can withstand these events. Instituting early warning infrastructure along riverbanks for instance is recommended as an alert mechanism against impeding floods. Even then, the capacity of sensitive infrastructure to withstand climatic hazards needs to be enhanced in readiness for tough times. Development of systems for ensuring regular maintenance of roads, bridges and culverts is worthy consideration. At a lower community level, this may as well involve maintenance of accessibility ladders that residents depend upon to traverse the difficult rugged terrain in order to access water sources, markets, schools and other social services.

6.2.9 Institutional and regulatory reforms

As far as institutional and regulatory reforms are concerned, institutional strengthening and formulation of community bylaws is important. Existing networks like the Mt. Elgon Stakeholders' Forum that seek to coordinate efforts of various actors need to be strengthened, as these are likely to outlive the lifespan of individual projects. Such networks also provide vertical linkages to macro-level institutions that influence policy and may enable communities to access rare resources that are necessary in adapting to climate change. They also facilitate landscape-wide interventions that deliver higher environmental dividends than scattered farm-level attempts.

Strong institutions are closely linked to enforcement of regulatory mechanisms. Putting in place community bylaws to regulate land use behaviour of residents (e.g. in soil and water management, riverbank conservation, tree growing etc.) is recommended along with supportive institutions to effect these regulations and where necessary reprimand non-compliance.

6.2.10 Market and value addition

There is need to locate strategic markets and add value to local produce as a way of increasing market access. Promotion of bulk marketing; post harvest management as well as formation and strengthening of farmer-based marketing organization are considered plausible interventions. Given that the majority are smallholder farmers, and hence can hardly influence the market, there is need to enhance the functionality of bulking centres and bulk marketing through grass root farmer organizations. Thus formation and strengthening of farmer-based marketing organization should be a priority. In addition, post-harvest management through community-based storage facilities i.e. granaries, silos, community warehouses etc. can enhance storage for improved sales.

6.2.11 Alternative income generating activities

Most of the people in the Mt. Elgon region are resource poor smallholder farmers who largely depend on agriculture and extractive forestry. There should be deliberate efforts to enhance household incomes through alternative income generating activities. Prospective income generating activities include:

1. Community based tourism: aimed at improving the relationship between the park authorities and people as well as enhancing natural resource management and livelihoods. The benefits of community based tourism can be numerous, ranging from economic, environmental and socio-cultural to the building of skills and empowerment of local people.
2. Small business development: where farming is no longer feasible off-farm employment opportunities should be supported. Developing and supporting small business development would be an appropriate strategy to boost off-farm sources of income and enhancing adaptive capacity of smallholder farmers.
3. Bee keeping: Bee keeping is very amicable with ecosystem management and can greatly enhance household income. Bee keeping interventions would be highly fitting of the areas adjacent to the park since already Mt. Elgon bee keepers communities are allowed to practice bee keeping in the park. Such communities should be organized into groups and supported with equipments such as improved bee hives as well as in packaging and branding their honey so as to attract good return on the local and national market.

6.2.12 Improved environmental knowledge systems

This assessment recommends strengthening of disaster early warning systems; extension services and sensitization as strategies for enhancing knowledge systems in order to improve people's adaptive capacity to climate change impacts. Early warning systems against floods, landslides, drought, excessive rains etc. are recommended to reduce the magnitude of human casualties when these events occur. Even in the absence of such extremes, land users are better placed to use preventive measures through extension and sensitization. This assessment further recommends strengthening people's capacity for building upon the knowledge acquired from the early warning, sensitization and extension efforts. Part of enriching knowledge systems should involve inquiry into land users incentives and disincentives for pursuing prescribed interventions and adaptation measures.

6.2.13 Population control

Exposure to climatic hazards is closely linked to the population scenario in the Mt. Elgon region. As such, suggestions are often fronted seeking to address the problem from the root cause that happens to be population increase. This assessment weighs two options in this regard. First, in the short term, attempts may be made to relocate people from highly exposed locations. This though often meets resistance as it is disruptive of people's livelihood strategies and social networks. A cautious approach is proposed where fragile locations are used for non-residential purposes e.g. cultivation, grazing, tree growing etc., while land users are resettled somewhere safer.

