THE REPUBLIC OF UGANDA

IN THE HIGH COURT OF UGANDA AT MBALE

MISCELLANEOUS CAUSE NO.024 OF 2020

TSAMA WILLIAM & 47 ORS ::::::::::::::::::::::::::::::::::: APPLICANTS

VERSUS

1. ATTORNEY GENERAL
2. NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY } **::::RESPONDENTS**
3. BUDUDA LOCAL GOVERNMENT COUNCIL

2nd RESPONDENT'S AFFIDAVIT IN REPLY

I, **JULIUS MUYIZZI** of C/o National Environment Management Authority, Legal Chambers, P. O. Box 22255 Kampala, do solemnly make oath and state as follows:

1. That I am a male adult Ugandan of sound mind working as a Senior Geographic Information System and Sensing Officer with National Environment Management Authority. I am familiar with the facts surrounding the matter before court and swear this affidavit in that capacity.

2. That I have read and understood **Miscellaneous Cause No.024 of 2020** and the 49 supporting affidavits deponed by **Vincent Yiga, Tsama William, Weanga John, Namee Ester, Nabende Alex, Nabende Vincent, Kutosi Yefusa, Walimbwa Vincent, Wanzonele John, Namono Joyce, Kutosi Francis, Kigai Emma, Shinyale Julius, Kibone Angela, Wephukhulu Damasco, Nabutiti Zoena, Kuloba Boniface, Wabuyombe Richard, Namono Annet, Tsemoi Irene, Khainza Aidah, Kibone Sylvia, Tsama Damasco, Kusolo Moreese, Watsakula Joseph, Wameyo Wilson, Kakala Simon, Butsiba Julius, Wekesa Grace, Nabianyaka Yefusa, Wabuyombe Fred, Mabonga Mary, Wamboka David, Matete Sam, Wanzonele Patrick,**

Nandutu Jenipher, Mangobe Richard, Shirundu Vincent, Namasopo Maria, Mutabali Bosco, Muyekho Floretina, Muyima Joseph, Wanyela Peter, Namasopo Beatrice, Kalenda Jane Florence, Watsakula Moses, Nandutu Robinah, Nabulo Grace, Mundeyi Castant and herein reply.

3. In specific reply to paragraph 13 (e), (f) and (h) of the affidavit in support of the application deponed by Vincent Yiga, I state as follows:

(i) That the mandate of the 2nd respondent is to regulate, coordinate, supervise and monitor environmental activities and works in collaboration with other lead agencies to regulate such activities in accordance with the law and does not enforce nor implement laws and regulations.

(ii) That the applicants are bound by the principles established under the National Environment (Mountainous and Hilly Areas Management) Regulations to facilitate the sustainable utilization and conservation of mountainous and hilly areas.

(iii) That in 2013, a report on "Climate Profiles and Climate Change vulnerability Assessment for the Mbale Region of Uganda", recommended for enhanced climate change mitigation and adaptation interventions including strategic weather stations, wareness creation, capacity building, adherence to the carrying capacity and enforcement of regulations. **(A copy of the Report is attached and marked Annexture "A")**

(iv) That the 2nd respondent worked with the Ministry of Water and Environment to identify and map out hilly and mountainous areas in the Elgon sub-region at risk from landslides. **(Copies of reports on Land Risk Assessment are attached and marked Annextures "B" and "C")**

(v) That the 2nd respondent implemented measures to prevent loss of life and property and the environment, including- conducting community awareness programmes, a call in Radio talk show on Open Gate FM and community meetings. **(the measures are found in paragraph 4.0 Annexture "B" attached hereto)**

(vi) That the poorly carried out human activities of residents in the Elgon sub-region, including the applicants' have contributed to landslides in the area, these activities include, poor agricultural practices, vegetation clearance, poor cultivation. **(the human activities are found in paragraph 3.3 Annexture "B" attached hereto)**

(vii) the 2nd respondent made recommendations prohibiting human activities in areas prone to landslides in Bududa District. **(the recommendations are found in paragraph 5.0 Annexture "B" attached hereto)**

4. That in reply to the affidavits in support of the application deponed by the 48 applicants, I know that the affidavits do not speak to the 2nd respondent.

5. That in further reply to the affidavits in support of the application deponed by the 48 applicants, I am reliably informed by my Lawyers, which information I believe to be true that the affidavit deponed and evidence of Vincent Yiga clearly exonerate the 2nd respondent.

6. That I am reliably informed by my Lawyers which information I believe to be true that the 2nd respondent is not

liable for the loss occassioned and my Lawyers will apply for the 2nd respondent to be struck off with costs.

7. That I swear this affidavit in opposition of the application.

8. That whatever I have stated herein above is true and correct to the best of my knowledge and belief save for the information that has been provided which sources are disclosed herein.

SWORN at Kampala this....17th....day of....May....2021.

By the said, **JULIUS MUYIZZI** ....

DEPONENT

BEFORE ME

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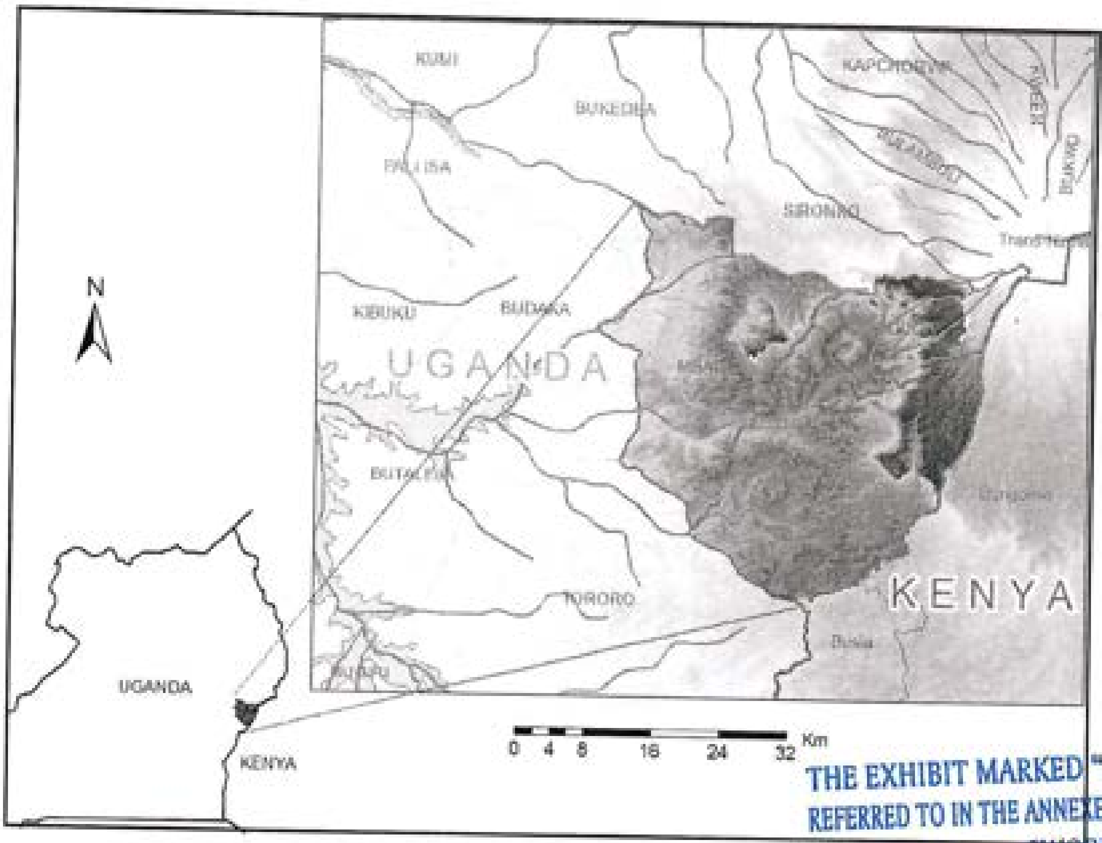
ANNEXTURE A

Climate Profiles and Climate Change Vulnerability Assessment for the Mbale Region of Uganda[1]



May 2013

Empowering lives.
Resilient nations.

[1] Shortened version of full report prepared by Dr Michael Mbogga in 2012

Summary

This report presents an assessment of meteorological data, descriptions of the current climate and an assessment of climate projections and vulnerability to climate change for the Mbale region of Uganda.

Weather station data were obtained for the Mbale region covering the period 1960 to present. The quality and quantity of available climate data limited the description of climate for the Mbale region, as well as the development of strategies to deal with the impacts of climate change. The Mbale region historically had a good coverage of weather stations, most of which are currently non-functional. Efforts are therefore needed to collect weather data from as many representative locations as possible to be able to support climate risk management activities, as well as provide information that can be used for long-term climate change mitigation and adaptation planning.

There is evidence that climate in the Mbale region is changing, with expected continuing changes in future projections of temperature and rainfall. There has been an increase of between 0.4 and 1.2 °C in monthly temperatures in the Mbale region during the 2001-2011 period when compared to the 1961-1990 period, which is consistent with GCM projections for the future of an increase in temperature for the next 30 years. Recent changes (2001-2011) in rainfall are more difficult to detect and appear to be influenced by multi-decadal variability, sometimes trending in the same direction as future projections from Global Circulation Models (GCMs). For example, the observed reduction in February rainfall and increases in May rainfall during the 2000-2011 period is similar to projections from the majority of GCMs. More annual average rainfall is projected during the 2010 - 2039 period compared to the 1961-1990 average.

Reduced rainfall during the December to February period, as projected by the GCMs in the future, will likely increase water stress for crops and may lead to scarcity of water for domestic use during that period. Whilst beneficial for crops and domestic water use, higher rainfall in the wet seasons (March, April, May and September, October and November) can be expected to increase erosion, especially on steep slopes, as well as flooding in valleys and siltation of streams and rivers, especially if it is associated with increases in rainfall intensity. Higher rainfall, especially during the September to October period, however, provides an opportunity for growing a wide range of crops during the second rain season. Overall increases in temperature are expected to increase the spread of pests and diseases such as the coffee berry borer. Higher temperatures will also facilitate the spread of malaria to high elevation areas. Over the last one and half decades at Mbale, there has been a clear shift from April to May as the wettest month, with the onset of the rainfall season delayed. The other major trend has been towards more rainfall during the previously "shorter" rains period of September to November. Overall, a clear trend of more rainfall throughout the year is becoming apparent.

A multi-faceted approach is required to enhance the resilience and adaptive capacity of the environment and the people of the Mbale region to climate change impacts. One crucial area is population growth that was mentioned by all stakeholders, because resources in the region are already overstretched. Whereas reducing population pressure is a long-term objective, immediate interventions that promote improved farming techniques, increase awareness among the people about climate change, its impacts and the role each member of society needs to play for the enhancement of livelihoods are urgently required. Building on existing resources, the banana-coffee system will need to be strengthened through encouraging shade trees for the coffee, and adding minimum tillage crops to the system. Fruit trees would also help provide valuable income, necessary nourishment and protect soils. In terms of soil and water conservation, terraces will need to be encouraged and regulations implemented to limit cultivation on steep slopes, as well as encouraging tree planting.

Encouraging farmers groups and cooperatives will help improve incomes derived from agricultural produce, as well as the exchange of information and technologies between farmers. The current

willingness of the local government and political leaders needs to be harnessed for any climate change related intervention. This will also ensure the streamlining of climate change adaptation into relevant government interventions in the Mbale region.

Abbreviations and Acronyms

ACCRA	Africa Climate Change Resilience Alliance
ACTED	Agency for Technical Cooperation and Development
BCU	Bugisu Cooperative Union
CCAFS	Climate Change Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
CRU	Climate Research Unit, at the University of East Anglia, UK
CSA	Climate Smart Agriculture
DEM	Digital Elevation Model
DfID	Department for International development - UK
DJF	December January February season
DRR	Disaster Risk Reduction
FACE	Forests Absorbing Carbon dioxide Emissions
FIEFOC	Farm Income Enhancement and Forest Conservation
GCM	General Circulation Model
IPCC	Intergovernmental Panel on Climate Change
ITCP	Integrated Territorial Climate Plan
JJA	June July August season
MAM	March April May season
MERECP	Mt. Elgon Regional Ecosystem Conservation Programme
MWE	Ministry of Water and Environment - Uganda
NAADS	National Agricultural Advisory Services
NAPA	National Adaptation Plan for Action
NUSAF	Northern Uganda Social Action Fund Project
PRECIS	Providing Regional Climates for Impacts Studies
SON	September October November season
SRES	Special Report on Emissions Scenarios by the IPCC
TACC	Territorial Approach to Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UWA	Uganda Wildlife Authority
WorldClim	set of global climate layers (climate grids) with a spatial resolution of about 1 square kilometer developed by Hijmans *et al* (2005)

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1 Introduction

1.1 Background

The Territorial Approach to Climate Change (TACC) project for the Mbale region of Uganda is implemented by the United Nations Development Programme (UNDP), with financial support from the Danish Embassy, the UK Government's Department of International Development (DFID) and UNDP, also from technical and development support provided by the Welsh Assembly Government. The TACC-Mbale is one of the pilot projects for the Global Initiative, "Down to Earth: Territorial Approach to Climate Change". The Global initiative is a collaborative effort involving the UNDP, the United Nations Environment Programme (UNEP) and eight associations of regions around the world. This global initiative aims at supporting sub-national governments to identify and develop projects which can meet local needs while building both climate resilience and the infrastructure needed for low-carbon growth. The initiative helps to achieve this through promoting robust collaborative actions amongst regions within industrial and developing countries, with international organizations, UN agencies and the private sector to foster knowledge transfer and direct investment to deal with the impacts of climate change.

The TACC-Mbale project is providing a coordinated mitigation and adaptation plan to address the negative impacts of climate change in three districts (Mbale, Manafwa and Bududa) of the Mbale Region of Uganda. The project will enable the region realize low carbon and climate change resilient development. Towards this objective, the TACC-Mbale project is assisting the Mbale Region to develop its own Integrated Territorial Climate Plan (ITCP), which integrates climate change adaptation and mitigation strategies into regional development planning. The process of developing the Mbale Region ITCP includes developing a policy and investment plan that identify appropriate regulatory and financial instruments for the implementation of the actions that have been selected by the ITCP and assist the region to access, combine and sequence a variety of financial resources needed to implement the plan. Outputs of the TACC-Mbale project include; a platform for climate change planning and programming, capacity building to integrate climate change issues into regional development plans and actions; an Integrated Territorial Climate Plan (ITCP) for the Mbale region; a climate change policy and investment package; and synthesis and dissemination (within and beyond Uganda) of lessons learned and best practices. This consultancy report presents climate profiles and an assessment of climate change risk and vulnerability for the Mbale region.

The Mbale Region of Uganda as defined for the TACC Mbale project comprises the present Bududa, Manawa and Mbale Districts (total area 137,128ha or 1371.3 sq km). The population of the districts is estimated at close to a million people, making the Mbale region one of the most densely populated regions of Uganda. The large number of people, together with the physiographic make-up of this region (mountainous, with steep terrain combined with high rainfall and unstable soils) make it very vulnerable to the impacts of climate change. Landslides of various magnitudes already occur nearly every year, some of which cause extensive damage to property and loss of life (NEMA, 2010). These landslides are mainly triggered by high rainfall, loss of tree cover and cultivation on steep slopes.

The Uganda National Adaptation Programmes of Action (NAPA) (RoU, 2007) notes that climate change may lead to an increase in the frequency and intensity of extreme weather events, including droughts, floods, landslides and heat waves. The report further notes that; rainfall is the most sensitive climate variable that affects social and economic activities; observed rainfall has been falling with greater intensity in some regions; western, northern and north-eastern districts are experiencing long droughts, which are becoming more frequent, recent years have witnessed erratic onset and cessation of rainfall seasons. These impacts are coupled with increasing frequency of droughts and sustained warming, particularly over southern parts of Uganda. The Mbale region has always has an erratic rainfall regime, which is intensifying; more intense rainfall due to increasing weather variability is already having devastating consequences to agricultural production and livelihoods.

A temperature increase of about 1.0 to 3.1°C has been projected, accompanied by low to moderate increase in precipitation over the next 40 years for most areas of Uganda (McSweeney et al., 2010). Changes in climate in sub-Saharan Africa will likely result in increased food insecurity, higher incidence of pests and diseases, soil erosion and land degradation, and reduced agricultural productivity and disrupting the functioning of natural systems (Parry et al., 2005; Schmidhuber and Tubiello, 2007). All these will ultimately affect livelihoods of smallholder farmers as well as the urban poor, whose numbers are projected to rise to more about 50% of the country's population by 2020. Smallholder farmers, who comprise the bulk of the country's population, have dealt with climate variability and extremes of weather in the past, for example the people of Mbale have braved hundreds of landslides in the last century. However, concerted effort is required to help these people to cope with current and projected changes in climate. Uganda's farming households are highly vulnerable to climate change because of a number of reasons. Production systems have rarely changed over the last 5 or so decades, almost all agricultural production is rain-fed, with little to no use of irrigation, fertilizers or other inputs. Without appropriate adaptation, these production methods will be threatened by changes in climate.

Because of recent and projected changes in climate, the only option for smallholder farmers is to adapt farming systems and other sources of livelihood to climate change. Development of adaptation strategies requires that climate trends are well understood, as well as information on the vulnerabilities of natural and human systems. Therefore understanding historical, current and projected climate of the area forms one of the most fundamental steps in the process of developing climate change adaptation strategies. The next stage is to have a good understanding of how vulnerable current systems are to the projected changes in climate.

The major goal of this report is to present current and projected climate profiles for the Mbale region and to assess vulnerabilities of the environment, society and the economy of the region to the projected changes in climate. Details of the prospective range of climate projections for the Mbale region are needed to inform investment strategies that will facilitate the transition to climate-resilient development. Assessment of vulnerability is important for efforts to develop climate change adaptation strategies.

Weather station data from station in the Mbale region and neighbouring districts has been used to describe the current climate for the Mbale region. Baseline climate for the region is described using spatial climate grids, WorldClim developed by a consortia or organizations working on climate change and agricultural and natural resources (Hijmans et al., 2005; Ramirez-Villegas et al.). Projections of future climate simulated by global circulation models (GCMs) and three emissions scenarios – A1B, A2 and B1. The magnitude of projected changes in climate were used together with socio-economic and topographic data to provide likely exposure of the Mbale region to climate hazards during the 2010-2039 and 2040-2069 future time slices. The final tasks involved assessing the how the environment, society and economy can be harnessed to enhance adaptive capacity of the region to climate change over the 21st century.

1.2 General information about the Mbale region of Uganda

1.2.1 Location and general description

The Mbale region of Uganda covers the present day districts of Bududa, Manafwa and Mbale (see Figure 1). The three districts were recently created out of three counties of the old Mbale District, (Bungokho, Manjiya and Bubulo), together with Mbale municipality. The Mbale region extends from the lower to the upper slopes of the southwestern slopes of Mt. Elgon in eastern Uganda and share a border with western Kenya.

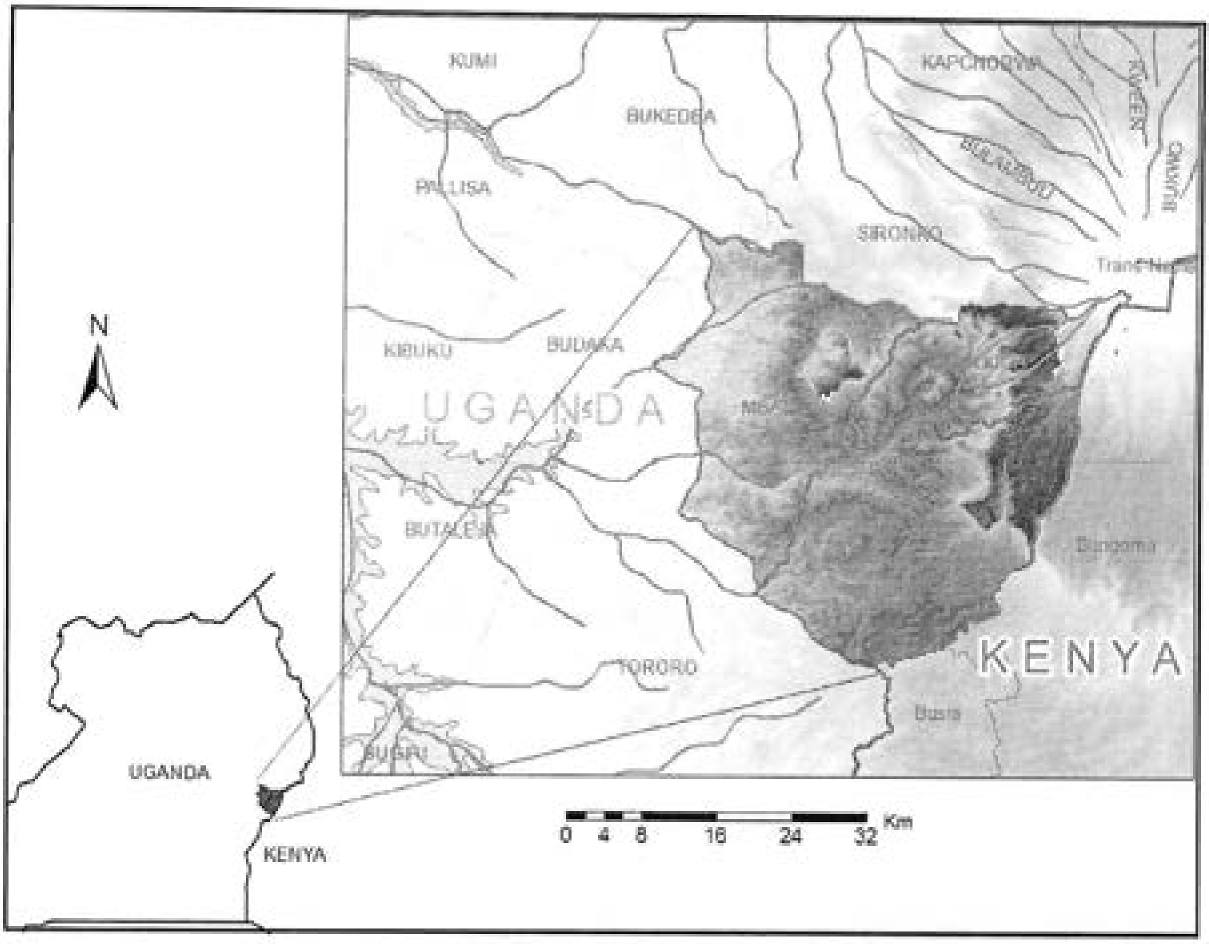

Figure 1: Map of the Mbale region districts (Bududa, Manafwa and Mbale)

Mbale District, the western-most district of the trio, is low to medium in elevation, with Wanale Hill the highest point in the district. Manafwa District is mainly medium to high elevation ranging from 1200m to 1800m asl. Bududa is also medium to high elevation, with most of its highest areas lying within Mt. Elgon Forest National Park. The Mbale region receives relatively higher rainfall compared to other locations at similar altitudes in other parts of the mountain. Rainfall received in the forest zone of the mountain makes Mt. Elgon an important catchment area for several million people in the region (van Heist, 1994). The administrative sub-divisions of Bududa, Manafwa and Mbale districts are shown in Figures 2, 3 and 4. Administratively, Bududa district has 7 sub-counties namely Bududa, Bubiita, Bukibokolo, Bukigai, Bulucheke, Bumayoka and Bushika (Figure 2). Manafwa district has 10 sub-counties including Bubutu, Bugobero, Bumbo, Bumwoni, Bupoto, Butiru, Buwabwala, Buwagogo, Kaato, and Sibanga (Figure 3). Mbale has the following 11 sub-counties Bufumbo, Bukonde, Bukyiende, Bungokho, Bungokho-mutoto, Busano, Busiu, Busoba, Nakaloke, Namanyonyi Wanale and 2 divisions, namely Industrial Northern Division and Wanale Division (Figure 4).