Secondly, promoting family planning initiatives is the more long-term option for reducing natural increase, and thus minimizing likelihood of climatic hazards being disastrous. There is, however, a labyrinth of socio-cultural compulsions that underpin people's preference for large families. These range from psycho-social aspects (e.g. prestige, tradition and spiritualism) to rational economic considerations (e.g. labour supply, social security and wealth accumulation). The innovation in this regards is to avoid the temptation to tow the conventional family planning line, but seek solutions to the underlying forces behind the population increase. The latter will inevitably require a lot more time to bear results. A combination of partial relocation and population control is therefore recommended.

6.2.14 Collective action in natural resource management

Specific interventions involving collective action in natural resource management are adoption of the catchment approach and organizing land users into group/communal labour. A catchment approach in Mt. Elgon ecosystem would be a better option for effective and visible impact of EBA interventions as this approach enhances resilience of the socio-ecological system. The most important areas in Mt. Elgon region where the catchment approach is critical are rivers and streams as well as wetlands. The increasingly degraded low-lying wetlands of Ngenge and Kiriki Sub counties should benefit from the catchment approach for their restoration and subsequent management. De-silting of rivers and streams should also follow this same collective approach for it to be relevant to flood control in the highly susceptible sub counties. Adjacent communities particularly the youths should be involved in this management approach.

Group/communal labour particularly to natural resource management should be encouraged in Mt. Elgon region. The concept of communal labour is rare for instance in land management in many societies within the Mt. Elgon ecosystem although social capital is evident in other aspects of life like clan and neighbourhood networks. Labour is a major basis for most adaptation strategies in Mt. Elgon region and labour availability is thus a key determinant of a given adaptation strategy. Group/communal labour is crucial in labour intensive adaptation options such as contour construction for soil and water conservation like in the midstream and upstream Sub counties where soil erosion is big problem. Furthermore, group/communal labour can be critical in construction of fuel wood saving stoves which is another major EBA option in Mt. Elgon region. Additionally, group/communal labour can also be used in highly time-bound/seasonal crop farming activities such as planting and harvesting for instance when rain season is shortened and or flooding is possible respectively. However, the formation of such group be based on the perceived local problems by the prospective group members in order to ensure their sustainability as groups easily disintegrate.

6.2.15 Farm and land use planning

Farm planning as recommended by this assessment includes providing farmers technical guidance in crop selection, farm infrastructure and spatial arrangement of enterprises to suit their farm context. Land use planning bears the similar considerations in resource management, but this time at a larger landscape scale.

Plate 6.3. *Good farm planning and conservation practices as shown above would contribute greatly to soil conservation and control of landslides*

Since farming is the major land use in Mt. Elgon region, farm enterprise-selection should be based on farm location. For instance, EBA interventions that minimize cultivation like coffee-banana/shade tree intercrop systems should be promoted where minimum tillage is a prerequisite for soil conservation like upslope and mid slope locations. Furthermore, crop and animal species selection should be guided by hazard occurrence for instance crops (e.g. yams, sugarcane) and animals/birds (e.g. ducks) that are water loving and or tolerant should be encouraged in flood prone areas such as: The design of farm infrastructure like granaries and shelter should also be guided by hazard occurrence for instance in flooded locations raised buildings should be encouraged.

Mt. Elgon region is endowed with numerous natural resources such as wetlands, trees/ forests, mountain ranges, land, rivers and streams, whose management must be planned. Therefore, relevant natural resources departments/directorates at the district such as District Forestry Services, Environment, Land and Survey should endeavour to make and follow management plans as they inform use and interventions for such vital natural assets.

ANNEXES

ANNEX 1: TERMS OF REFERENCE

1. OVERALL PROJECT DESCRIPTION

The Ecosystem Based Adaptation (EBA) Programme for Mountain Ecosystems in Uganda, Nepal and Peruaims strengthen the capacities of these three countries, which are particularly vulnerable to climatechange impacts, to strengthen ecosystem resilience for promoting ecosystem-based adaptation (EBA)options and to reduce the vulnerability of communities, with particular emphasis on mountainecosystems.