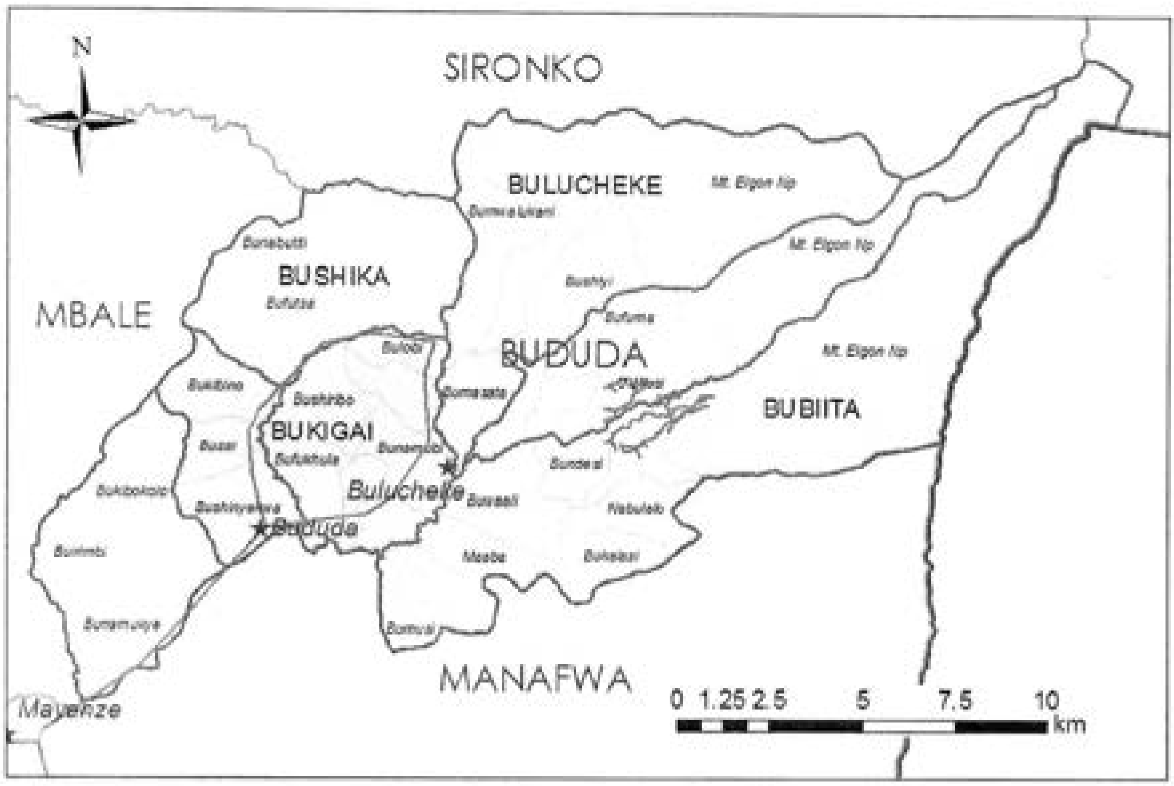

Figure 2: Sub-counties of Bududa District

1.2.2 Geology and Soils

The Pre-Cambrian rock system and the Cainozoic rock formations are the major formations underlying the Mbale region. The pre-Cambrian rock system is mainly granitic or high to medium metamorphosed formations, consisting of undifferentiated gneisses and elements of partly granitic and metamorphosed formations (NEMA (National Environment Management Authority), 2004). Cainozoic formations consist of Pleistocene to recent sediment, alluvium, black soils and moraines. The impermeable nature of these rocks make most of the areas adjacent the Mount Elgon Park susceptible to landslides in the rainy seasons of the year (NEMA 2004). Soils are majorly clayey in the highlands, clay loams in mid-altitude areas and sandy in the lowlands and valleys.

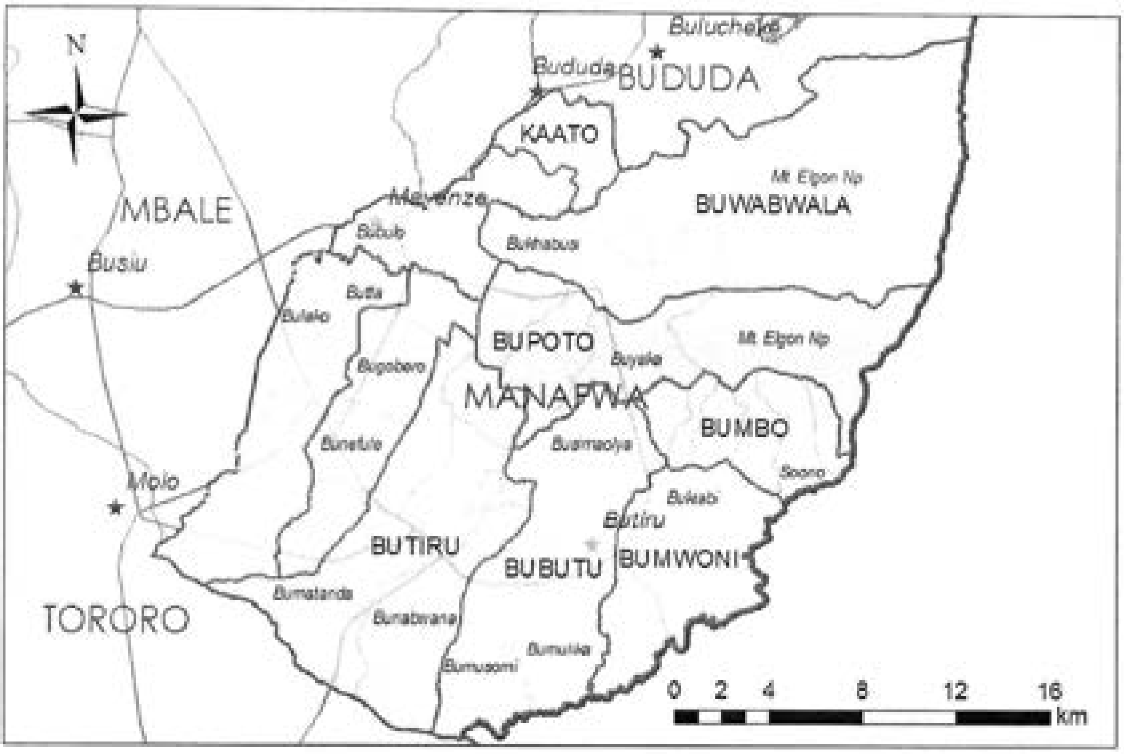

Figure 3: Sub-counties of Manafwa District

The geomorphology of Bududa is greatly controlled by the volcanism and doming of the rocks. The main geology is fenitized basement rocks and in the central part known as Bukigai, a pre-Elgon alkaline volcanic structure, the Butiriku carbonatite Complex stands out. This carbonatite intrusion of Oligocene-Miocene age (King *et al*, 1972) is one of the sub-volcanic complexes that occur along a 65km stretch in south-eastern Uganda. The Mt Elgon area is covered with the agglomerates. Soil surveys done by Isabirye *et al*, (2004), show that soils in this area have a sequence where the central carbonatite dome is covered by Rhodiandic Nitisols and the surrounding areas by Rhodiandic Luvisols, Hapliclixic Ferralsol and Humicandic Nitisols.

1.2.3 Vegetation

The Mbale region is heavily cultivated, with little to no remnants of natural vegetation in the lower and mid elevation areas. Natural vegetation remains in the higher elevation areas, most of which fall within the Mt. Elgon Forest National park. In the higher altitudes, the natural vegetation changes from montane, to grassland, bamboo then heath and moorland in that order. The supra-tropical forests up the mountain are dominated by with Camphor, *Aningeria adolfi-friederici*, *Podocarpus latifolius*, *Olea hochestetteri* and *Prunus africana* (Hamilton and Perrott, 1981). Mixed bamboo occurs at about 2,500-3,000m, which turns into open woodland dominated by *Hagenia abyssinica* and African rosewood, the heath zone 3,000-3,500m characterized by giant heath with grassy swards of tussock grass. The Afro-alpine region stretches from 3,500m to 4,321m asl, dominated by *Senecio elgonensis*.

Figure 4: Sub-counties of Mbale District

Mt. Elgon National Park, which lies to the northeast of the region, was formerly a forest reserve with some members of the public still holding cultivation permits within the reserve. These permits were partly responsible for the degradation or encroachment on the forest, especially during periods when governance broke down in Uganda. Today the national park is relatively well protected and over recent years there have been several efforts to try to restore parts of the degraded forest.

1.2.4 Socio-economic characteristics

The Mbale region has about 590 persons per square km, making it one of the most densely populated parts of Uganda. Mbale town is the major urban area with a population of more than 150,000. There are numerous other smaller towns, including Bududa, Manafwa that are now growing since each now hosts the headquarters of their respective districts. The majority of the people of Mbale region are ethnic Bagisu, who have inhabited the western slopes of Mt. Elgon for centuries. Most people are engaged in agriculture, which is the main economic activity employing more than 80% of the population. The major crops grown at high altitudes include banana, arabica coffee and Irish potatoes, while at lower elevations the dominant crops are maize, millet, cassava, beans and sweet potatoes, cabbage and tomatoes. The Mbale region as well as other parts of the slopes of Mt. Elgon is the major Arabica coffee producing areas in Uganda. The coffee is normally intercropped with bananas, maize and beans. Occasionally the coffee is grown under trees *(Albizia* or *Cordia*) for shade.

There has been increasing concern about climate change and its impacts to the Mbale region. The region is highly vulnerable given its high population, high poverty levels, and mountainous landscape. The region has had numerous outbreaks of cholera particularly in the rain season. Rural areas in mid to high elevation areas have had landslides, siltation of rivers as well as washing away of top soil, which depletes soil nutrients hence affecting agricultural yields.

1.3 Objectives of the study

This study was to develop climate profiles for the Mbale region and evaluate the vulnerability of the region to projected climate changes over the 21st century.

Specific objectives include:

i) Evaluate meteorological data available in the Mbale region;
ii) Describe and map current and projected climate for the Mbale region;
iii) Assess and map risks and vulnerability of the environment, society and the economy of the Mbale region to climate change.

Specific tasks for each of the objectives include the following:

Objective 1. Analyze available meteorological data for the Mbale region
Under the first objective, quality of available data was evaluated and an attempt was made to detect homogeneities in the data due to factors other than climate change. In addition, historical climate trends were described. Under this task a review of simulated change for the wider eastern Africa region was also performed.

Objective 2. Develop past and projected climate change profiles for the Mbale region.
Building on outputs of objective one, objective two used other available climate data sources, a climate database for the Mbale region has been developed covering baseline (1961-1990) and 21st century projections. Future climate to cover two time "slices" the 2020s (2010-2039) and 2050s (2040-2069) are projected.

Objective 3. Assess risk and vulnerability to climate change
The third objective evaluated how the environment, society and economy of Mbale, Manafwa and Bududa Districts will be affected (i.e. how sensitive it is to the changes), including how existing sectors of society will be affected by the projected climate changes. In addition, interaction of socio-economic trends and their impact on sensitivity to climate change, and the potential to cope with, recover and adjust to the impacts of climate change (i.e. its adaptive capacity) were assessed.

Objective 4. Develop climate change vulnerability maps
The objective developed digital vulnerability maps through analysis using a computer-based geographical information system (with maps of topography, hydrology, soils, vegetation / land use and aspects of human population). The analysis was verified with local and national experts.

1.4 Structure of this report

Following this general introduction, section two of the report covers analysis of meteorological data, section three provides Mbale region climate profiles with both current or baseline and projected climate for the 21st century. Section 4 discusses the risk and vulnerability of the region to climate change. Section 5 summaries key findings and messages of the report. A glossary of key terms related to climate change and climate change vulnerability assessment used in this report is provided in Annex 1.

2 Analysis of Meteorological Data for the Mbale Region

2.1 Role of meteorological data in climate studies

The first and most fundamental step in climate change studies is to gain a good understanding of climate trends (both historical and projected), which will help determine whether a change in climate is occurring against the natural variability and the magnitude of any changes. This information forms the basis for the development of climate change mitigation and adaptation strategies, as well as for incorporating climate change issues into development planning. Typically, climate data are generated from daily weather records taken at weather stations. In a few instances, climate data will be sourced from satellites. Thus having a good network of weather stations and taking regular and accurate records from a good number of weather variables are very crucial. Typically in Uganda, weather stations are located close to settlements, with very little coverage in remote areas. These weather stations will record rainfall, minimum and maximum temperature, relative humidity and wind velocity, among other weather variables. Weather station records are then used to describe the climate of an area. Climate is normally computed as long-term averages (usually 30 years) for each of these variables (see Annex 1 for definitions).

Assessment of climate trends as well as climate impact studies normally rely on weather data collected from weather stations and then used to describe climate for those locations as well for the development of climate grids that are often used in spatial analysis and climate impacts modeling. These regular climate grids are normally generated using a number of interpolation techniques including kriging, weighted distance, thin splines (Daly, 2006). The starting point in creating these grids is current climate data, which is compiled from weather station locations, whereas future climate projections are based on model experiments that attempt to recreate the global climate system and project likely changes in the future based on greenhouse gas forcings.

Future climate projections are generated as deviations or anomalies from climate for a chosen baseline period, following assumptions of future human activities and theories corresponding impacts on the global climate system. Keeping track of past and present changes in climate is important because these trends and associated impacts can inform resource managers about likely impacts of projected changes in climate. As projections of the future climate are usually made as deviations from the present or a chosen baseline, if the baseline is wrong, then future projections will also be unreliable. Thus climate change detection and climate change impact modelling require high quality observed weather / climate data to be able to accurately describe trends in climate as well as correctly relate observed impacts to changes in climate (Hofstra et al., 2008).

The following section uses observed weather station as well as other available climate grids for the Mbale region to evaluate the meteorological data available for climate description and climate change assessment for the Mbale region. Climate trends since 1960 for the region are described.

2.2 Climate profiles for Mbale region - data sources

Describing the climate profile for the Mbale region was performed using climate data from two major sources. The first was weather station records from the Mbale region and surrounding areas and the second was climate grids that have been developed by international climate research centers. The WorldClim data used for baseline climate grids was compared with another set of spatial climate data developed from regional climate modeling PRECIS (Providing REgional Climates for Impacts Studies).

Future climate projections are typically generated by general circulation models (GCMs) at very coarse resolution, usually at grid cells of several hundred kilometers, requiring downscaling before they can be used regionally or locally. GCMs simulate the global climate by calculating three dimensional evolution of the atmosphere typically over a 20-minute timestep, based on the physical laws for atmospheric mass, momentum, total energy, and the effects of various atmospheric components such as water vapour (Randall et al., 2007). Outputs of GCMs have been shown to closely reflect historical (Jansen *et al*, 2007) and current changes in climate in several regions around the world (Randall et al., 2007).

GCMs are realized based on greenhouse gas emission scenarios developed by the Intergovernmental Panel on Climate Change (IPCC). These emission scenarios are alternative representations of the future, also referred to as "story lines" of potential population growth and economic development and corresponding levels of greenhouse gases in the atmosphere (Nakicenovic et al., 2000). There are generally four major story lines or emissions scenario families (A1, A2, B1, B2), recommended by the Intergovernmental Panel for Climate Change (Nakicenovic et al., 2000).

- A1 represents a trend of globalization, resource-intensive economic growth and rapid population increase;
- A2 assumes slower population growth and regionally fragmented economic growth;
- B1 assumes the same global population growth as A1, but a shift towards a service and information economy;
- B2 represents the lowest population increases and local, environmentally sustainable economies. The B2 scenario was not used because it has been deemed very unlikely given that recent emission correspond to projections for the B1 and A1 scenario families.

Climate change projections are highly uncertain. Climate model simulations differ for a range of reasons including technical issues such as spatial and vertical resolution, parameterization issues like representation of processes such as clouds, water vapour, ocean mixing, terrestrial processes, and feedbacks relating to water vapour, clouds, snow and terrestrial (Beaumont et al., 2008). Beaumont *et al*, (2008) suggest that more fuel intensive emissions scenarios such as A1 and A2 over the more conservative B1 and B2 scenarios be used because recent studies have demonstrated that fossil fuel CO_2 emissions since 2000 have increased at a greater rate than previous decades (Canadell *et al*, 2007; Raupach *et al*, 2007).

2.3 Quality control of available meteorological data

Weather stations used to provide meteorological data around the Mbale region include Mbale weather station (which is currently closed, Manafwa (recording only precipitation), Bugusege Coffee Research Station, and one in Buginyanya (recording minimum and maximum temperature, precipitation, relative humidity and wind velocity) (Table 1). A weather station was started in Bududa in late 2010 recording only rainfall. Data from this station could not be used in the description of climate profiles for this region because the station has not been in operation long enough. It is important to note that none of these weather stations has a complete record of all-weather variables from time when each of these stations started operating. Gaps in data have mainly been due to failure of the people responsible for taking weather records to take readings for all days.

Table 1: Weather stations, data collected and period covered in the Mbale region

Station Name	Data available	Time period	Operational
Mbale	- Maximum temperature - Minimum temperature - Rainfall	1960-1987 1960-1987 1970-1987	No
Manafwa	- Rainfall - maximum temperature - minimum temperature		Yes

Bududa	- Rainfall	2010 to present	Yes
Nabumali	- Temperature	1960-1976	No
Buginyanya	- Maximum temperature - Minimum temperature - Rainfall - Relative humidity - Wind velocity	1960 to present 1960 to present	Yes
Bugusege	- Rainfall	1940 to 1993	No

Given the recent changes in climate in the Mbale region, such as increasing frequency and magnitude of landslides, there have been efforts to improve weather data collection. A few weather stations have been set-up, however, issues remain with the weather data for the Mbale region include the following:

- Missing data results in no records for temperature, (on some datasheets it is mentioned that the officer is away on official duties);
- Use of different data entry forms or lack of proper data entry forms;
- Errors in calculation of monthly precipitation values;
- Areas not well covered by weather stations.

It is the role of the Meteorology Department in the Ministry of Water and Environment to compile weather data from all locations in the country. However not much of the data collected in the region had been entered. Thus, the author had to obtain some of the weather data for this study directly from field data sheets. It is recommended that the Meteorology Department should streamline the responsibility of regulating weather data recording, as well as coordinating the compilation and description of weather data recorded not only in the Mbale region but the entire country.

The rain gauge network in Uganda was relatively extensive and well maintained up until about 1990; however, reliable time-series data are difficult to obtain and, once obtained, there tend to be significant gaps in the time series (Asadullah *et al*, 2010). Whereas rainfall data can be derived from remotely sensed data, such products have been found to underestimate rainfall over mountain areas, attributed to satellites failing to pick up the orographic enhancement of rainfall (Asadullah *et al*, 2008 and Ebert *et al*, 2007). In other cases, satellite data overestimates dry season rainfall in mountainous areas (Dinku *et a,l* 2010).

2.4 Detecting homogeneities

The only weather station in the Mbale region with a near complete record of rainfall and temperature data since 1960 is the Buginyanya weather station. This weather station is actually not located within the Mbale region, but in Bulambuli District, Buginyanya lies a few kilometers to the north at 1835m above sea level. This elevation is representative of high elevation locations in Manafwa and Bududa Districts. Data collected at this weather station is however not representative of the weather conditions at lower elevation locations in the region such as in western parts of Mbale district of southern Manafwa. Another weather station that was valuable for rainfall data was located the Bugusege coffee station located in Sironko district to the north of the region at about 1400m asl. This elevation is representative for locations in Manafwa and Bududa districts. Spatial distribution of weather station used to describe historical and current climate for the Mbale region are shown in Figure 5.