The programme is funded by the German Federal Ministry for the Environment, Nature Conservationand Nuclear Safety (BMU) through its International Climate Initiative, and is implemented through apartnership of the United Nations Environment Programme (UNEP), the United Nations DevelopmentProgramme (UNDP) and the International Union for the Conservation of Nature (IUCN).Climate change impacts are already affecting the functioning and integrity of several ecosystems and on Mt. Elgon and are adding to the stress resulting from other anthropogenic interventions such as unsustainable land use practices. The project countries and targeted ecosystems have been identified as particularly vulnerable to climate change impacts. A multitude of communities depend upon the services provided by these ecosystems. EBA is defined as the use of biodiversity and ecosystem services as part ofan overall adaptation strategy to help people to adapt to the adverse effects of climate change. EBA uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. Specifically the project will support:

(i) the development of methodologies and tools for mountain ecosystems;
(ii) the application of the above tools and methodologies at the national level;
(iii) the implementation of EBA pilots at the ecosystem level; and
(iv) the formulation of national policies and building an economic case for EBA at the national level.

The project will create new opportunities for experimental learning between regions and among countries within the same region. Through parallel and cooperative development and application of methodologies and tools and the implementation of pilot projects, the project will shorten the learning curve of local and national institutions and fast-track the transfer of knowledge and experience inrelation to building ecosystem resilience.

The four year (2011-2014) Ecosystem Based Adaptation to climate Change Adaptation (EBA) Project is implemented by the Ministry of Water and Environment in partnership with UNDP, IUCN and UNEP. The different partners are responsible for certain components through the coordination by the Programme Management Unit (PMU) within the MWE, covering the implementation in the districts of Kapchorwa, Kween, Bulambuli and Sironko.

2. OVERALL REQUIREMENTS AND OBJECTIVES

The company selected for this assignment will produce supporting and baseline information, analysesand maps to enable the detailed design, monitoring and evaluation of the project's strategy and implementation plan for promoting ecosystem based adaptation (EBA) to climate change in the Mt.Elgon region. It will contribute to the fulfilment of the following project components in Uganda:

1. Development of methodologies and tools for EBA decision-making in mountain ecosystems.
2. Application of methodologies and tools at ecosystem level.
3. Implementation of EBA pilots at ecosystem level.

The Project Document and Results Framework describe a number of Outputs and Activities for theproject components. This consultancy will be to undertake the following Activities for Component 2:

- Activity 2.1.2 - Conduct Climate Change Vulnerability Impact Assessment.
- Activity 2.1.3 – Develop maps to inform spatial planning for EBA.

The results of this assignment will be used by the project team, in consultation with key stakeholders, tosupport achievement of the following Outputs in the Project Results Framework:

- Output 2.2: EBA strategy identified using decision-making tools, including an economic assessment of EBA options and land use option maps.
- Output 3.2: Institutional capacity of local Governments and other key national institutions toplan, monitor and enforce EBA enhanced.
- Output 3.3: Pilot projects focusing on water resources management and enhancement ofsoil conservation measures implemented.

3. ASSIGNMENT ARRANGEMENTS

The contract will be performance-based, spanning a period of 6 months. The company selected will beunder the overall supervision and guidance of the EBA Programme Management Unit (PMU) and willreport every two weeks. Coordination of the assignment activities with the EBA partner/implementing organizations, and stakeholders in the Mt. Elgon districts and national level, will be conducted withthe EBA secretariat (PMU), to ensure appropriate communications about the project and easy access tostakeholders.

Companies not having all required expertise are allowed to form consortiums with other organizationsand the must inform of such arrangements in their proposals by including a copy of the Memorandum of Understanding/Agreement or Letter of Intent to form a consortium, specifying the roles and responsibilities of each entity and identifying the lead entity (which must be Ugandan) with which the contract will be signed.

The contract requires the use of a Geographic Information System (GIS) and the compilation of relevant data sets. UNEP-WCMC will provide guidance for the detailed technical design and implementation of the activities, in co-ordination with the Uganda EBA National Programme Coordinator. The assignment technical reports will be submitted to the Uganda EBA National Programme Coordinator and will be commented on and approved by UNDP, IUCN, and UNEP (including UNEP-WCMC). The company may be invited to present the results of the contract at workshops or meetings of the project. Costs for any such participation are not to be included in the financial proposals by offerors. The financial proposals should only include costs needed by the company to achieve the deliverables.