From Figure 5, which also indicates the duration for which weather data is available for each of the stations, it is evident that at one time the region had a reasonably good coverage of weather stations, particularly for the low elevation areas, however the majority of these stations recorded weather for fewer than 20 years. In addition, these mainly recorded only rainfall. High elevation areas in western parts of Bududa and Manafwa were not well represented.

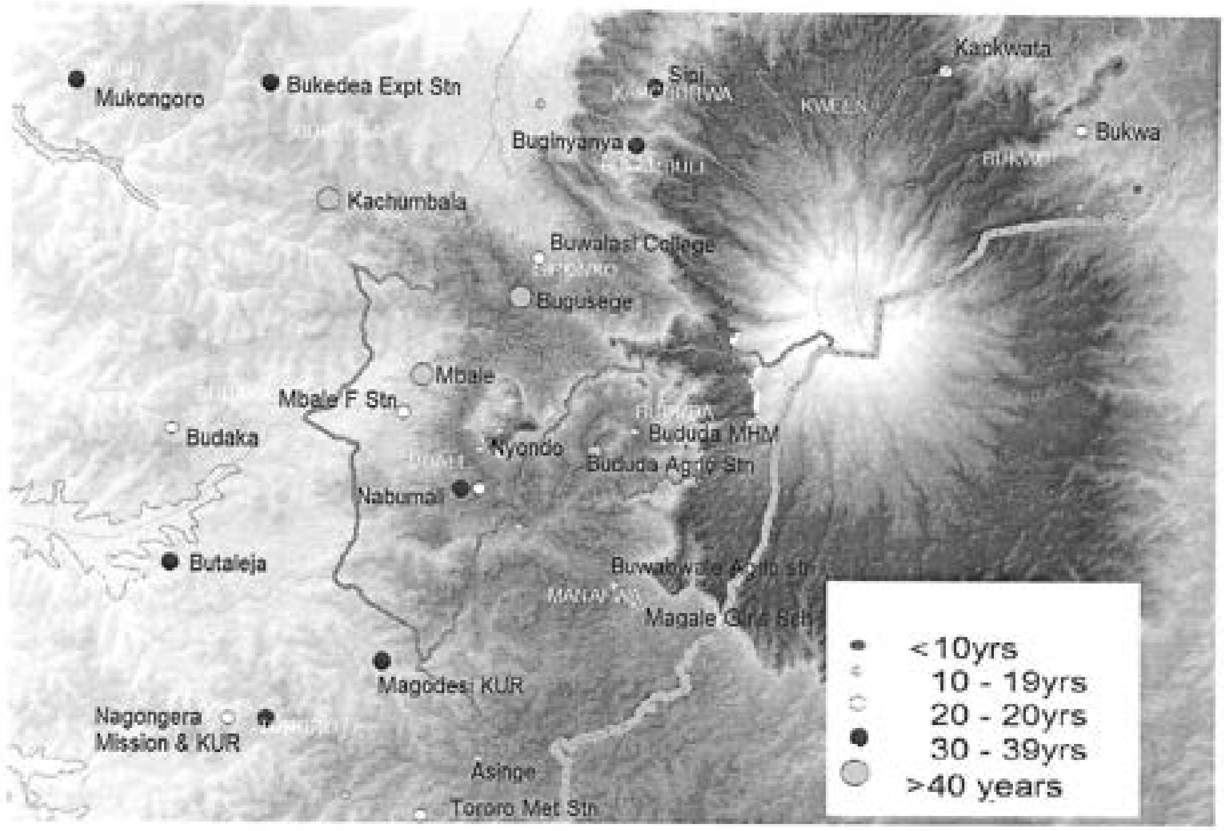

Figure 5: Spatial distribution of weather stations in and around the Mbale region, with the period covered by the weather records

This relatively good coverage of weather stations was not unique to the Mbale region, but was the case for the entire country. Coverage of weather stations in the country was reasonably ok in the 20the century up to about 1980s, however most of these stations are no longer operational. It is recommended that a fully functioning weather station should be maintained within each of the districts. In addition, given the wide range of elevations, Bududa and Manafwa could each operate at least two weather stations, one located in the mid elevation and another in the high elevation areas. These stations should preferably record rainfall, temperature, wind velocity and relative humidity.

2.5 Analysis of historical and current climate for the Mbale region

2.5.1 Historical and baseline climate data

In this study, all climate data collected prior to 2000 is described as historical and the 30-year period from 1961 to 1990 as the baseline climate. Temperature in the region varies both in time and space. Spatial variations in temperatures are larger than variations in time throughout the year (i.e. changes in temperature as one moves up the mountain are larger that seasonal changes in temperature in any one area). The large spatial temperature variation is driven by the large change in elevation from about 1100m asl to more than 4000m in the northeast. Mean annual temperature in the region ranges from 21-23 °C in the low elevation areas in the east to 15 to 16°C in the high elevation areas in the west. Mean annual temperatures drop to as low as 2 °C high up the mountain in Eastern Bududa district. On an annual timescale, February has historically been the warmest month in the region with average maximum temperature of about 31.1°C (Figure 6, is an example of temperature from Buginyanya station representative of high elevation areas in the region, such details temperature records were not available for low elevation areas). Thus, the warmest three months are December, January and February. From March as the rain season sets in temperatures, start dropping up to June and July, which are the coolest months with average maximum temperature of 28°C. Then temperatures gradually rise again in August (Figure 6). Generally, there has been an increase in temperature in the Mbale region over the last 40 years. Again, February, which is the warmest month, registered higher changes in temperature than other months over time (Figure7).

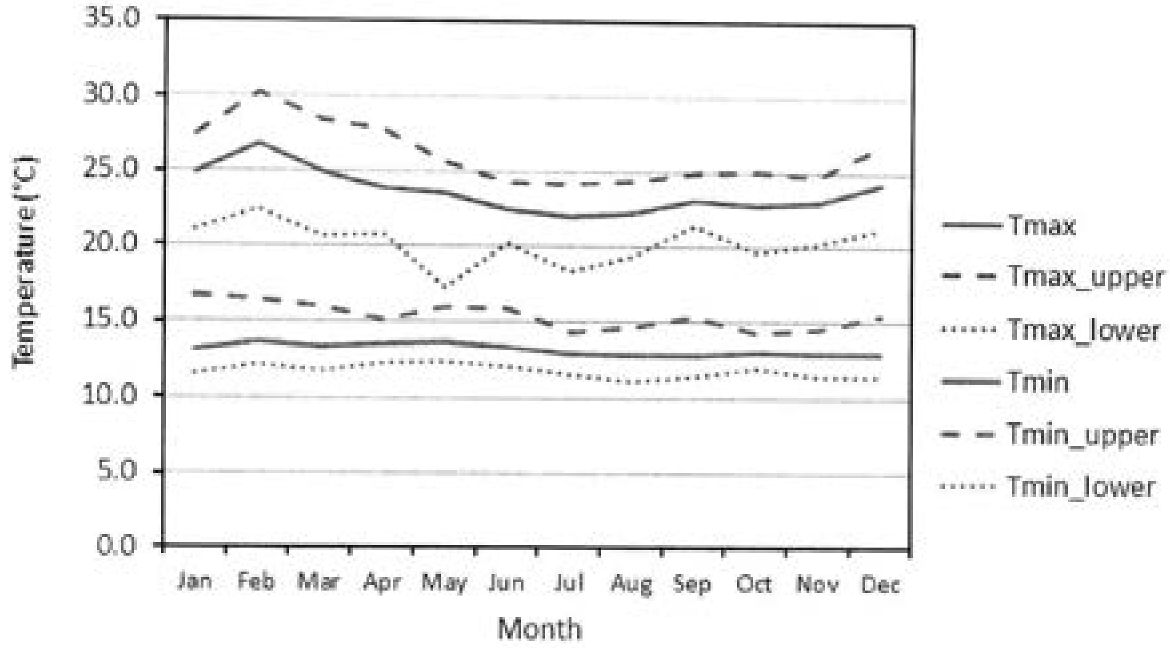

Figure 6: Mean monthly temperature range (maximum and minimum temperature, upper and lower limit of maximum and minimum temperature) for Buginyanya weather station for the 2002-2011 period.

As expected, temperatures in lower elevation areas in Mbale Region are warmer than high elevation areas up the Mount Elgon. There is wide temperature range from the low elevation such as west of Mbale town to the high elevation areas within the Mt. Elgon National Park in the eastern part of Bududa District (Table 2). Rainfall also varies with altitude, with high elevation areas wetter than low elevation areas.

There has generally been a 1°C increase in temperature in the last decade compared to the 1971-2000 normals. Larger changes in both minimum and maximum temperature have occurred in the dry season months, particular December, January and February (Figure 7 and 8). Figures 7 and 8 indicate differences between annual values from a long term 1971-2000 average and also indicate that overall, the change in minimum temperature is higher than the change in maximum temperature for most months of the year (September to April). February registered the highest change in temperature (Figure 8). The figures also show the large year-to-year variation in mean temperature values. However, despite the large year-to-year variation in mean temperatures the long-term trends for both minimum and maximum temperature are clear.

In terms of precipitation, Mbale District on average receives a lower rainfall than surrounding areas in Bududa and Manafwa Districts. The exception to this generalization is Wanale Hill, which receives high rainfall due to its altitude (Table 2).

Table 2: Comparing the annual temperature range and spatial temperature variation for five towns in the Mbale region

Variable		Town /Elevation (m asl)				
		Mbale / 1141	Bulucheke/ 1347	Butiru/ 1384	Wanale / 2109	Mayenze / 1328
Mean annual temperature (°C)		23	21.4	19	14	22.3
Min temperature (°C)	Feb	16.9	15.2	14.9	12.6	16.1
	June	16.8	14.9	14.5	12.2	15.8
	Oct	16.3	14.8	14.6	11.2	15.5
Max temperature (°C)	Feb	31.4	29.9	29.8	29.8	30.6
	Jun	28.2	27.0	26.9	23.6	27.5
	Oct	28.9	27.5	27.8	23.9	28.2
Mean annual precipitation (mm)		1183	1452	1458	2064	1373

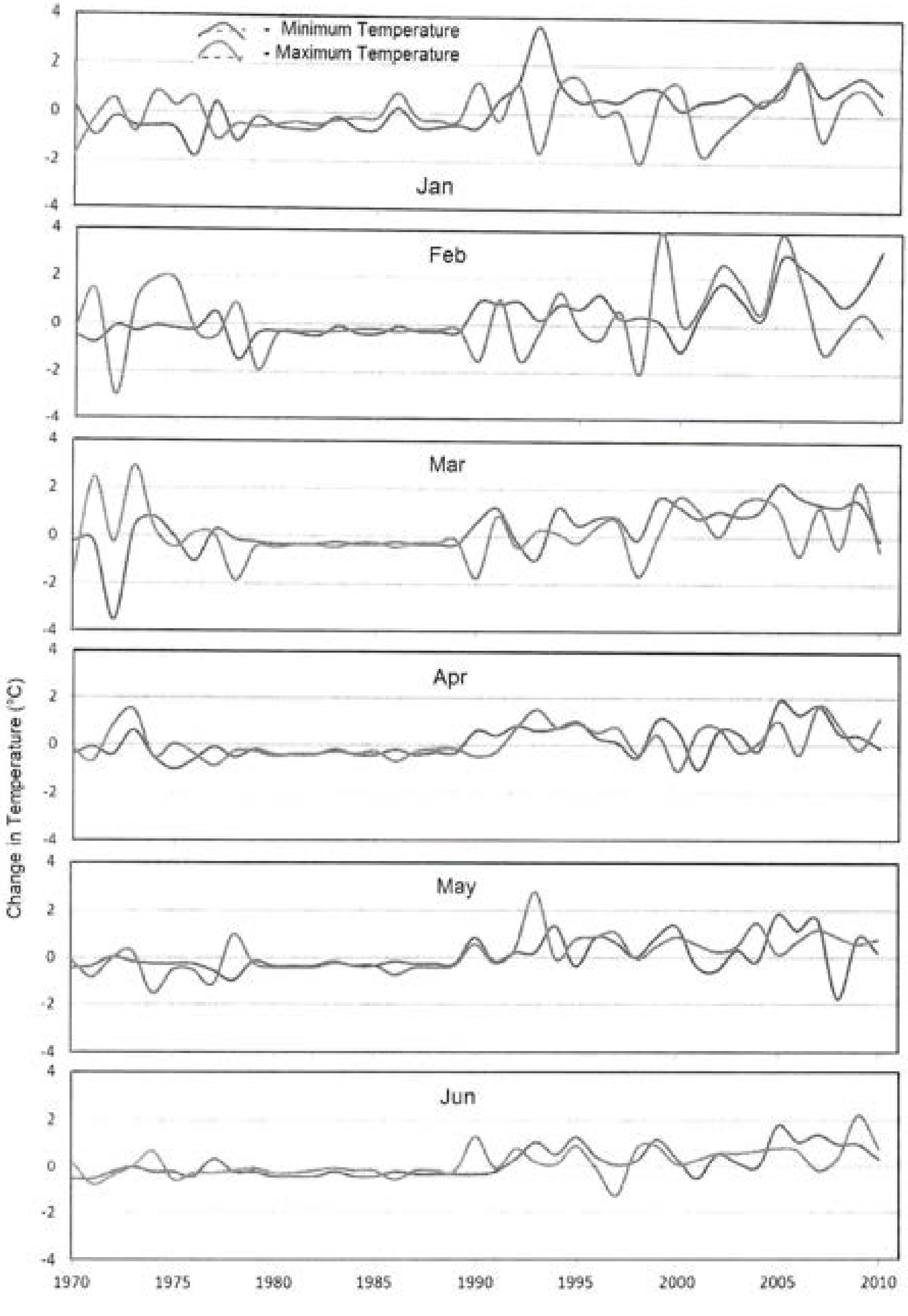

Figure 7: Temperature trends over a 40-year period for Buginyanya for January to June. Change in temperature is indicated as the difference between month values for each year from the 1971-2000 30-year average.

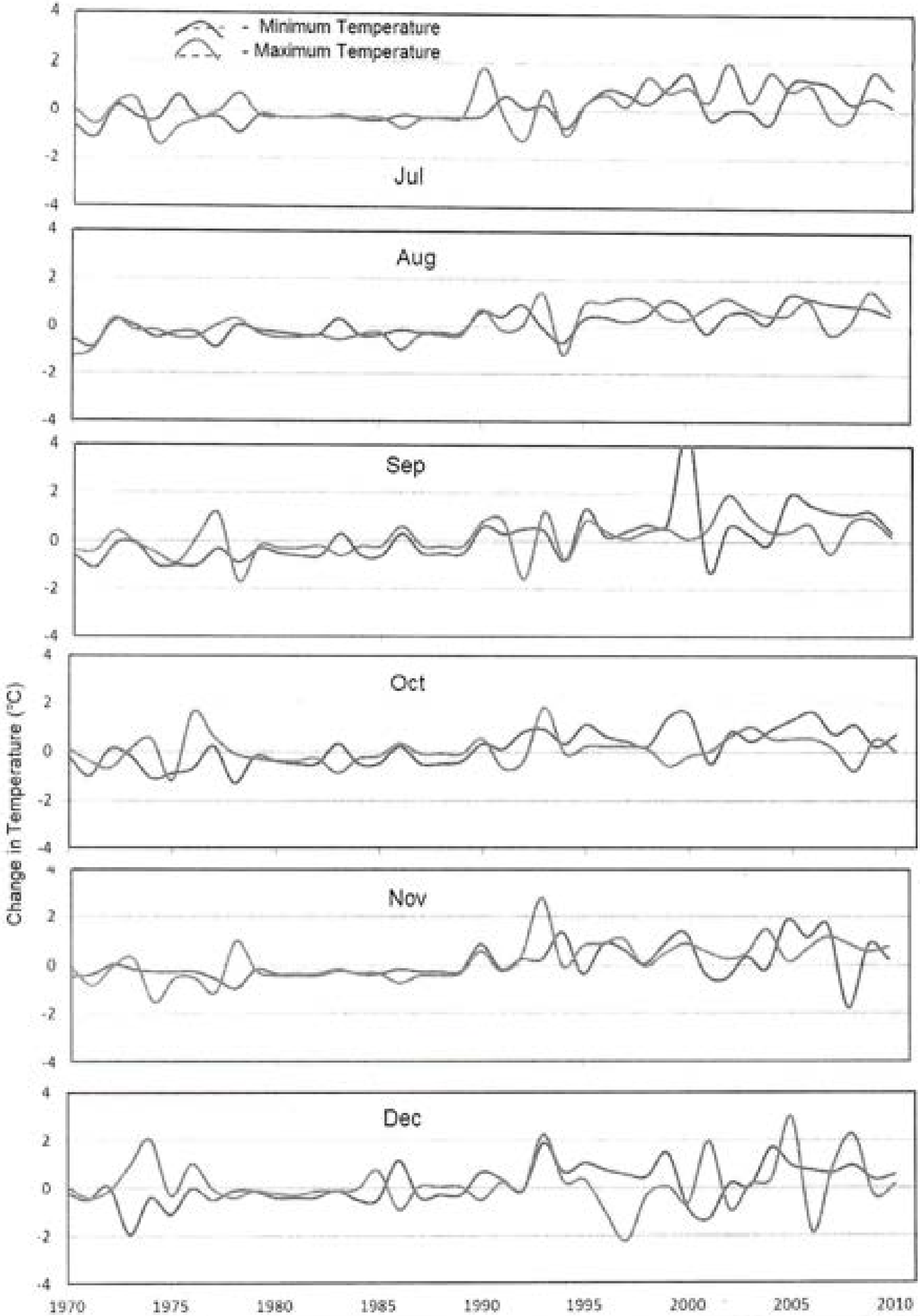

Figure 8: Temperature trends over a 40-year period for Buginyanya for July to December. Change in temperature is indicated as the difference between month values for each year from the 1971-2000 30-year average.

Table 3: Thirty-year average (1961 to 1990) monthly minimum, maximum temperature and monthly rainfall at Mbale (1141 m asl) and Buginyanya (1870 m asl) weather stations

Month	Minimum Temp (°C)		Maximum Temp (°C)		Rainfall (mm)	
	Mbale	Buginyanya	Mbale	Buginyanya	Mbale	Buginyanya
January	16.4	16.5	31.7	30.6	31	45
February	16.9	17.0	31.4	30.7	52	73
March	17.3	17.3	30.5	30.2	89	123
April	17.5	17.4	29.0	28.8	147	217
May	17.2	16.9	28.2	28.0	170	233
June	16.8	16.4	28.2	27.8	102	180
July	16.5	16.1	27.5	27.4	106	190
August	16.3	15.9	27.9	27.8	111	243
September	16.2	16.0	28.6	28.7	86	199
October	16.3	16.4	28.9	29.2	92	217
November	16.4	16.3	29.4	29.0	76	134
December	16.3	16.0	30.0	29.9	37	41

The rainfall pattern in the region is bimodal, with two rain seasons (Figure 9, 10 and 11). The first (main) rainy season starts at the end of March and stretches to end of May. The march to May rain comprise the main rain season. The second ("short") rainy season starts around June and continues to August or even October in some locations (Figures 9-11). In the past, the August to October period brings relatively less rainfall compared to the March to May period for most locations. The dry season in the Mbale region extends from the end of October until the end of February (Figures 9-11). The number on rainy days per month ranges from about 2-3 days in the dry season to about 12 days per month in the rainy season.

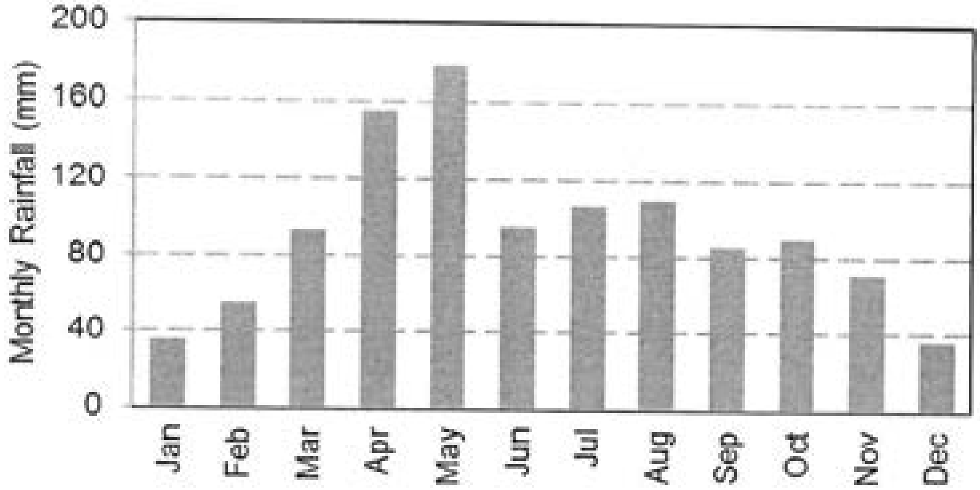

Figure 9: Average monthly rainfall totals recorded at Mbale weather station over the 1960 to 1987 period

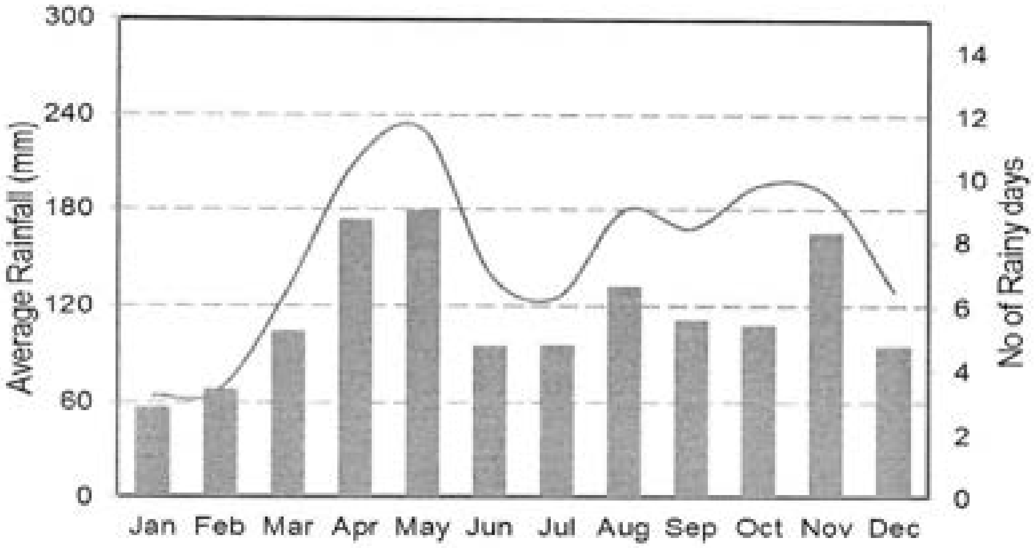

Figure 10: Average monthly rainfall totals and average number of rainy days per month recorded at Manafwa weather station over the 2002 to 2011 period

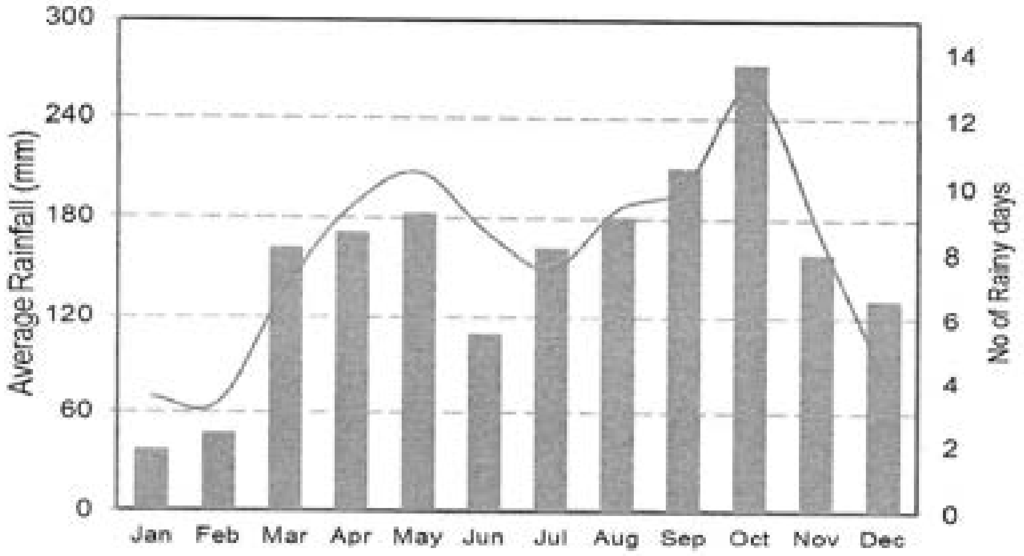

Figure 11: Average monthly rainfall totals and average number of rainy days per month recorded at Buginyanya weather station over the 2002 to 2011 period

The general trend for rainfall is not as straight forward as that for temperature; there is high variation in monthly rainfall amounts over time. For example, over the last 5 decades, the December to February period, which is a relatively dry season received on average less than 50mm of rainfall per month for both low elevation (Figure 12 and 13) and high elevation areas (Figure 14 and 15). There has been a recent trend towards higher rainfall amounts being received towards the end of the main rainy season, with more rainfall in May than in April or March. At the end of June, there is a short-duration dry spell but the region continues to receive some rainfall until November. This second rainy season peaks around September to October.

Low elevation parts of the Mbale Region in Mbale and Manafwa District, receive relatively lower rainfall amounts than high elevation areas in Bududa and Manafwa Districts (Table 3). Despite this elevation gradient, the distribution of rainfall in these areas is similar throughout the year.

Changes in rainfall have not been uniform throughout the region. Whereas higher elevation areas have recently received more rainfall (above 1961-1990 mean values), lower elevation areas to the west particularly around Mbale town are receiving moderately lower rainfall than the 1961-1990 mean values for all months except October (Figures 12 and 13). In other locations, the recent decades have seen higher rainfall totals recorded compared to the 1961-1990 normals. More rainfall was recorded at Buginyanya weather station for all months in the last 10 years except the dry season months of December, January and February and March (Figures 14 and 15). These values are in agreement with information gathered in discussions with local farmers and what is reported elsewhere on the dry season getting worse than before and the rains coming late. Typically, rains were expected at the beginning of March but more often, the rainy season now starts towards the end of March or even in April.

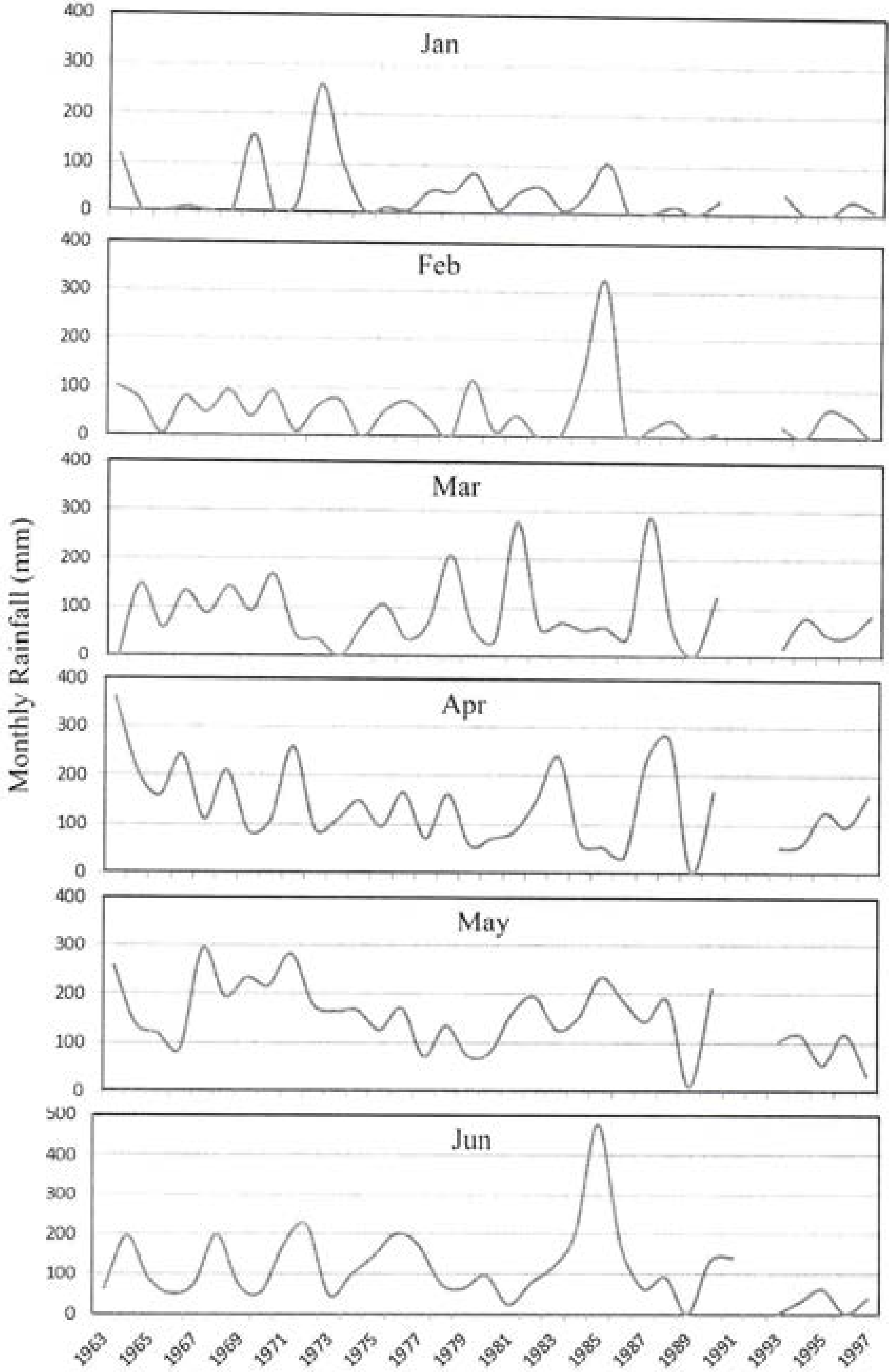

Figure 12: Trends in January to June rainfall recorded at Mbale weather station from 1963 to 1997

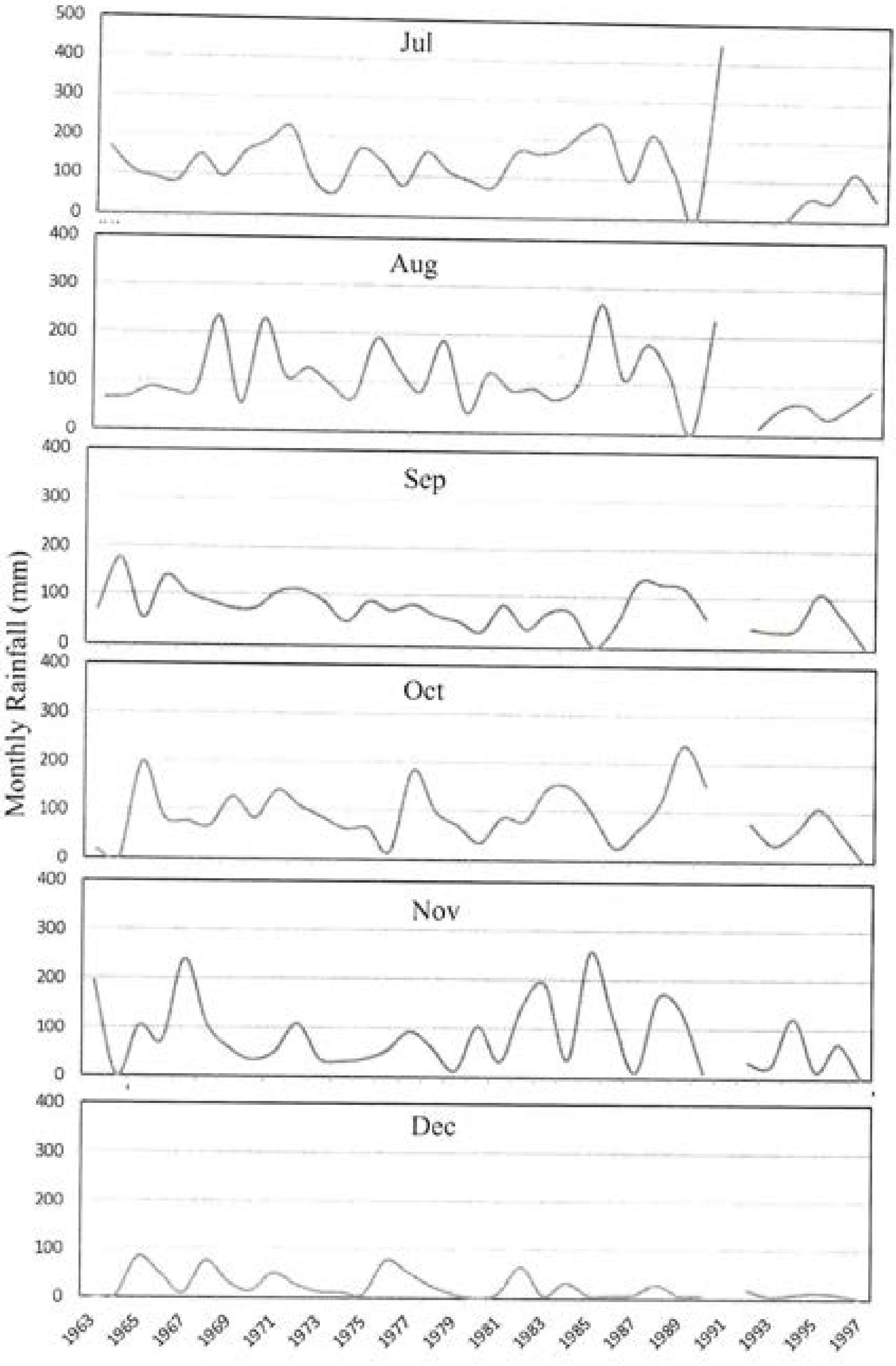

Figure 13: Trends in July to December rainfall recorded at Mbale weather station from 1963 to 1997

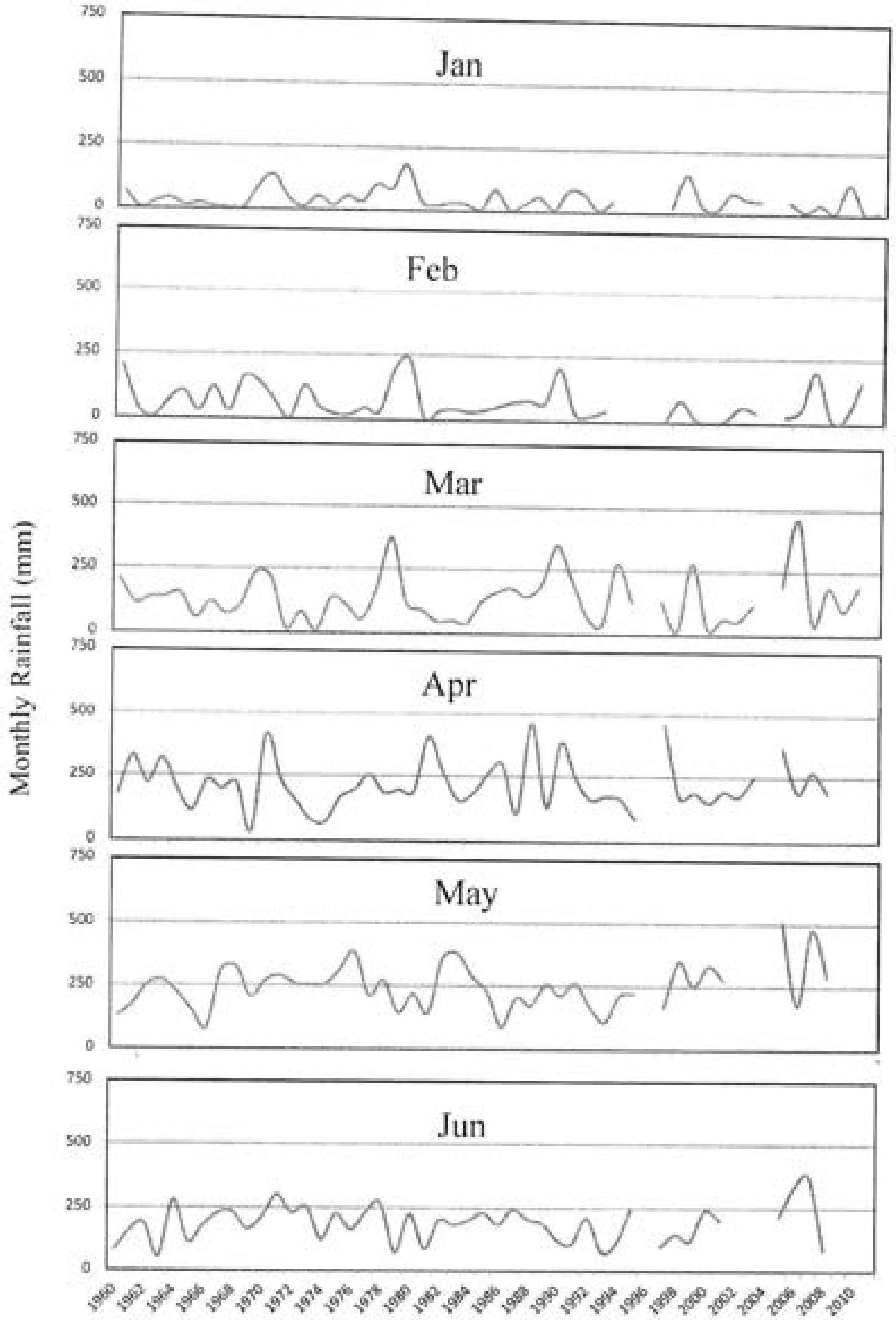

Figure 14: Trends in January to June rainfall recorded at Buginyanya weather station from 1960 to 2010

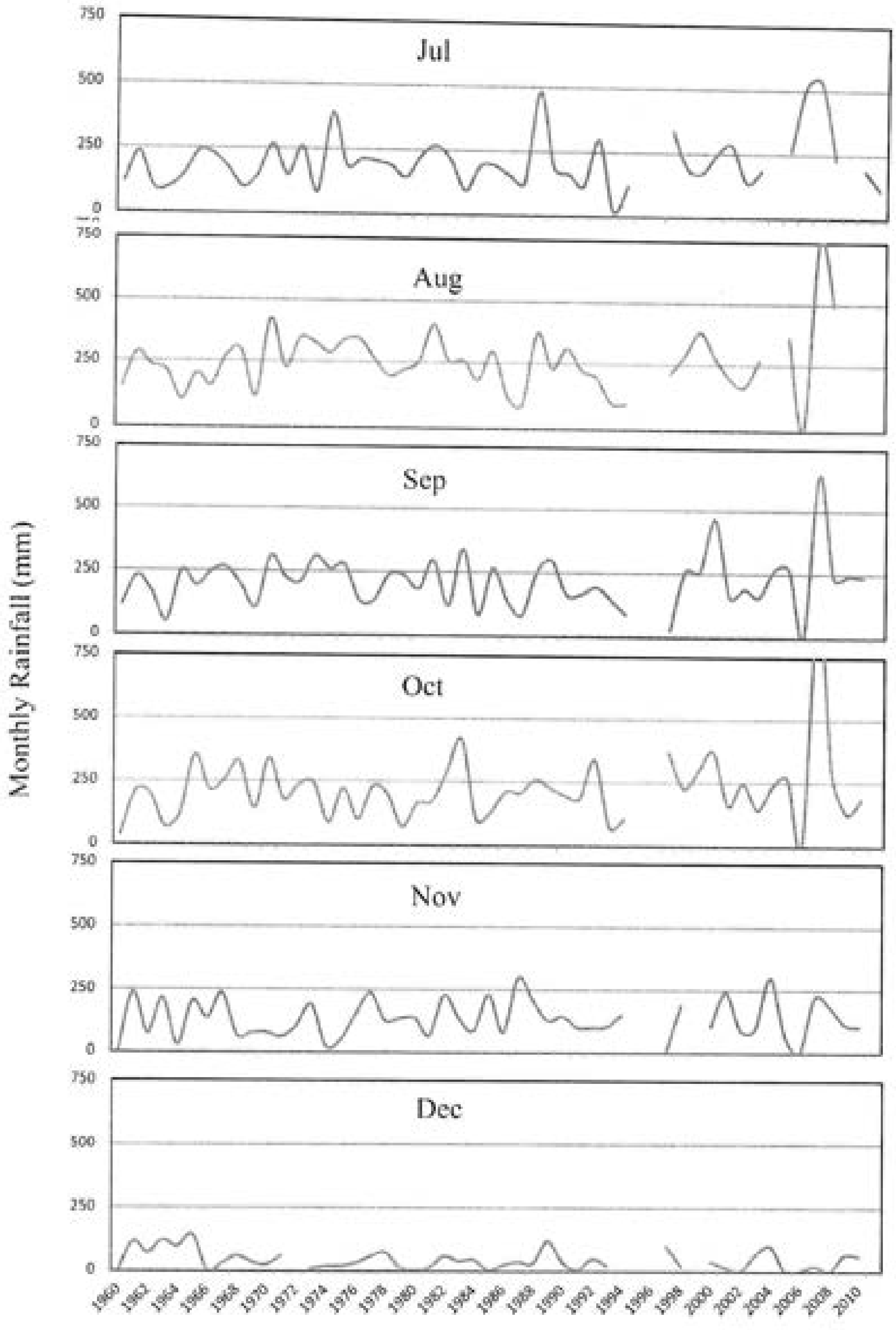

Figure 15: Trends in July to December rainfall recorded at Buginyanya weather station from 1960 to 2010

2.5.2 Baseline climate grids

Evaluation of climate change impacts typically makes use of both baseline and projected climate data to make spatial predictions of species habitat and anticipated changes in the future (Hijmans and Graham, 2006; Pearson and Dawson, 2003). Baseline climate data serve as the reference point for describing climate change. The other use of baseline climate grids data is that it is this data, which is combined with changes or anomalies which provide projections of future climate. Baseline climate data is used to establish the current vulnerability of environmental and socio-economic systems, identifying critical climate thresholds in characterizing risk and in defining features of high impact (extreme weather events) under present day climate (Lu 2007). The IPCC recommends the use of 1961 – 1990 period as the baseline for the assessment of climate change over the 21st century. This report will also use the 1961 – 1990 30-year period as the baseline for assessing change in climate over the Mbale region.

Numerous climate modeling efforts have generated climate grids, mainly from weather station data using a number of interpolation techniques. The quality of the climate grids is a function of the original weather station records as well as the interpolation techniques used to generate spatial grids from point climate data. Current climate data for the Mbale region of Uganda, as for many locations around the world, are available from global interpolation efforts such as Worldclim (Hijmans et al., 2005) that generated climate grids for maximum and minimum temperature and monthly precipitation at 30arc min or the equivalent (approximately 1km). The other common global scale climate dataset commonly used is from the Climate Research Unit (CRU) at the University of East Anglia in UK, which is at a 0.5 degree resolution (Mitchell and Jones, 2005). It is however recognized that the seemingly higher resolution in the Worldclim dataset is largely a result of the interpolation process and not related to the availability of 'extra' climate data.