4. DETAILED ASSIGNMENT ACTIVITIES

The company will produce:

1. A VIA for Mt. Elgon with a focus on the links between ecosystems and people, to enable EBA
2. Maps of the vulnerability to the most relevant types of climate change impacts of local communities and the ecosystem services that support them in the Mt. Elgon region.
3. Maps of current and possible future ecosystem service supply for the Mt. Elgon region
4. GIS data sets suitable for the national and District project stakeholders to explore options for locations suitable for EBA activities.

There are different approaches and methods to VIA but the assessment of ecosystem services and their resilience to climate change is not currently integrated within mainstream VIA methods. UNEP-WCMC is working to produce guidance to close this gap as part of the 'Mountain EBA Project', and this guidance and technical assistance in its application will be made available to the company awarded.

Outputs 1 and 2

1) A VIA for Mt. Elgon with a focus on the links between ecosystems and people, to enableEBA.
2) Maps of the vulnerability to the most relevant types of climate change impacts of local communities and the ecosystem services that support them in the Mt. Elgon region.

Activity Steps

1. Define the exact scope and focus of the VIA with stakeholders.

a. the geographical boundaries of the VIA and mapping work.

The geographical scope of the VIA and mapping work is the Mt. Elgon region in Uganda, butthe exact geographical boundaries need to be determined. It is also necessary to categorise theMt. Elgon region into upper, middle and lower slopes as the ecological, livelihood andclimate conditions are different in these regions.

The company will compile information on the boundaries of relevant planning and administrative bodies and the availability of relevant data and make a proposal for the geographical boundaries of the VIA, including upper, middle and lower slopes, to the Project implementing agencies to decide on the VIA and mapping boundaries.

Within the Mt. Elgon region Component 3 of the Project (Implementation of EBA pilots atecosystem level) is being carried out in the four Districts of Sironko, Bulambuli, Kween and Kapchorwa, and the VIA and maps will be used to assist the development of the Project strategy in these Districts in a participatory manner with the District Governments. The VIA and maps will also be used by regional organisations such as the Mt. Elgon Stakeholder Forum to inform their decisions.

b. the timeframe of the VIA

   The timeframe for the analysis of possible future impacts of climate change needs to be determined. The company will identify the future timescales of the relevant planning frameworks in the region and the timescales of suitable climate change scenarios or models.The timeframe of the VIA development is expected to be 6 months as detailed in Section 6“Assignment Timetable”.

c. the aspects of local livelihood, the infrastructure and the ecosystem services that will be assessed for their vulnerability to climate change in the VIA (these are the adaptation targets).

The company will review the Project document and previous Project consultancy reports toproduce a preliminary list of the important aspects of local livelihood, the infrastructure and theecosystem services that will be assessed for their vulnerability to climate change. Aspects oflocal livelihoods that are connected to ecosystem services and that are likely to be amenable to Ecosystem-based Adaptation should receive particular attention, but other major issues (e.g.vulnerability of infrastructure to direct climate impacts) should be covered as well where appropriate. This list will be finalised in consultation with the Project implementing agencies and representatives of relevant District and national government agencies.

2. Determine indicators for the VIA to assess the sensitivity to climate change of people'slivelihoods, infrastructure, and ecosystem services, and to assess people's adaptive capacity with regard to these climate change impacts.

   In order to allow the identification of the groups of people that are particularly vulnerable to climate change, it is recommended to assess the sensitivity of the natural and other assets that form the basis of their well-being, and people's capacity to adapt to climate change impacts on those assets, through the use of appropriate indicators. Appropriate indicators to assess the sensitivity and/or resilience of ecosystem services may be linked both to the type of ecosystem (e.g. some forest typesmay be more sensitive / less resilient than others) and to the current condition of the ecosystem (e.g. forests that have already been degraded through anthropogenic pressure may be more sensitive / less resilient than intact ones).

3. Determine the climate variables that are relevant to assessing the vulnerability of the adaptation targets, taking into account the VIA scope and focus. Having identified the key livelihood aspects, infrastructure and ecosystem services that may be atrisk from climate change (identification of adaptation targets as described in step 1), the climate variables that have the biggest influence on these assets are to be determined (e.g. maximum or minimum temperature, number of days above or below a certain temperature, average rainfall peryear, maximum or minimum rainfall per month, duration of dry periods etc.).

4. Use the results of Steps 2 and 3 to determine the vulnerability to climate change of the adaptation targets.

   The company will collect data on past and current levels of the climate variables identified in Step 3, including risks of extreme weather events. They will then use projections from climate changemodels to assess the probability of changes in relevant climate variables. This information will thenbe used to determine the vulnerability to climate change of the adaptation targets, as measured bythe indicators.