An evaluation of a third climate dataset was performed to decide which set to use for describing climate for the Mbale region. Climate data from PRECIS (Providing REgional Climates for Impacts Studies) experiments for Uganda and surrounding region were part of Regional Climate Model (RCM) experiments conducted in by Lucinda Mileham at the Geography Department of the University College of London using PRECIS developed at the Hadley Centre of the UK Met Office. This data was also found to be at a coarser resolution than the WorldClim data and is dependent on model biases which render it unsuitable for describing the baseline climate of the region. The Worldclim dataset was therefore finally selected for the analysis of baseline and projected climate (Figure 16). The downscaled WorldClim data provides data which can be used for detailed analysis at local and regional scale (bearing in mind that its accuracy is ultimately dependent on the number of stations and interpolation technique used to produce the grids), such as for the Mbale region, compared to PRECIS or original GCM data, which provides one or two readings for the entire region..

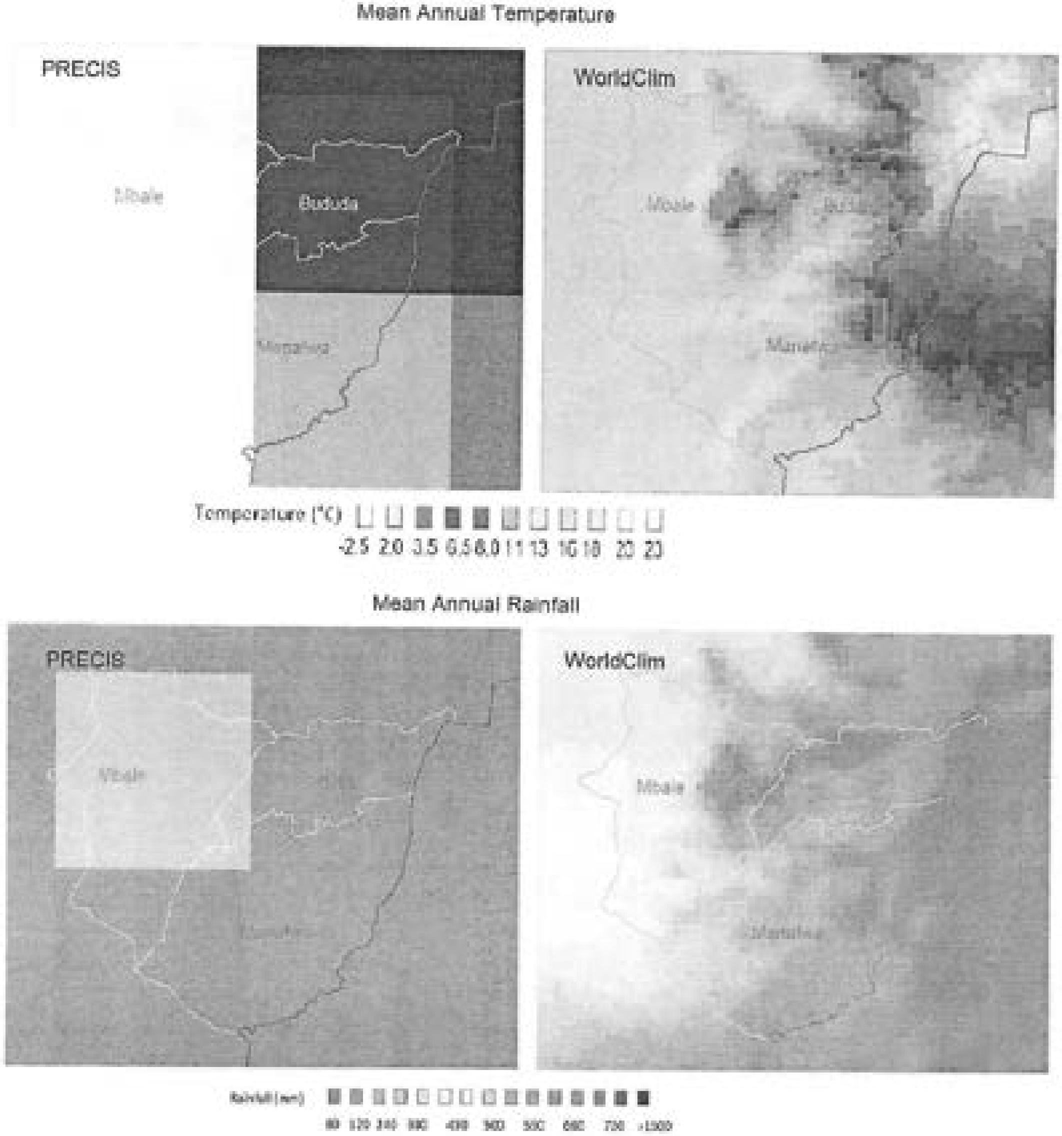

Figure 16: Comparison of available Mean Annual Temperature and Mean annual Precipitation grids for the Mbale region data for the 1961-1990 period from PRECIS and CCAFS downscaled Worldclim datasets

Based on mean annual temperature for the 1961 – 1990 period (Figure 17), within the Mbale region, western and southern parts of the region, particularly the sub-counties of Nakaloke, Bungokho, Busoba, Busiu and Bukiende in Mbale District and Sibanga and Bugobero in Manafwa District are relatively warm. Mid and high altitude locations that lie to the northeast of the region are relatively cooler. High temperatures through the year coincide with the dry season, conversely; the coldest quarter coincides with the main rainy season (Figure 18). Information on seasonal variation in temperature is valuable because this can be used to determine the expected levels of water stress for crops and plants, despite the general increase in rainfall amounts in the region.

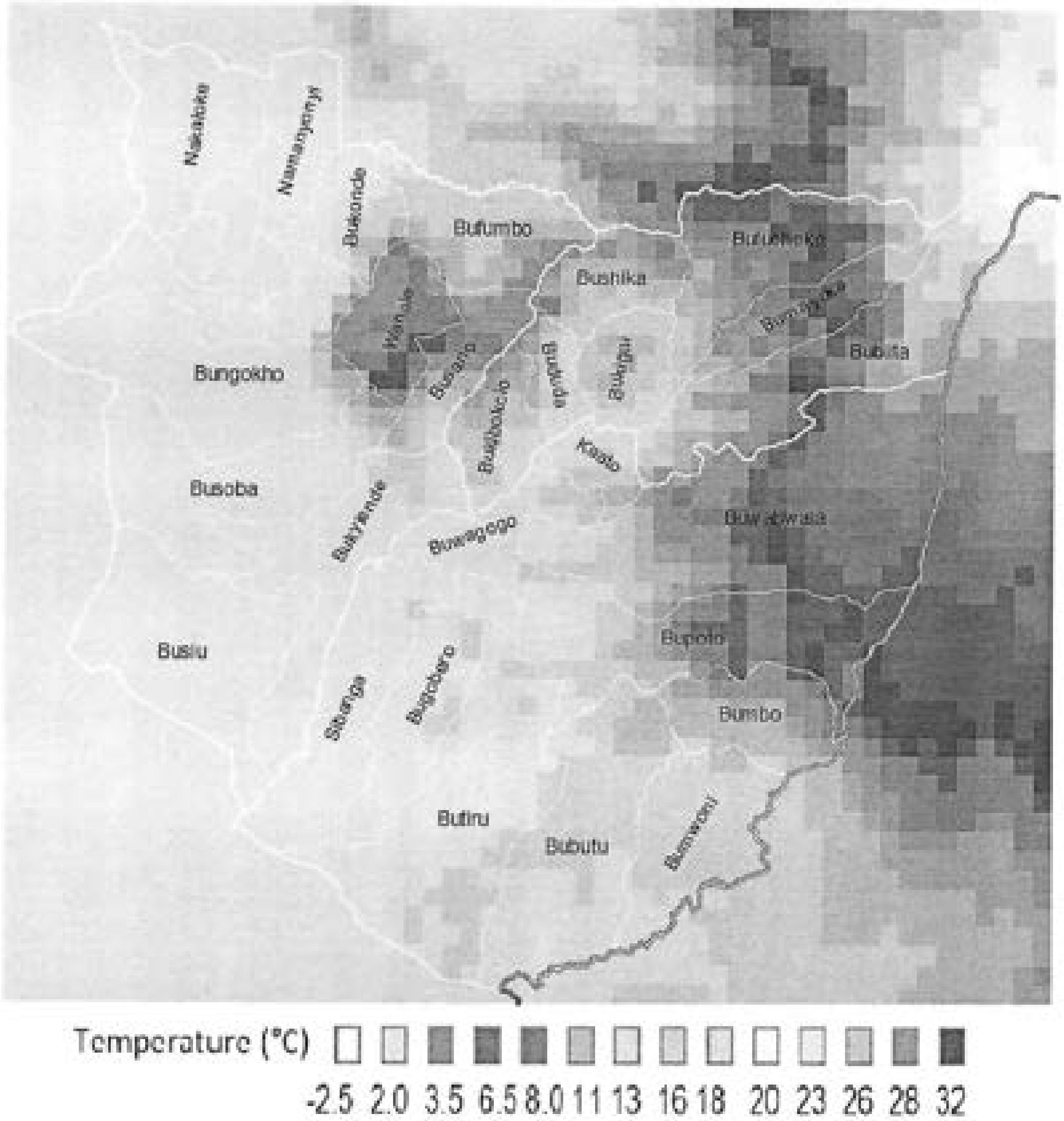

Figure 17: Mean annual temperature for the 1960-1990 baseline period for part of the eastern Africa region

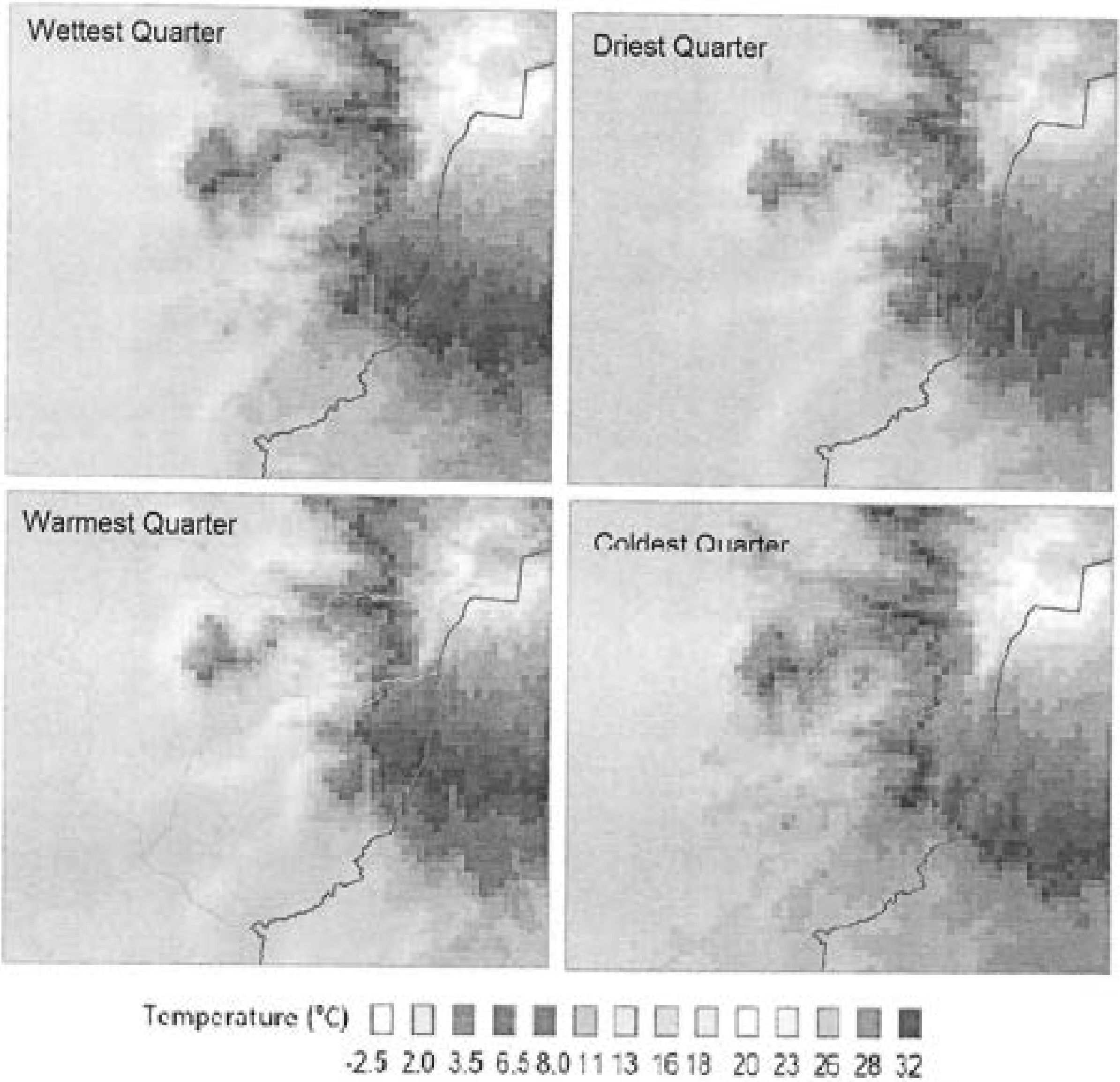

Figure 18: Mean temperature for the warmest, driest, wettest and driest quarter for the 1960-1990 periods

On a monthly time scale, minimum (Figure 19) and maximum temperatures (Figure 20), January February and March are much warmer than May, June and July. Maximum temperatures slowly rise from August and September; by December temperatures have risen to the dry season levels. The range of minimum temperatures in the region throughout the year is much narrower than the range of maximum temperatures.

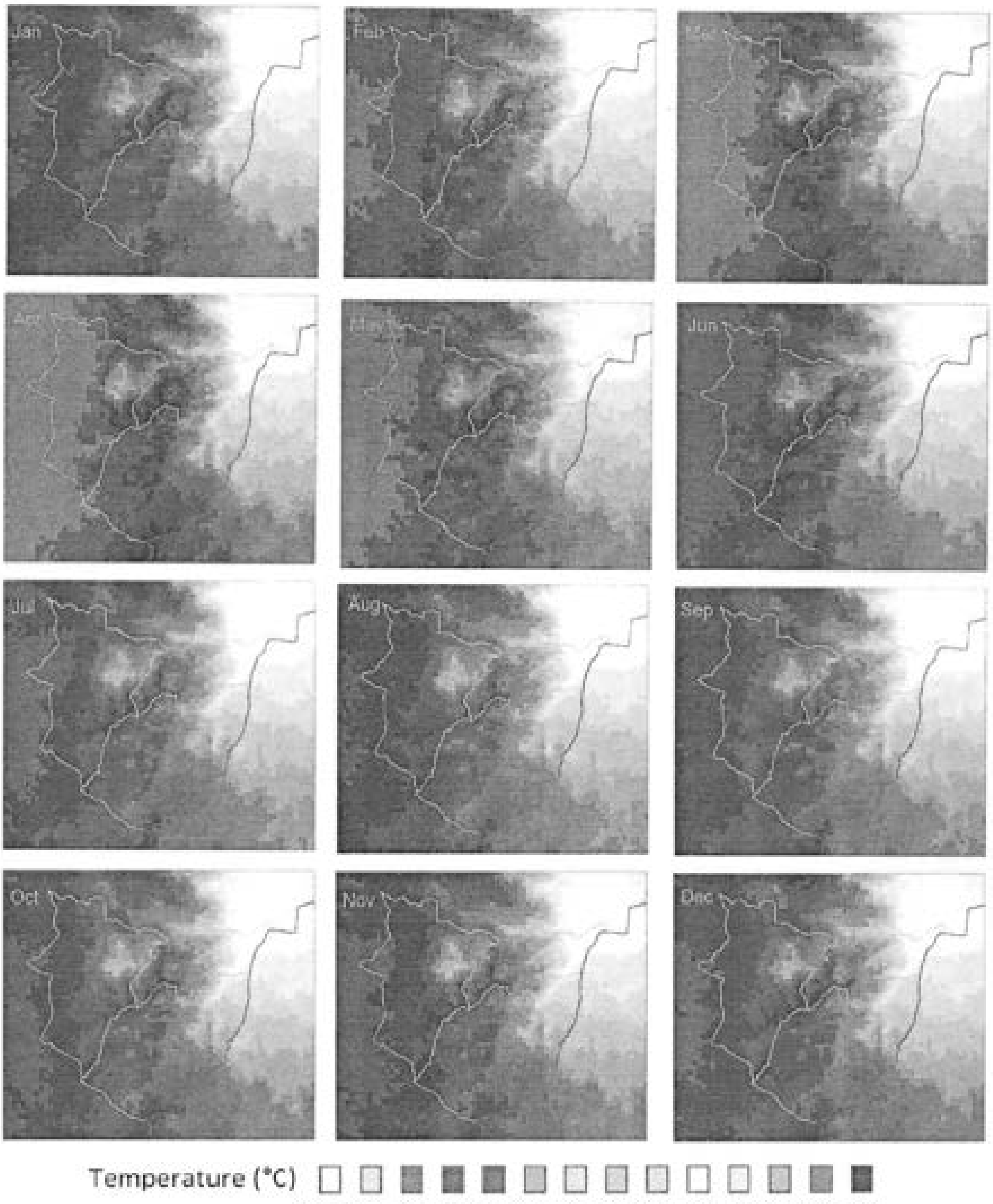

Figure 19: Average monthly minimum temperature for the 1961-1990

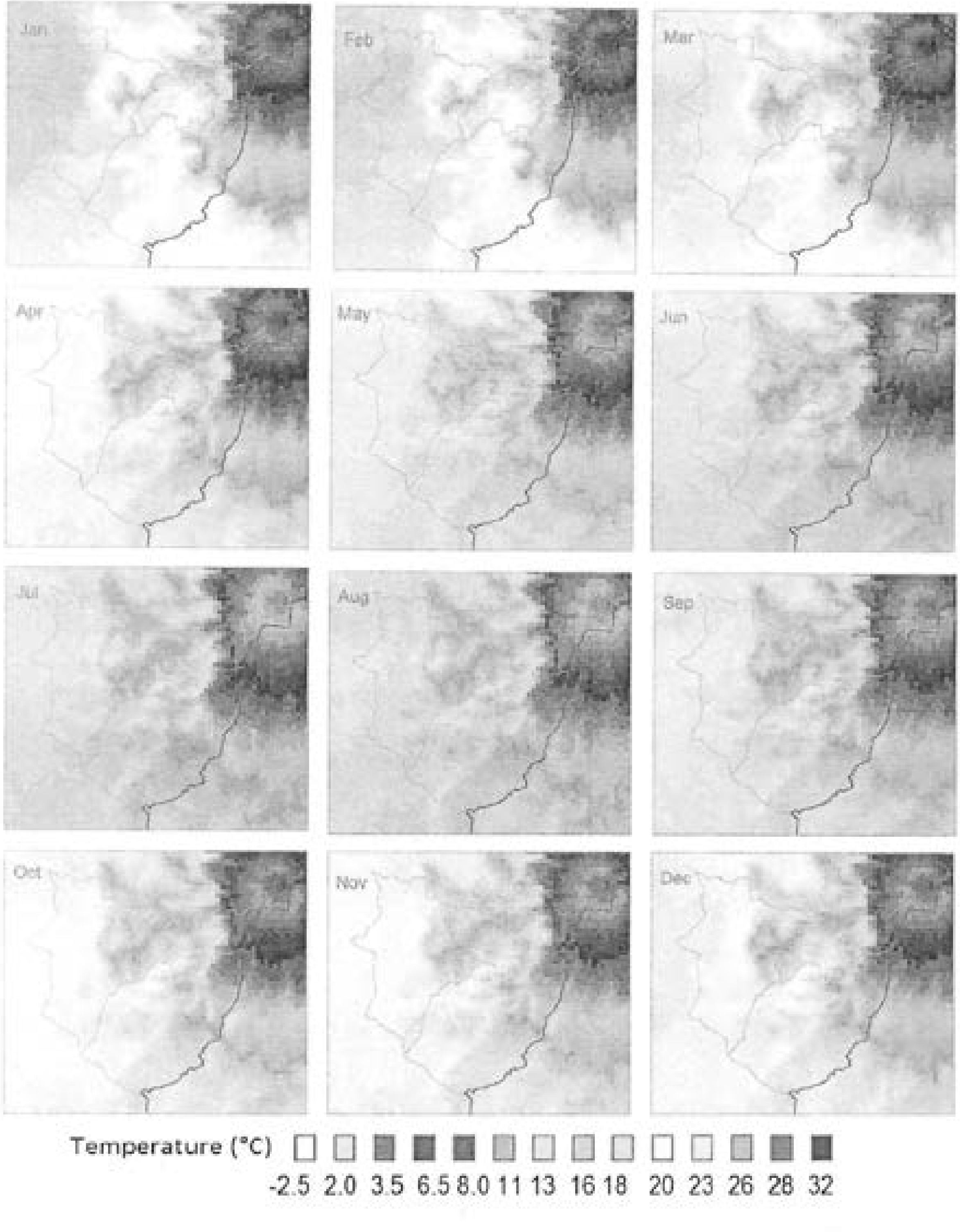

Figure 20: Average monthly maximum temperature for the 1961-1990 period for the Mbale region

Spatially, the amount of rainfall received is not uniform throughout the Mbale region. In general, there is higher rainfall in higher elevation areas. Sub-countries located in the eastern parts receive more rainfall than those to the western. Eastern sub-counties including the Mt. Elgon National Park (Bulucheke, Bumayoka and Bubiita in Bududa, Buwabwala, Bupoto and Bumbo) receive more rainfall probably because they lie at mid and high elevations (Figure 21). Wanale Hill, which is a high elevation area (>1800m asl) in Mbale District also receives relatively higher rainfall than the surrounding low elevation areas (~1200m asl).