   Vulnerability is a combination of the sensitivity and adaptive capacity of the adaptation target to exposure to a climate change variable. If there is more than one likely climate change impact that could affect an adaptation target then separate analyses for each impact are required.

5. Map the vulnerabilities to climate change that result from expected impacts on each of the adaptation targets, with separate maps for each impact.Maps will be produced that show where the combination of high sensitivity of an asset with low adaptive capacity of the people who depend on this asset leads to high vulnerability. These mapscan inform the planning of adaptation measures, including EBA.

6. Refine the VIA results with feedback from stakeholders.The consultants will communicate the initial results of the VIA and maps in a report and apresentation to the Project implementing agencies and relevant stakeholders. The analyses and presentation of the VIA and maps will then be refined on the basis of their feedback.

Output 3

1) Maps of the current and possible future potential for the provision of ecosystem services that are relevant to climate change adaptation in the Mt. Elgon region. These maps will be used to help decide on suitable EBA options and locations. To some degree itmay be possible to produce them by using the same information that was used in the VIA stepsdescribed above to assess the sensitivity / resilience of ecosystem services that people depend on, but new services may need to be included (as it may be possible to address loss of one service bymaking use of another). Maps of current land use and tenure need to be included.

Activity steps

1) Receive a list from the Project implementing agencies of the ecosystem services whose current and potential future supply in the Mt. Elgon region needs to be mapped. This list will take into account previous Project consultancy reports and the results of the VIA.

2) Determine for each ecosystem service that is relevant to the planning of EBA measures, thetypes of ecosystems (including agricultural lands) and topographic conditions which supply the service, the degree to which they supply it, and the way in which anthropogenic pressures affectthe capacity of the ecosystems to supply the service.

3) Produce maps for each ecosystem service of the distribution of the ecosystems that currently supply the service, and the degree to which the service is supplied in different locations, taking into account current land use and any relevant pressures on the ecosystem. Where it is not possible to map service provision quantitatively, appropriate semi-quantitative scaling mayneed to be used.

4) Produce maps for each ecosystem service of the potential future distribution of the ecosystems that could supply the service in terms of climate and topography, and the degree to which theycould supply it, taking into account the impacts of climate change and assuming that anthropogenic pressures on the ecosystems would be mitigated.

Output 4

Produce GIS data sets that are suitable for the national and District project stakeholders to explore options for locations suitable for EBA activities.Based on the maps of current and potential ecosystem service supply, possible areas for the implementation of EBA measures will be identified, taking into account relevant factors such as land availability / land demand for other uses, acceptability to stakeholders, costs etc. The institution that hosts and uses the GIS data sets will be defined by the Project implementing agencies and PMUonce the company for this contract have been selected.

5. ASSIGNMENT DELIVERABLES

1) A report of the results of the VIA to climate change for the Mt. Elgon region. 100 pages maximum, excluding appendices.
2) Maps of the vulnerability to climate change impacts of local communities and the ecosystem services that support them in the Mt. Elgon region.
3) Maps of ecosystem services potential in the Mt. Elgon region to inform the analysis of where EBA is feasible.
4) GIS data sets suitable for the national and District project stakeholders to explore options for locations suitable for EBA activities.
5) A report of the methods and data sets used to conduct the VIA and produce the maps.
6) A report of the lessons learnt in the process and recommendations on improving the methods and data sets and guidance materials provided by UNEP-WCMC.

6. ASSIGNMENT TIMETABLE

Week 1:
Review of relevant EBA Project Documents. Meetings with EBA secretariat (PMU), UNDP andIUCN and UNEP-WCMC (by telephone) to have clarity of the scope and requirements of theconsultancy work.

Week 2:
Submission of Inception Report on methods and timetable, including addressing skills and datagaps.

Week 3-4:
Incorporation of comments from EBA secretariat and stakeholders as advice on the work planfor the task. Training by UNEP-WCMC in incorporating ecosystem services and resilience intoVIA and mapping tools.

Week 5-8:
Determine the indicators for the VIA of sensitivity and adaptive capacity to impacts of climate change on people's livelihoods, infrastructure, and ecosystem services. Determine the climate variables that are relevant to assessing the vulnerability of the adaptation targets. Data collection.