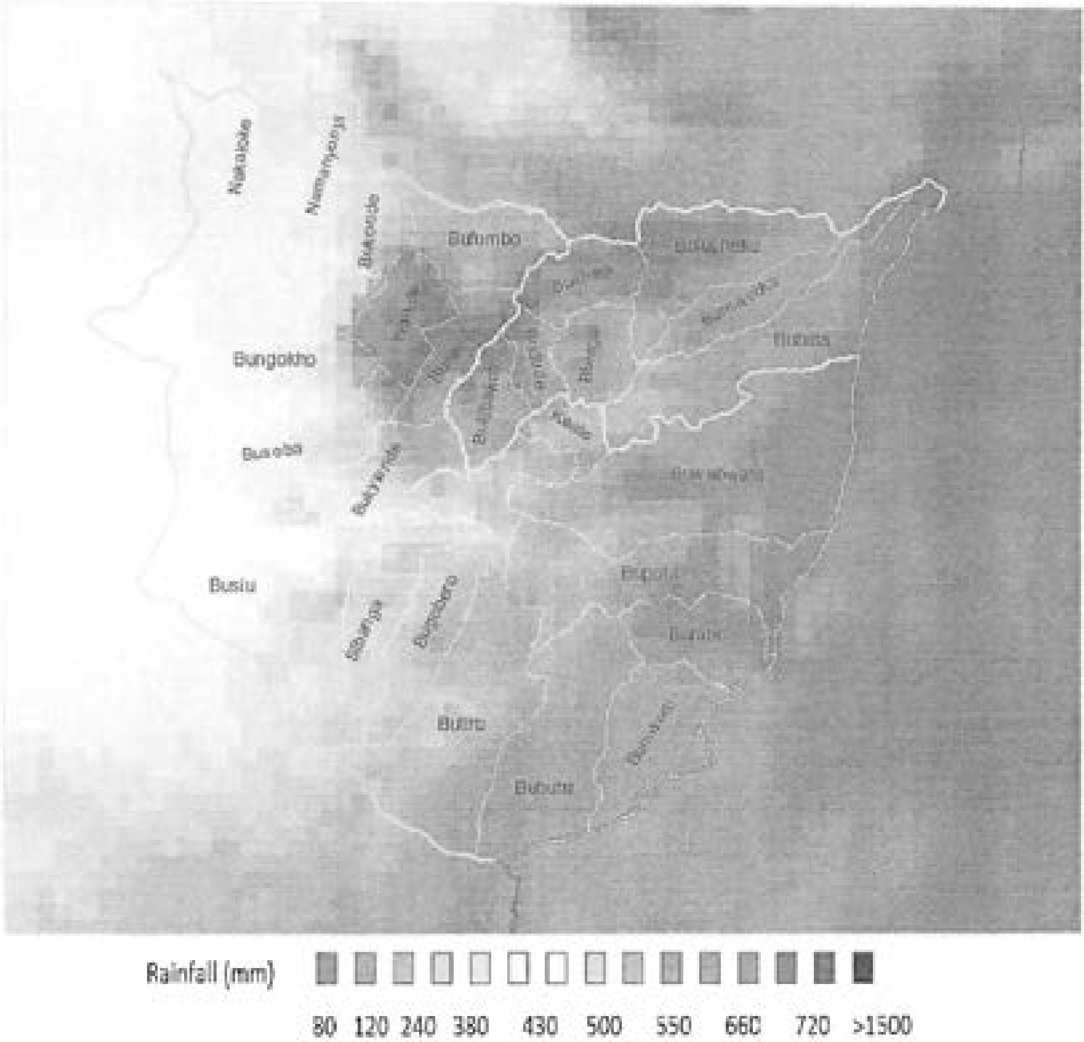

Figure 21: Mean Annual Precipitation for the 1960-1990 baseline period for the Mbale region

December and January were the driest months during the 1961-1990 period receiving less than 40mm rainfall. The first rain season starts in March and peaks in May with a monthly average of 180mm. Rainfall amounts drop in June to about 100mm for the next three months. For the next few months, August to December receive lower rainfall amounts, averaging to about 70mm per month. Patterns of rainfall in other parts of the region are similar to that in Mbale, only varying in magnitude (e.g. Buginyanya station averages about 200mm from April to October during the 1961-1990 period) (Figures 22 and 23).

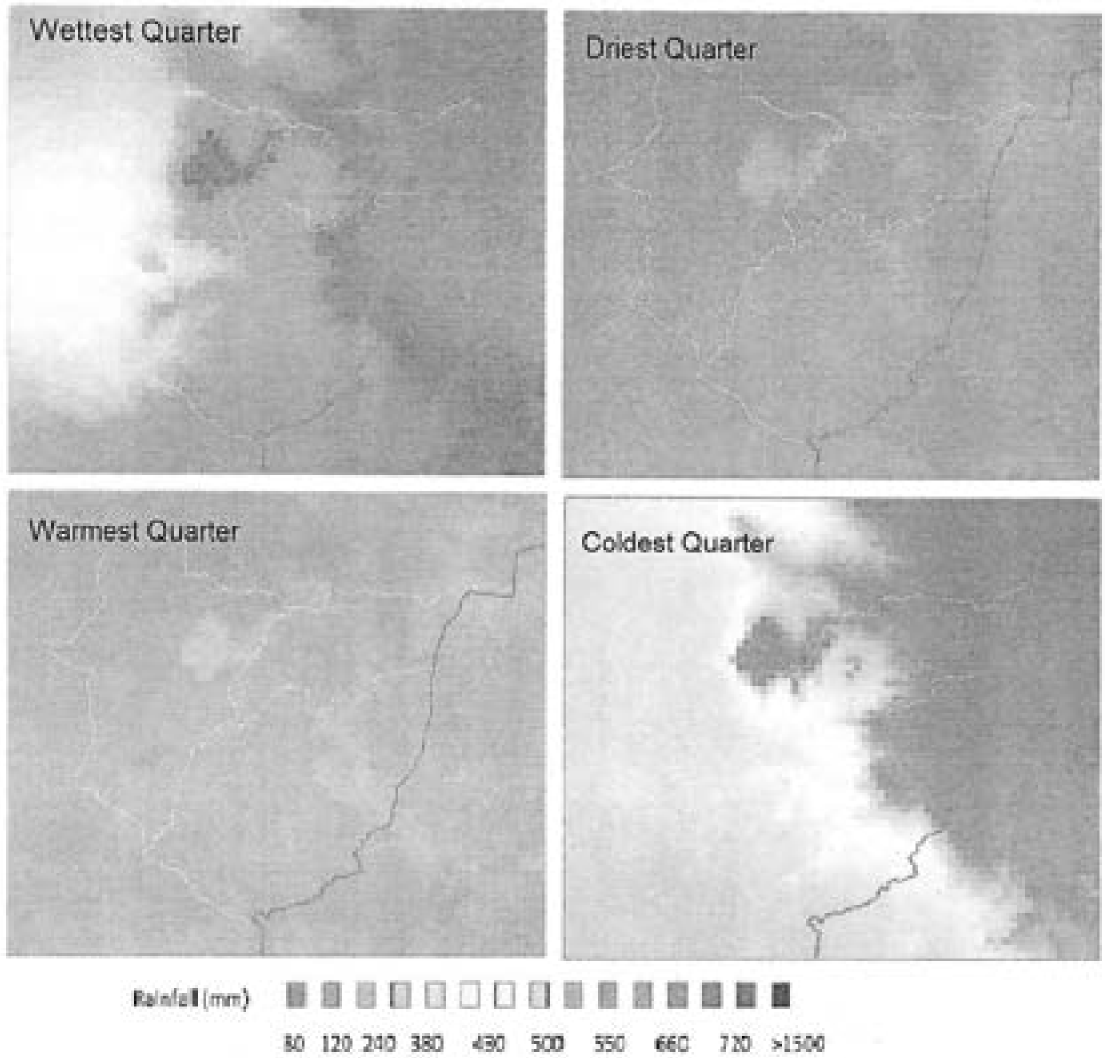

Figure 22: Mean Precipitation for the warmest quarter, coldest Quarter, wettest and driest quarters during the 1960-1990 baseline period for part of the eastern Africa region

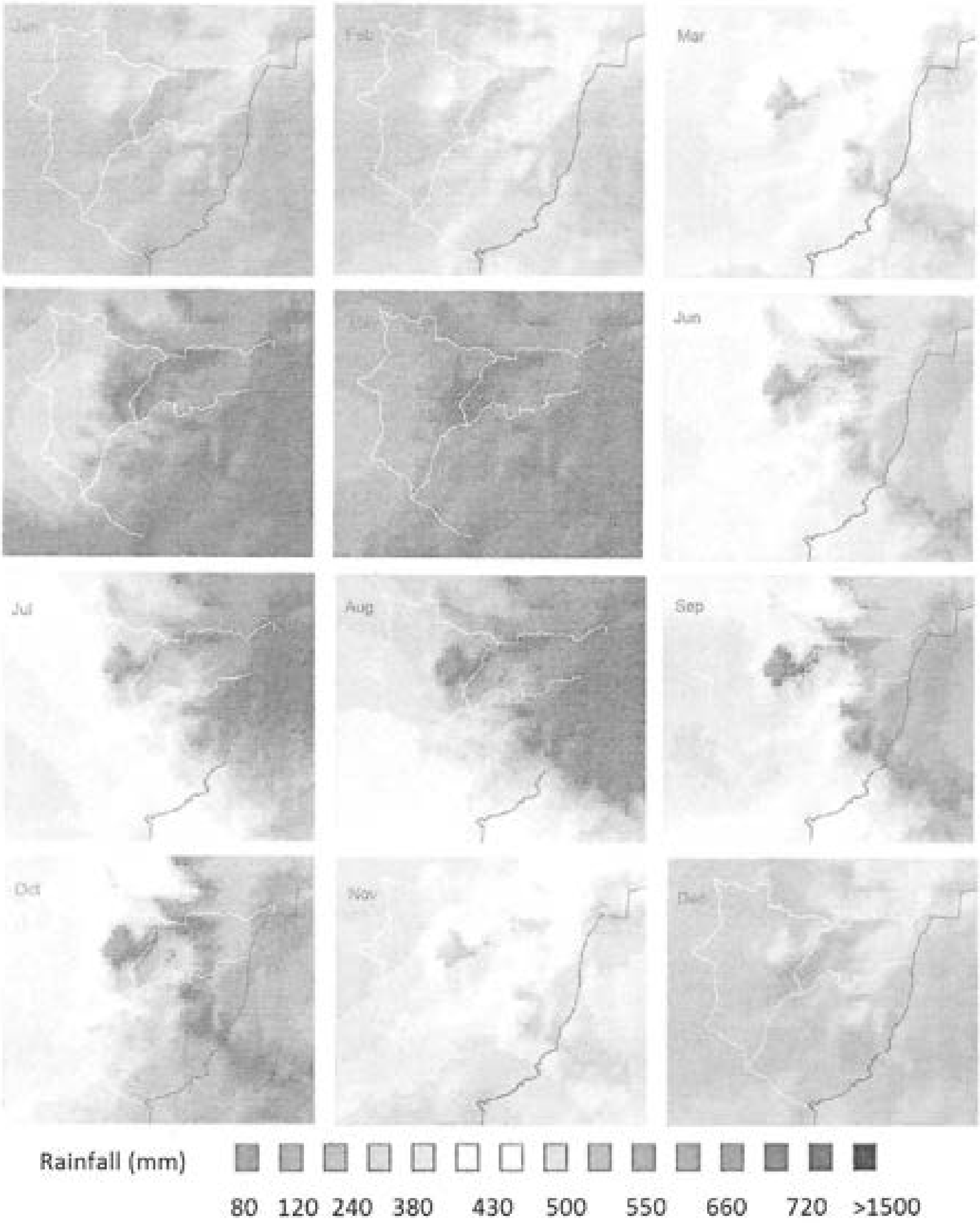

Figure 23: Average monthly rainfall for the 1961-1990 period for the Mbale region

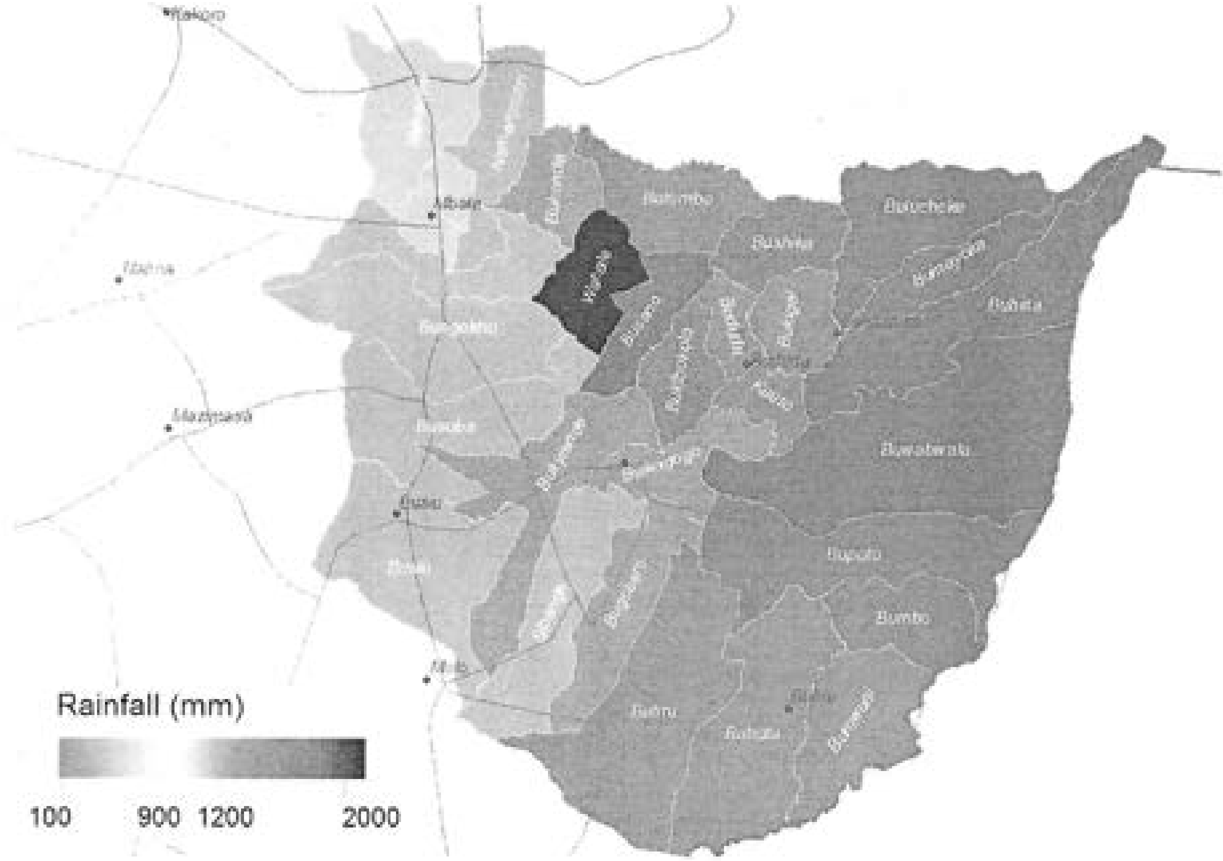

Figure 24: Mean annual precipitation by sub-county in the Mbale region for the 1961-1990 period

2.5.3 Current climate (2000-2011)

Mean maximum temperature over the last decade (2002 to 2011) for Buginyanya lie between 26.9 °C in February and 22.2°C in July. Maximum temperatures have ranged between 30.2 °C and 17.2°C. Mean minimum temperature ranged between 13.7°C and 12.9°C. There has been an increase of between 0.4 and 1.2°C in mean monthly temperatures in the Mbale region during the 2001-2011 period over the 1961-1990 normals (Table 4).

The three districts (Mbale, Bududa and Manafwa) lie on the southwestern slopes of Mt. Elgon. The rainy season begins in March. There has been no significant change in the last two decades for March, April precipitation. However, whilst there are indications that May, June and July have received up to a 13-15% increase in rainfall in the last decade at Buginyanya station (Table 5), there were often decreases in the previous decade relative to the 1961-1990 baseline period. This suggests that multi-decadal changes (wet and dry periods over 10-20 year periods) are significant and care must be taken in attributing rainfall changes over 10 years to climate change.

Rainfall has remained biomodal, as described during the baseline period, the main rainy season being March to May and the other rainy season from September to November. One noticeable trend from data recorded at the Buginyanya station is that of relatively higher rainfall in the September to November period (Table 5, Figure 14-15) during the last decade with increases greater than any decreases experienced in the previous decade.

2.5.4 Observed climate changes in the Mbale region

Despite projections into the future, there is no better evidence of changes in climate than the current trends. The most recent decade (2001-2010) has on average been warmer than the three previous decades (1961-2000). According to data from Buginyanya weather station, changes in temperature have been more pronounced in February during which maximum temperature has increased by 1°C and minimum temperature, which is 1.4°C higher than then 1971-2000 average. Overall, maximum temperature in the last decade has increased mainly in January, February and the May to August period. On the other hand, maximum temperatures have increased mainly during the February to March as well as in May to September (Table 4).

Temperature and rainfall records from the Buginyanya station (Table 4 and 5) indicate that the changes in rainfall over the last decade are indicative of more rainfall for the region as a whole, though this is using data from only one station. Rainfall for February, the driest month has continued to reduce over the past 40 years (Table 5). The recent 20 years (1991-2010) period was more than 20% drier than normal. Timeseries for April at Mbale (figure 12) also suggest that rainfall has been decreasing, leading to a later start of the rains in May at that station. In contrast the April to December period (with the exception of June) has become wetter than the baseline at Buginyanya. The increase in rainfall during the July to November period presents an opportunity for growing a wider range of crops than before during the hitherto short second rain season, though it should be stressed that it is not clear if this situation will persist in the future.

Table 4: Changes in minimum (T-Min) and maximum (T-Max) temperature at Buginyanya weather station for the 2001-2010 (10 year average) compared to the 1961 to 1990 baseline

Month	T-Min (°C)		T-Max(°C)	
	1971-2000	10-yr change (2001- 2010)	1971-2000	10-yr change (2001- 2010)
Jan	**16.1**	+1.0	**30.7**	+0.4
Feb	**16.6**	+1.4	**31.0**	+1.0
Mar	**16.9**	+1.2	**30.4**	+0.9
Apr	**17.3**	+0.6	**29.2**	+0.4
May	**16.8**	+0.5	**28.4**	+0.8
Jun	**16.2**	+0.7	**28.0**	+0.7
Jul	**15.9**	+0.6	**27.6**	+0.9
Aug	**15.7**	+0.8	**28.2**	+0.8
Sep	**15.6**	+1.2	**28.8**	+0.6
Oct	**16.1**	+0.9	**29.4**	+0.3
Nov	**16.2**	+0.6	**29.1**	+0.1
Dec	**15.8**	+0.3	**30.0**	+0.4

Table 5: Changes in monthly rainfall at Buginyanya weather station for the 1991-2000 and 2001-2010 (10 year averages) compared to the 1961 to 1990 baseline period

Month	Baseline (1961-1990)	1991-2000 change (%)	2001-2010 change (%)
Jan	**45**	+18.8	+4.4
Feb	**73**	-25.7	-27.0
Mar	**123**	+4.2	-1.3
Apr	**217**	+1.6	+4.8
May	**233**	-11.8	+14.5
Jun	**180**	-27.9	-2.6

Jul	**190**	-9.1	+20.5
Aug	**243**	-9.4	+24.6
Sep	**199**	-13.0	+30.3
Oct	**217**	+1.8	+31.5
Nov	**134**	-4.5	+10.9
Dec	**41**	-14.6	+37.3

2.6 Projecting future climate data for the Mbale region.

Comparisons of projections of future climate were performed for 44 climate variables (monthly maximum and minimum temperature monthly precipitation for 12 months). In addition, data for biologically important variables such as mean annual temperature, mean temperature of the warmest quarter, mean temperature of the coldest quarter, mean temperature of the wettest quarter, mean temperature of the driest quarter, total precipitation of the wettest quarter, total precipitation of the driest quarter, precipitation of the hottest quarter and precipitation of the coldest quarter (see Annex 2 for a description of all the climate variables).

Data presented covers the 2011 to 2040 and the 2041 to 2060 30-year time slices or the 2020s and 2050s respectively and from the 4 general circulation models and 3 emissions scenarios as indicated in Annex 3. The general trend shows more warming in the future. Changes in minimum temperature are small compared to those in maximum temperature for all locations. Large increases in temperature during the wettest quarter means that the effect of higher rainfall may not be as significant as if temperatures remain unchanged, due to increasing evaporation. On the other hand, higher temperatures during the driest quarter points to worsening of the dry season in the Mbale region, due to increasing evapotranspiration.

Projected changes in rainfall are not uniform in space and time, some months are projected to get wetter while other drier (see above). Despite this, there is a reasonable level of consistency in the projected trends for higher annual rainfall. For example, all models agree with the projected reduction in the rainfall for April for both the 2010-2039 to 2040-2069 periods (Table 5). Additionally there is agreement in projected increase in rainfall for May for the 2010-2039. There is little agreement in projected changes in rainfall for the 2040-2069 period. This is not considered a serious a limitation in the context of this study, since the near future (2010-2039) is the most relevant period for most development planning in response to climate change.

Table 6: Range of projected changes in mean annual rainfall at six selected sites in the Mbale region

Location	Baseline (mm)	Projected changes (% min to max)	
		2020s	2050s
Buluchecke	1776	-5.1 to +8.3	-5.1 to +8.3
Bududa	1188.0	-7.6 to +11.4	-7.6 to +11.4
Mayenze	1783.0	-5.1 to +8.1	-5.1 to +8.1
Butiru	1226.0	-7.4 to +11.3	-7.4 to +11.3
Busiu	1781.0	-5.1 to +8.3	-5.1 to +8.3
Mbale	1178.0	-8.0 to +11.6	-8.0 to +11.6

Projected changes in precipitation or temperature remain uncertain. Uncertainties in projections come from various sources, including emissions scenarios. Firstly, the link between economic development, global population growth and their corresponding effects on the global climate system are not very direct. Most population growth in the 21st century is expected in sub-Saharan Africa, yet the per capita impact of Africa's population is very small compared to that of people in the developed world. Other factors of uncertainty in future climate projections are the numerous global circulation models that realize the emissions scenarios, each of the climate modeling groups is driven by a different set of assumptions and build their atmosphere–ocean coupled general circulation models differently. Despite high levels of uncertainty associated with future climate projections, there is high level of confidence in projections for the Mbale region simply because these changes are already being observed in the weather over the decade to 2010 (i.e. reduction in rainfall during the dry season has been observed coupled with increase in rainfall during May as well as for the October and November).

Future climate projections are valuable for a number of reasons; they provide levels of potential climate-related risks and can be used to gauge the likely future hazards. Future climate data can be an integral part of planning process, with the effects of climate change being incorporated in the plans, with provisions to cater for any shortfalls as a result of changes in climate or take advantage of any opportunities climate change may bring out. Indeed, it is also becoming common practice to use recent climate trends in addition to future climate projections for development planning. This helps reduce the level on uncertainty associated with projections enabling development planners prepare for realistic changes in climate. However, for planning adaptation interventions, it is recommended to use a range of projections this give resource managers the probability of success in dealing with changes in climate that will eventually manifest in the future.

3. Mbale Climate Change Profiles

3.1 Developing climate profiles

This section presents a description of climate for the Mbale region for the 1961-1990 baseline period as well as future climate projections for two time slices; the current 30-year period (2010-2039) and for the 2040 to 2069 period. For each time slice, data is available for 55 climate variables including monthly maximum and minimum temperature, monthly precipitation/rainfall (that is; minimum temperature for 12 months, Tmin01 –tmin12, maximum temperature for 12 months Tmax01 – Tmax12, monthly precipitation for 12 months, prec01-prec12) together with a list of 19 other biologically important variables (Annex 2 provides a list of all variables,).

The description of the Mbale region baseline and projected climate is based on downscaled version of the WorldClim data set. WorldClim is a set of global climate layers (climate grids) with a spatial resolution of about 1 square kilometer (Hijmans *et al*, 2005). Future climate projections were available from a downscaled GCMs projection by the CCAFS. This data is available for down load from this website http://www.ccafs-climate.org/

Projections of future climate for the Mbale region are based on two emissions scenarios (A1b and A2) and are from at least 5 General Circulation Models. This implies that for each of the 55 climate variables there are at least 10 likely options (2 emissions scenarios x 5 GCMs). Such a range of projections would require a huge effort on the part of resource managers in deciding which one of these versions is likely to manifest in the future. Obviously, such a task has no quick answer. First, the IPCC recommended in 2001 that each of the emissions scenarios should be treated as a potential scenario of what might happen in the future. Then, in terms of the GCMs, it is a question of which is the right or more realistic. Recent studies are now recommending that a whole range of future climate scenarios is used to provide a picture of what is likely to happen in the future, with an emphasis to be put where most of the scenarios and GCMs agree most. Since 2001 when the SRES was released, we know that the most conservative emissions scenarios B1 and B2 are very unlikely because observed emissions have exceeded these and are now in the A1 and A2 range.

Projected changes have been presented as average of GCMs values for each emission scenario.

3.2 Climate change projections for Mbale region

The Mbale region is projected to get warmer in the future. Projected changes in temperature are larger for maximum temperature as opposed to changes in minimum temperature. Whereas some GCMs project reductions in minimum temperature for some months during the earlier period (2020s), due largely to natural decadal variability (Table 8, 9 and 19), there is general agreement across all GCMs and Scenarios that monthly maximum temperature will go up over the 2020s and 2050s. Larger temperature changes have been projected for January and February and in June, July and August for most locations in the region (Table 8, 9 and 10 and Figures 28 and 29).

It is also clear from the projected trends that high elevation areas such as Bulucheke (1,776m asl), are cooler than lower elevation areas such as Mbale (1,170m asl). Despite the elevation driven spatial variation in temperature in the Mbale region, projected changes are of the same magnitude for different locations in the region (Tables 6, 7 and 8), largely because the data is interpolated from the coarse scale GCM data.

Table 7: The range of projected changes in minimum and maximum temperature from three emission scenarios for Bulucheke, in Bududa district a high elevation location within the Mbale region

Month	Minimum Temperature (°C)			Maximum Temperature(°C)		
	Baseline	Projected Change		Baseline	Projected Change	
	1961-1990	2020s	2050s	1961-1990	2020s	2050s
Jan	15.0	-1.0 – +1.5	+1.6 – +2.2	29.8	+0.9 – +12	+1.4 – +14
Feb	15.2	-0.7 – +1.5	+2.1 – +2.2	29.7	+0.5 – +12	+1.5 – +14
Mar	15.7	-0.6 – 0.0	+1.6 – +2.4	29.1	+0.8 – +11	+2.2 – +12
April	15.6	-0.7 – +0.3	+1.4 – +2.3	27.9	+0.2 – +8	+1.8 – +9
May	15.2	-0.3– 0.0	+1.8 – +3.0	27.3	+0.3 – +8	+2.6 – +8
Jun	14.9	-0.9 – -0.1	+1.3 – +3.1	27.0	+1.9 – +9	+3.7 – +9
Jul	14.9	-1.6 – +0.1	+1.4 – +3.3	26.4	+2.3 – +10	+3.2 – +11
Aug	14.8	-0.9 – +0.1	+1.6 – +2.8	26.8	+1.0 – +10	+2.1 – +11
Sep	14.7	-0.7 – 0.0	+1.2 – +2.3	27.2	+0.6 – +9	+1.9 – +11
Oct	14.6	-0.3 – 0.1	+1.6 – +2.2	27.5	+0.2 – +8	+1.6 – +9
Nov	14.8	0.1 – +0.2	+1.6 – +2.2	27.6	+0.1 – +7	+2.4 – +8
Dec	15.0	-0.5 – +0.9	+2.0 – +2.3	28.3	+0.8 – 9	+1.7 – +10

Table 8: The range of projected changes in minimum and maximum temperature from three emission scenarios for Butiru, a mid-elevation location in Manafwa district within the Mbale region

Month	Minimum Temperature (°C)			Maximum Temperature(°C)		
	Baseline	Projected Change		Baseline	Projected Change	
	1961-1990	2020s	2050s	1961-1990	2020s	2050s
Jan	14.7	-1.2 – +1.5	+1.7 – +2.3	29.7	+1.2 – +12	+1.2 – +14
Feb	14.9	-0.7 – +1.5	+2.1 – +2.2	29.8	+0.7 – +12	+1.7 – +14
Mar	15.4	-0.7 – +0.1	+1.7 – +2.4	29.3	+1.1 – +11	+2.2 – +12
April	15.4	-0.7 – +0.7	+1.4 –	28.0	+0.7 – +9	+1.8 – +9

			+2.3			
May	**13.1**	+1.5 – +1.6	+3.6 – +4.5	**27.1**	+0.8 – +8	+2.8 – +8
Jun	**14.5**	-1.1 – +0.1	+1.4 – +3.0	**26.9**	+2.2 – +9	+3.4 – +9
Jul	**14.2**	-1.7 – +0.8	+3.2 – +1.6	**26.4**	+2.6 – +10	+3.3 – +11
Aug	**14.2**	-1.0 – +0.3	+1.8 – +2.8	**26.6**	+1.6 – +10	+2.2 – +11
Sep	**14.3**	-0.7 – +0.2	+1.4 – +2.3	**27.3**	+0.9 – +9	+1.8 – +11
Oct	**14.6**	-0.5 – 0.0	+1.6 – +2.2	**27.8**	+0.2 – +8	+1.9 – +9
Nov	**14.7**	-0.1 – +0.2	-1.6 – +2.1	**27.9**	+0.1 – +7	+2.4 – +8
Dec	**14.6**	-0.6 – +0.9	+1.9 – +2.2	**28.4**	+1.0 – 9	+2.7 – +10

Table 9: The range of projected changes in minimum and maximum temperature for Mbale Town, a low elevation area within the region

Month	Minimum Temperature (°C)			Maximum Temperature(°C)		
	Baseline	Projected Change		Baseline	Projected Change	
	1961-1990	2020s	2050s	1961-1990	2020s	2050s
Jan	16.4	-0.9 – +1.7	+1.7 – +2.3	31.7	+0.9 – +12	+1.2 – +14
Feb	16.9	-0.7 – +1.6	+2.1 – +2.2	31.4	+0.4 – +12	+1.8 – +14
Mar	17.3	-0.3 – +0.2	+1.7 – +2.6	30.5	+0.8 – +10	+2.3 – +12
April	17.5	-0.3 – +0.7	+1.3 – +2.4	29.0	+0.4 – +9	+1.8 – +9
May	17.2	-0.2 – -0.5	+1.6 – +2.5	28.3	+0.1 – +8	+2.8 – +8
Jun	16.8	-1.2 – -0.3	+1.3 – +3.1	28.2	+1.8 – +9	+3.6 – +9
Jul	16.5	-1.3 – -0.5	+1.6 – +3.3	27.5	+2.3 – +10	+3.3 – +11
Aug	16.3	-0.6 – +0.3	+1.8 – +2.8	27.9	+1.2 – +10	+2.3 – +11
Sep	16.2	-0.5 – +0.2	+1.4 – +2.3	28.6	+0.5 – +9	+1.9 – +10
Oct	16.3	-0.2 – 0.0	+1.6 – +2.2	28.9	-0.3 – +8	+1.8 – +9
Nov	16.4	+0.1 – +0.1	+1.6– +2.2	29.4	-0.1 – +7	+2.4 – +8
Dec	16.3	-0.5 – +0.9	+1.9 – +2.2	30.0	+0.7 – +9	+1.8 – +10

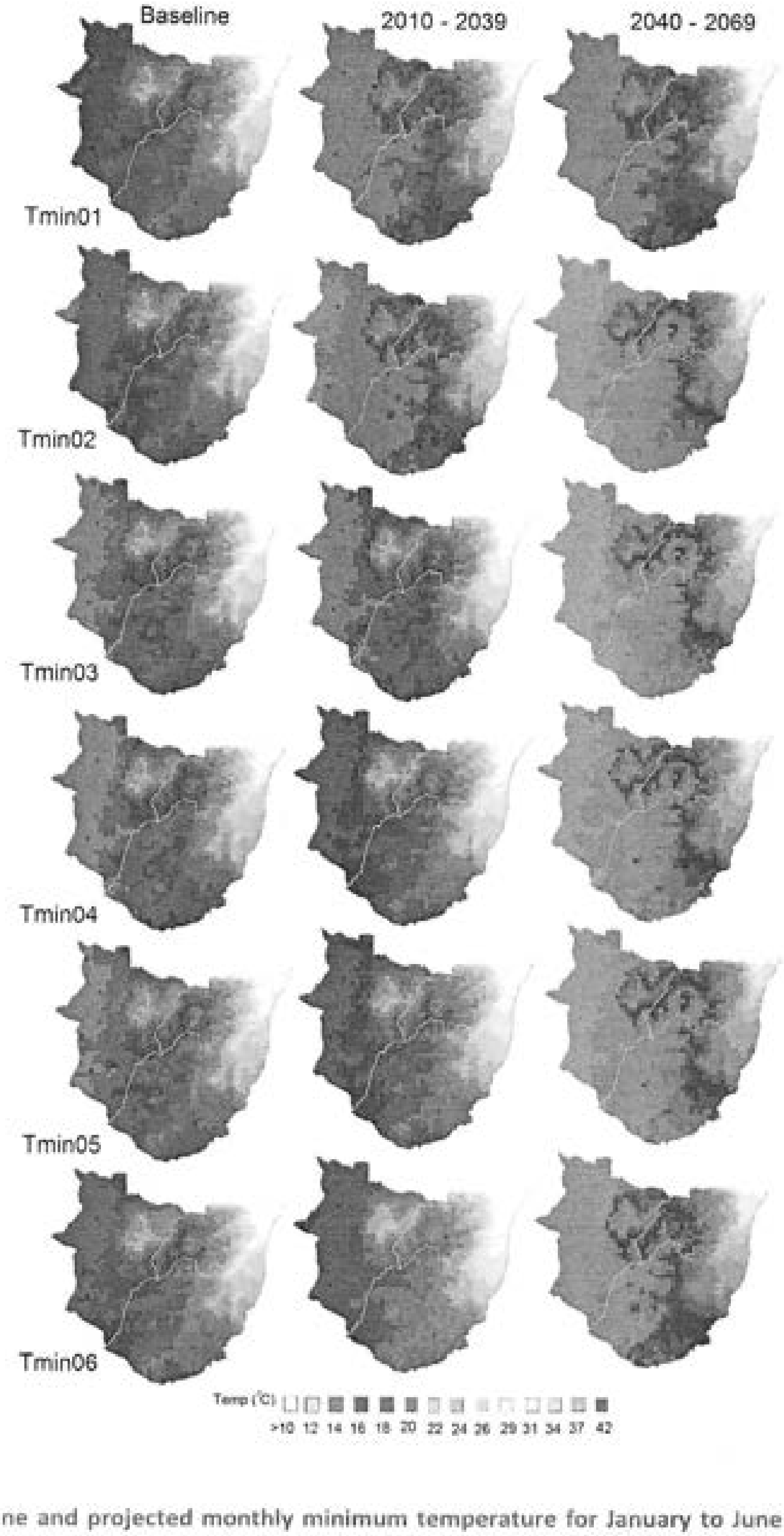

Figure 25: Baseline and projected monthly minimum temperature for January to June (Tmin01 – Tmin06) for two future time slices, the 2010 – 2039 (2020s) and 2040 – 2049 (2050s) for the Mbale region in Uganda

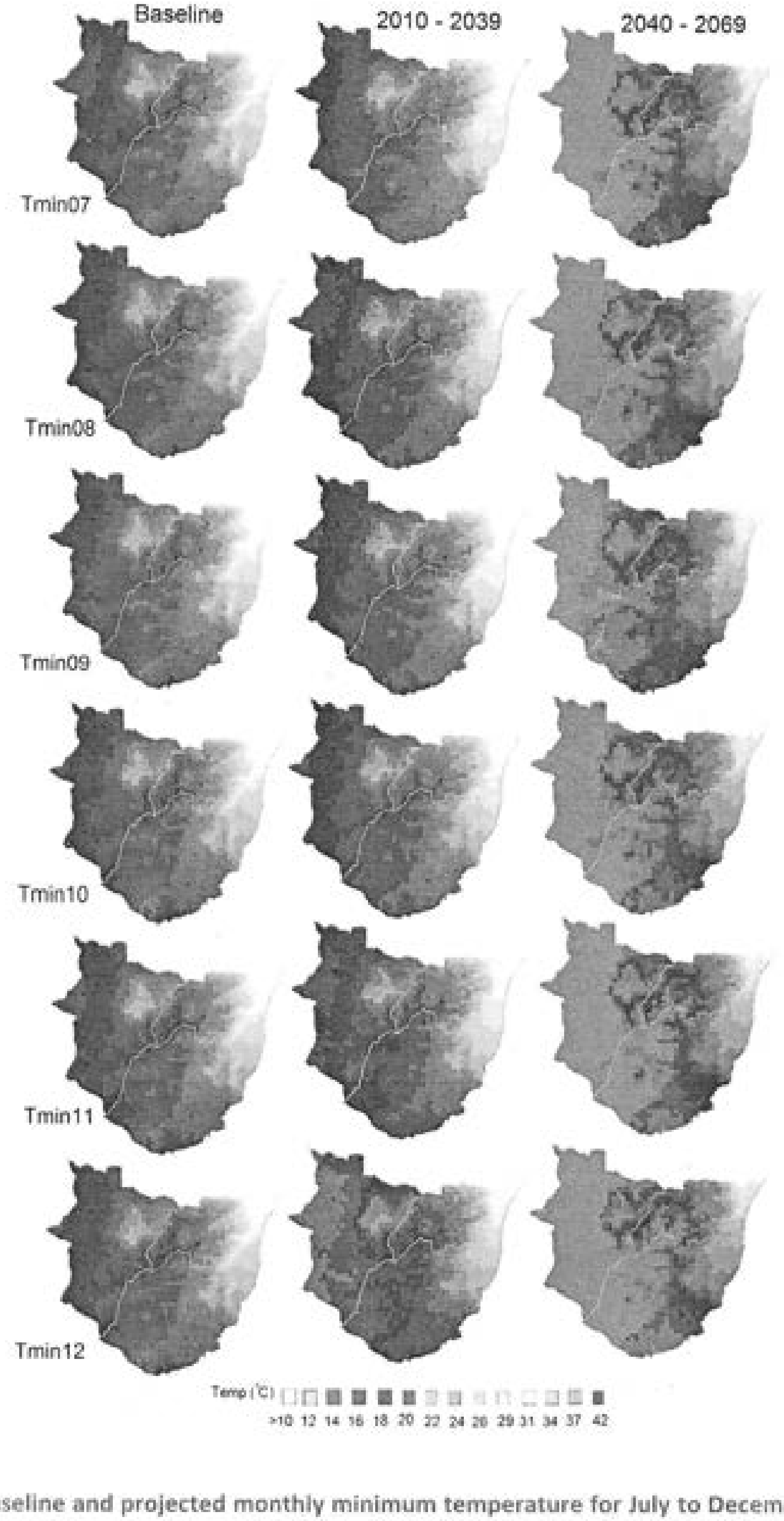

Figure 26: Baseline and projected monthly minimum temperature for July to December (Tmin07 – Tmin12) for two future time slices, the 2010 – 2039 (2020s) and 2040 – 2049 (2050s) for the Mbale region in Uganda

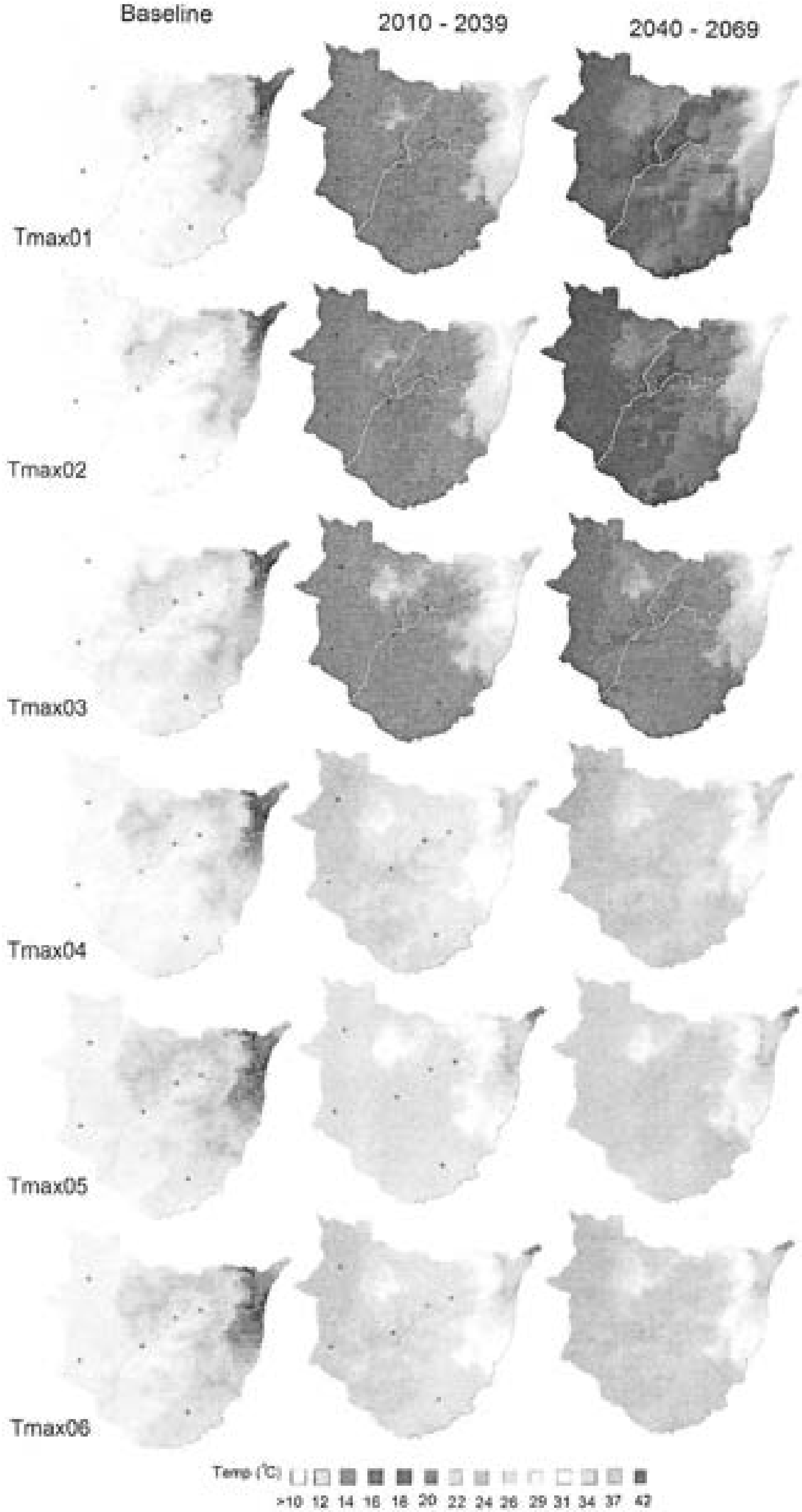

Figure 27: Baseline and projected monthly maximum temperature for January tor June (Tmin01 – Tmax06) for two future time slices, the 2010 – 2039 (2020s) and 2040 – 2069 (2050s) for the Mbale region in Uganda