Week 9-12:
Development of GIS datasets and trials of analytical tools. Preliminary maps.

Week 13-15:
Assess the possible impact of climate changes on the adaptation targets and their vulnerability.

Week 16-18:
Produce maps and interim reports. Map current and potential future supply of ecosystem services.

Week 19-20:
Review and improve the VIA and maps with Project stakeholders.

Week 21-22:
Deliver GIS data sets suitable for the national and District project stakeholders to explore options for locations suitable for EBA activities.

Week 24:
Submission of Final VIA report

ANNEX 2: GLOSSARY OF TERMINOLOGIES

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"[77].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"[78]. 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. ''[44]

Exposure

Exposure is defined as the nature and degree to which a system is exposed to significant climatic variations[44]. 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.[79]

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[80].'' 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"[81]. 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[82]. 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.

77 CBD [Convention on Biological Diversity]. 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Technical Series No. 41. Secretariat of the Convention on Biological Diversity (CBD). Montreal, Canada. 126 pp.

78 IPCC (2007). Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I. Cambridge University Press, Cambridge, UK, 976pp).

79 Lavell, A., Oppenheimer, M., Diop, C., Hess J., Lempert, R., Li, J., Muir-Wood, R., and Myeong, S. (2012). Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.K., Allen, S.K., Tignor, M., and Midgley, P.M. (eds.). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA,pp. 25-64.

80 IPCC (2007). Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I. Cambridge University Press, Cambridge, UK, 976pp).

81 IPCC (2001) The regional impacts of climate change: IPCC special report on regional impacts of climate change: An Assessment of Vulnerability

82 UNISDR, 2009. Terminology: Basic terms of disaster risk reduction.

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[83]. 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[49]. 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[84].

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.

83 IPCC (2007). Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I. Cambridge University Press, Cambridge, UK, 976pp).

84 Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.

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 3: LIST OF ECOSYSTEM SERVICES (DIRECT AND PROXY) INDICATORS FOR MEASUREMENT OR DETERMINATION DURING VULNERABILITY IMPACT ASSESSMENT

Ecosystem Services	Indicators
Food	Food yields (kgs)
	Food sales (kgs)
	Livestock density (per sq. km)
	Fish pond density (number per sub county)
Fresh water	Number of boreholes (per sub county)
	Number of protected springs (per sub county)
	Number of gravity flow schemes (per sub county)
	Number of rain harvesting structures (per sub county)
Climate regulation	Drought frequency
	Min-Max temperature
	Min-Max humidity
Water regulation	Flooding
	River run-off (bursting banks)
Erosion regulation	Presence of terraces/grass bands
Flood regulation	Frequency of floods
Landslide regulation	Frequency of landslides

ANNEX 4(a): 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). Farm/land 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.

ANNEX 4(b): DETAILS OF CLIMATE HAZARDS AND OPTIONS FOR ECOSYSTEM BASED ADAPTATION

EBA options / Programs	Affected adaptation target	Climate hazard being addressed	Specific interventions
Climate-smart agricultural practices	Livelihoods Ecosystems	Drought Soil erosion Soil nutrient depletion	Conservation tillage Integrated P&D management Organic manure Fallow systems Crop rotations/diversification Improved crop varieties/Crop breeding Terracing Contour banding Mulching Micro irrigation schemes Composting Use of cover crops Farm planning Use of legumes
Fresh water management	Livelihoods Ecosystems	Drought Soil erosion Flooding	Rainwater harvesting Riverbank management Gravity flow schemes Protected springs
Livestock management	Livelihoods	Drought Soil erosion	Zero grazing Livestock breeding Livestock diversification Support supply of livestock pesticides Fodder bank management
Forest management	Ecosystems	Landslides Drought Flooding Soil erosion	Collaborative Forestry Management (CFM) Tree planting and management(specially for indigenous species) Reforestation/afforestation (using indigenous species) Avoided deforestation
Agroforestry	Ecosystems Livelihoods	Soil erosion Drought Soil erosion	Integrated tree-crop-livestock systems Tree pruning Home-gardens Live fencing Fodder banks Hedgerows Alley cropping Soil and water conservation Woodlots
Wetlands management	Ecosystems	Drought Flooding Soil erosion	Sustainable wetland agriculture Demarcation, mapping and gazettement of wetland areas. Restoration of degraded wetland areas through natural regeneration. Enhancing the enforcement and governance systems through use of bylaws. Wetland management plans.

Sustainable energy options	Livelihoods Ecosystems	Drought Flooding Soil erosion	Energy saving technologies Biogas from manure waste Promotion of energy crops Micro hydroelectric power schemes Brick making (hydraform) Use of crop residues for energy Promotion of wind mills
Infrastructure, social and public services	Infrastructure Livelihoods		Infrastructure development Early warning infrastructure Grading of roads Construction/maintenance of bridges Promotion and maintenance of accessibility ladders.
Institutional and regulatory reforms	Ecosystems	Flooding Landslides Soil erosion	Institutional strengthening e.g. Mt. Elgon Stakeholder Forum Formulation and enforcement of community bylaws.
Market and value addition	Livelihoods	Drought Soil erosion	Promotion of bulk marketing Post-harvest management Formation and strengthening of farmer-based marketing organization
Alternative income generating activities	Livelihoods	Soil erosion Drought	Community based tourism Bee keeping
Knowledge systems	Livelihoods Ecosystems Infrastructure	Drought Flooding Landslides Soil erosion	Disaster early warning systems Capacity building (funds, knowledge) Extension (knowledge dissemination) Sensitization
Human Population Management	Livelihood Ecosystems	Soil erosion Landslides Flooding	Family planning Relocation of people
Collective action	Livelihood Ecosystems Infrastructure	Soil erosion Flooding Landslides Drought	Catchment approach Group/communal labor
Farm and land use planning	Livelihoods Ecosystems Infrastructure	Soil erosion Drought Flooding Landslides	Farm planning (incl. crop selection, farm infrastructure and design) Natural resource management planning.

ANNEX 5: LIST OF PERSONS CONSULTED

Bulambuli district

Name	Designation	Contacts
Mr. Richard Madete	Principal Administrative Secretary	0772-645721
Mr. Jotham Wokuri	District Fisheries Officer	0774-975998
Ms. Agnes Mukoya	Uganda Red CrossBranch Manager	0704-111615
Dr. Deogracious N.Wonekha	District Veterinary Officer	0772-488686
Ms. Hellen Madanda	District Environment Officer	0782-443822
Mr. David Walyaula	Borehole Supervisor	0772-545818
Mr. Nicholas Zebosi	Statistician/Population Officer	0782-725529
Mr. Alfred Tsekeli	District Agriculture Officer	0772-896504

Sironko district

Name	Designation	Contacts
Mr. Godfrey Mayeku	Chairman, District Disaster Management Committee	0772-880209
Mr. Stephen Mugusha	District Forestry Officer	0752-628311
Mr. Rashid Mafabi	District Natural Resource Officer	0772-435518
Dr. Charles Okori	District Veterinary Officer	0772-847439
Mr. Joseph Mayusa	District Fisheries Officer	0782-309630
Mr. H. K. Matanda	Resident District Commissioner	0772- 618716

Kapchorwa district

Name	Designation	Contacts
Mr. Silvester O.Ojangole	District Forestry Officer	0754-501676
Mr. Awadh Chemangei	District Natural Resource Officer	0772-645591
Mr. Francis Olaboro	Deputy Chief Administrative Officer	0772-469767
Mr. David Chepsikor	District Fisheries Officer	0703-869348
Mr. Sunday Cherop	District Veterinary Officer	0772-564414
Ms. Annet Cherop	Meteorology Officer	0784-966018
Mr. David Olal	District Water Engineer	0752-520789
Mr. Rajab	Population Officer	0702-718471
Mr. John Chekwel	Assistant Forest Officer	0752-652341

Kween district

Name	Designation	Contacts
Mr. Kessi Chericha	Population Officer	0773-276538
Mr. Michael Cherotic	Ag. District Inspector of Schools	0782-842751
Dr. Nelson Yesho	District Veterinary Officer	0776-524799
Mr. Samuel Chemusto	District Forestry Officer/Director, Natural Resources	0772-459166
Mr. Simon Mwanga	NAADS coordinator	0778-016295
Mr. Albert Anguri	District Water Engineer	0772-646460
Mr. Juma D. Chepsikor	Sub-County Chief, Ngenge	0782-374105

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