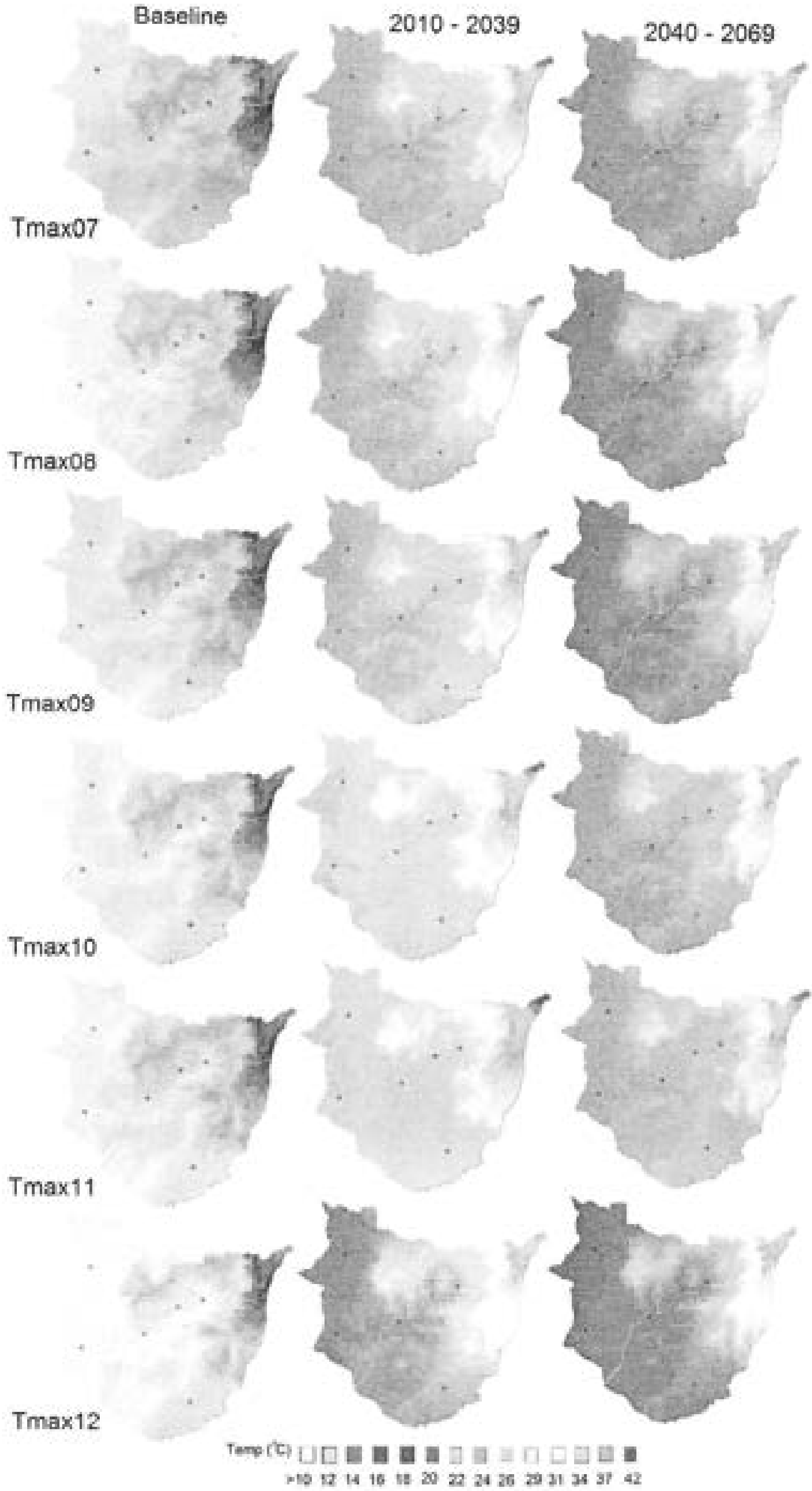

Figure 28: Baseline and projected monthly maximum temperature for July to December (Tmax07 – Tmax12) for two future time slices, the 2010 – 2039 (2020s) and 2040 – 2069 (2050s) for the Mbale region in Uganda

Most GCMs and emission scenarios project an increase in rainfall over the Mbale region for the 2010 - 2039 period. Projected rainfall, will in most locations, be higher than normals based on the 1961 - 1990 period. Rainfall will increase by up to 20% in all parts of the Mbale region (Figure 30). The projected increase in rainfall is not likely to be uniform both spatially and temporally. Some locations will see larger increase in rainfall compared to others. In addition, reduced precipitation has been projected for some locations in the region during the 2040-2069 period, particularly in the western sub-counties of Mbale municipality, Nakaloke, Bunghkho, Busiu. The western part of the Mbale region lie in some form of rain shadow and will generally receive less rainfall than the other region as is the trend with observed climate (Figure 31).

Whereas projected changes in temperature will steadily continue in the 21^{st} century, changes in precipitation will not follow the same trend. A good number of GCMs and scenarios project an overall precipitation increase in mean annual precipitation over the 2010-2039 and 2040-2060 period or the 2020s and 2050s respectively. However, GCMs do not seem to agree on precipitation trends during the 2049 to 2069 period. Some GCMS project continued increase (ECHAM, MUIB-ECHO) while others project reduced precipitation amounts compared to 2010-2039 totals (MEDRES, GISS). Faced with such information, most climatologists would advise adopting the direction or trend from the majority of projections. Nevertheless, it is also risky to ignore projections of a lesser or even contradicting changes.

Whereas the range of projected changes mean annual rainfall are up to +5% in the 2020s and +5 to 9% for the 2050s above the 1961 – 1990 mean values, projected changes in monthly rainfall amounts are much larger. Larger changes have been projected for November, December, January and February (Table 9). It is worth mentioning that it is not easy to get general agreement between the ranges of projections at the monthly level. The only obvious one is a trend towards more rainfall for the July to December period. The worst-case scenario for projected changes in rainfall includes up to 50% reduction in January and February rainfall. The best-case scenario are in the second rain season where there is a net increase projected for the July to December. Given this range of uncertainty in projected changes in rainfall, it is important that the region prepares for both the best-case and worst-case scenario for each month.

Projections of annual rainfall are summarized as averages from the different projections. This helps to give the overall trends, however this would not be a good way of summarizing monthly rainfall projections because of the large month to month variation in rainfall totals and the wide range in projected changes. Overall, the A1b and A2 scenarios project 2-5% increase in mean annual rainfall over the 1961-1990 values for the Mbale region for the 2020s and 5-9% increase for the 2050s (Figures 27 and 28). The A2 scenarios project slightly higher rainfall increase than the A1b scenarios for all GCMs (Figure 28). Whereas reduced rainfall is projected for some months by some GCMs (Table 9), the general trend is for more rainfall over the year.

Table 10: Range of projected changes in rainfall over three selected locations, Bulucheke in Bududa District, Butiru in Manafwa District and Mbale in Mbale district in the Mbale region

Month	Bulucheke			Butiru			Mbale		
	Baseline (mm)	Range of projected change (%)		Baseline (mm)	Range of projected change (%)		Baseline (mm)	Range of projected change (%)	
		2020s	2050s		2020s	2050s		2020s	2050s
Jan	37	-41 to +32	-41 to +46	45	-36 to +31	-36 to +44	32	-53 to +34	-47 to +50
Feb	73	-10 to +16	-8 to +26	85	-40 to +13	-6 to +24	52	-63 to +21	-13 to +35
Mar	110	-7 to +27	5 to +39	115	-8 to +25	6 to +38	100	-9 to +28	5 to +43
Apr	177	-36 to +8	-31 to +8	201	-32 to +6	-27 to +7	150	-76 to +9	-37 to +9
May	203	-3 to +14	-22 to +19	189	-3 to +14	-12 to +21	167	-4 to +17	-13 to +22
Jun	129	-14 to +19	-20 to +53	122	-15 to +20	-22 to +19	107	-17 to +24	-25 to +21
Jul	144	-15 to +24	-13 to +26	119	-17 to +28	-3 to +30	112	-19 to +29	-4 to +30
Aug	156	-19 to +10	-14 to +15	131	-23 to +13	-18 to +19	132	-21 to +11	-16 to +21
Sep	120	-22 to +25	-23 to +39	115	-22 to +26	-91 to +17	98	-28 to +28	-31 to +20
Oct	146	-16 to + 20	-21 to +43	150	-15 to +18	-18 to +42	96	-26 to +29	-25 to +66
Nov	107	-33 to +29	-26 to +48	123	-31 to +24	-24 to +31	85	-40 to +36	-32 to +44
Dec	49	-18 to +61	-10 to +133	63	-13 to +49	-10 to +103	52	-17 to +58	-10 to +125

mainly concerned with coffee. There several other cooperative that operates on village or county level. Such groups can help farmers access information easily, demand for improved services from government, purchase improved crop varieties or better equipment. An example of a small group of farmers is Peace Kawomera.

Thorpe and Fennell (2012) discuss supply chain responsibility to help small-scale producers deal with extreme weather events. Fluctuations in world coffee prices for instance can have significant effects on livelihoods of farmers in Mbale that depend on coffee. They suggest that companies can help the communities through activities such as providing reliable weather or climate information. Increasing awareness in the communities and supporting community development venture as well as providing much needed research information on financing, options for diversification or a responsible exit strategy. They point to an example of a coffee giant, Starbuck coffee that has worked with arabica coffee farmers in Colombia, to provide disease resistant varieties of arabica, access credit etc.

Table 14: Population distribution within the sub-counties in the Mbale region

Bududa		Manafwa		Mbale	
Sub-county	Population (no. of households)	Sub-county	Population (no. of households)	Sub-county	Population (no. of households)
Bubiita	32,000 (5255)	Bubutu	52,700 (8205)	Bufumbo	39,500 (7495)
Bududa	16,700 (2739)	Bugobero	30,700 (5099)	Bukonde	21,600 (3885)
Bukibokolo	21,600 (3265)	Bumbo	32,400 (5346)	Bukyiende	30,000 (5086)
Bukigai	32,900 (5567)	Bumwoni	41,000 (6820)	Bungokho	38,500 (6820)
Bulucheke	26,000 (4265)	Bupoto	34,500 (5564)	Bungokho-mutoto	47,000 (8591)
Bumayoka	11,400 (2099)	Butiru	53,000 (8603)	Busano	10,800 (1796)
Bushika	33,100 (4719	Buwabwala	38,500 (7095)	Busiu	33,200 (5529)
		Buwagogo	24,000 (3650)	Busoba	33,800 (5688)
		Kaato	17,300 (2730)	Nakaloke	39,500 (6368)
		Sibanga	31,300 (5139)	Namanyonyi	25,300 (4043)
				Wanale	17,800 (2678)
				Industrial	41,000 (7427)
				Northern Division	37,100 (7445)
				Wanale Division	13,700()
Total	173,700	Total	355,400	Total	428,800

Population data adapted from Rural Communications Development Fund www.ucc.co.ug/rcdf

Mbale region is one of the most densely populated parts of Uganda. According to the 2011 estimates, the three districts of the region nearly a million (957,900). Bududa is estimated to have 173,700, Manafwa 355,400 and Mbale is estimate to have 428,800 people. Table 11 shows population in the Mbale region by sub-county. Thus, one of the greatest resources for the region is its people. It is also important to point out that the high population also could the greatest liability for the region. Any intervention to improve livelihoods of the people of Mbale will go a long way in helping them deal with the impact of climate change. For example, education of all children of school going age needs to be taken seriously. It is here that children will learn the basic life skills. Numerous initiatives target children and youth in programmes such as tree planting. The best example is the Straight Talk Foundation that helps children in primary and secondary schools establish woodlots within the school premises.

On a more positive side, there has been a steady increase in the demand for agricultural produce. Demand comes from neighboring urban centers and other neighboring jurisdictions (Sironko, Kapchorwa in Uganda and Kitale in neighbouring Kenya). Whereas this drives the prices up ensuring that farmers have better returns, communities in the Mbale region could benefit from the expanded market by engaging in processing or produce.

Biogas is an important source of energy in the region. There is a relatively fair adoption of the use of biogas at the household level in the Mbale region. Increasing the level of adoption of biogas will reduce the demand for scarce fuel wood as the major source of energy in the household. This will free some labour at the household level for people to engage in other income generating activities other than finding fuel wood. The practice will also save a good proportion of the few planted or remnant trees in the agricultural landscape. In addition, biogas could be harnessed on a larger scale from human waste and garbage in urban centers that are already highly populated. The limitations to adoption of biogas include lack of animals, the initial high cost and a general lack of awareness. Intervention to address these challenges such as through more awareness, providing loans can help improve adoption of the technologies.

4.5.6 Climate-Smart Agriculture (CSA)

Farmers are one of the most vulnerable groups to climate change. However, farming can also be part of the solution to anthropogenic climate change during the 21st century. Agriculture contributes 13% of the global climate change emissions and agriculture together with deforestation, which is in most cases related or caused by expansion of agriculture contribute 30% of total emissions (Eliasch 2008). The phrase climate smart agriculture has been coined to reflect agriculture that increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) and enhances achievement of national food security and development goals. CSA increases organic content of the soil, water holding capacity increases and reduces erosion.

The triple win: interventions that would increase yields, make farms more resilient to the impacts of climate change, and make the farm a solution to the climate change problem rather than part of the problem.

Making use of technologies as old as the green revolution can go a long way in helping farmers cope with climate change. For example, irrigation can help farmers deal with drought or erratic rainfall that is now coming late.

4.5.7 Institutional and legal framework for climate change vulnerability

Adaptive capacity is not limited to resources available but also to the institutional framework that helps the community adapt to climate change (Adger et al., 2009; Hulme et al., 2007). Discussions identified some of the key players in helping farmers deal with climate change as NUSAF, NAADS Eco-Trust, UN-Habitat and local Councils. It was clear from discussions with stakeholders in the Mbale region that there is high-level commitment to dealing with climate change at both the professional and political level. There are challenges however to do with officials in elected offices whose approach undermines the professionalism. In addition, an integrated approach is also required. For instance promoting agriculture or certain crops such as coffee needs to be in tandem with the objectives of environmental and natural resources management promoted by the team in the natural resources and environment sector. Otherwise, objectives of sustainable development cannot be achieved if expansion of one crop leads to encroachment of forests or wetlands.

It was also pointed out that political influence should be dealt with because politicians have on several occasions disregarded the advice given to the farmers by technocrats and have on several occasions fought good climate protection causes. One of the challenges to developing an integrated climate plan for the Mbale region would be the political timeframe for Uganda is normally 5 years. This in essence requires that political leaders deliver results within this timeframe yet planning for activities for dealing with climate change will normally require timeframes longer than 5 years. How then can political leaders be motivated to actively contribute to activities whose benefits are only likely to be realized long after the political term of the politicians?

While global negotiations on mitigation continue, decision makers in Africa and elsewhere, must strive to develop a broad range of adaptation strategies to address current and future impacts of climate change (ADF, 2010).

Climate risk management (CRM) is the use of climate information to cope with possible impacts of climate change on development and resource management. It covers a broad range of potential actions including early response systems, risk spreading through diversification, dynamic resource-allocation rules, financial instruments, infrastructure design and capacity-building (ADF, 2010). CRM seeks to minimize adverse outcomes and maximize opportunities in climate-sensitive economic sectors through improved resource management. It addresses adaptation to climate change and disaster risk reduction in any climate sensitive development sector by focusing on actions that can be taken today to improve outcomes and preparedness, and by better understanding and then anticipating interactions of economic, environmental and social systems with possible future climates.

Climate risk management approach is that it provides immediate assistance to the public and private sectors, while helping stakeholders to confront possible future climate change scenarios. Climate risk management identifies immediate actions needed to manage the climate variability that is currently affecting societies. The main issues to be addressed in climate risk management are: climate monitoring, vulnerability assessment and institutional strengthening; climate services and information provision to decision makers and partnerships; deploying regionally-integrated and community-based early warning systems; and instilling and sustaining a shared culture of sectoral climate risk management.

Farmers in the Mbale region are already responding and taking actions to adapt to changes in climate and development pressures. However, the bulk of these interventions are reactive and focus on the short term, with very few of these being focused on dealing with climate change impacts on the longer term (Jones, ACCRA report for Uganda). For example, a lot of resources are spend whenever there is a land slide in Bududa, to respond to the crisis, but very little is done to improve resilience of the communities to future landslides in the region.

Table 15: Relevant institutions in the region for climate change adaptation

Name	Current/ Potential Role
Local governments in Mbale, Manafwa and Bududa districts	• Overall coordinator of development programmes in the districts.
Local councils (1-3) including sub-county chief	• Coordinate data weather data collection • Coordinate information dissemination
Schools	• Sensitive students on value of sustainable resource use • Training in better farming methods • Tree planting
Uganda Wildlife Authority	• Mt. Elgon watershed protection
	• Forest conservation, training
Cooperatives (eg BCU, and others) and other	• Value addition, processing of agricultural produce. • outreach
Community-based Organizations	•

Universities (Islamic University in Uganda, Busitema University)	• Research and outreach • Training of technical staff
NGOs (Local and international)	• Resource mobilization • Research and outreach • training
National Agricultural Research Organisation	• Research in locally adapted, disease resistant and/or early maturing crop varieties and livestock lines
	• Value addition, processing of agricultural produce

5. Conclusions and Recommendations

5.1 Conclusions

This work set out to answer very specific questions relating to climate in the Mbale region of Uganda. These questions fall into two broad groups: the first set of question on climate sought to get an assessment of meteorological data collected at Mbale weather station, compare this to that collected in neighboring areas and use it to make a description of the climate profile for the Mbale region as well as making projections into the future. Whereas weather records from the Mbale and other weather stations in the region have been used to describe current climate for the region. The work as detailed description of the climate profile for the Mbale region within the context of the wider eastern Africa region mainly relied on data that already existed. It should however be pointed out that the existing spatial grids used also rely on weather station data from the region as well as other locations. Again, description of future climate projections was based on spatial grids that have been done by a large team of climate and meteorology experts.

To ensure that all data on climate change about our region is reliable, we need to do a number of things, one establish a good number of weather stations, representative of the unique environments, such as the low lands, mid altitude as well as high elevation areas. This network could also benefit from expert knowledge for the region, for instance, the Mbale region receives more rainfall than other parts of the Mt. Elgon. However, some locations such as Mbale municipality lie is a clear rain shadow, receiving relatively low rainfall compared to surrounding areas at the same altitude. Capturing such information requires that weather stations are carefully positioned to represent these features. Efforts of the local or district governments need to be augmented by the central government in boosting the network of weather station in the country. Because weather data analysis required specialized skills, this again should be strengthened at the meteorological department in the Ministry of Water and Environment.

Climate in the Mbale region can be described as...rainfall is mainly bimodal with the first rain season occurring late march to June and from September to November. Over the last one and half decades, there has been a clear shift from April to May as the wettest month meaning that the onset of the first rains delays until sometime in April. The other major trend has been towards more rainfall during the previously "shorter" rains period of September to November. Overall, all a clear trend of more rainfall throughout the year is apparent.

Temperature increases have been noticeable in the warmest February month of the year. The implication of increasing temperatures during the driest period of the year point to likely increase in water stress over the dry season.

Projections of temperature and rainfall over the Mbale region point to an overall increase in minimum temperature, and increase in the dry season temperature particularly in February. Additionally, more rainfall is projected about 5- 14% more in the rain season. More rainfall will be expected in the SON (Sept / Oct / Nov) season.

Whereas biophysical attributes of the Mbale region such as clay soils and hilly terrain make it vulnerable to effect of climate change particularly erosion. These attributes also make this region unique; the cool temperatures make the growing of arabica coffee possible. Arabica coffee, grown together with bananas, are the sources of livelihoods for majority of people. Changes in climate will threaten coffer growing in two major ways; increased temperatures affect yield and quality of coffee in addition make conditions favourable for coffee pests, most important of these is the coffee berry borer. Better methods of cultivation and soil and water management can enhance the adaptive capacity of the region to climate change. These techniques include terraces, mulching.

Vulnerability of the Mbale region is increased by the high population of the region. With more than 590 persons per square km the Mbale region is the most densely populated part of Uganda.

Stakeholders emphasized that methods of controlling population growth are required if the region is to cope with climate change.

The lack of adequate climate records for the Mbale region combined with uncertainty in climate change projections and climate change impacts can become limiting factors in helping communities deal with the impacts of climate change. What have been obvious for this region are the direct, often disastrous impacts of extreme weather events. Thus, responding to climate change impacts does not have to wait for more accurate projections of climate, because projected changes in temperature and rainfall for the Mbale region in recent decade (2000-2011) are comparable to what was projected for the 2010-2039 period. Information flow and management is key to dealing with climate change, information about climate trends, projected impact. Adaptive management of resources, involves changes in the techniques and methods of responding to climate change in response to changes in climate that are underway.

5.2 Recommendations

Recommendations will mainly focus on aspects and interventions that will help to enhance the development of climate change mitigation and adaptation interventions for the Mbale region of Uganda.

One of the constraints to climate change studies for the Mbale region is limits on weather data collected. There is need to **improve collection of weather data in the region**. Whereas weathers station are normally located in urban areas, weather stations need to be strategically distributed within the region to adequately represent low and high elevation areas. Improvement of weather data collection will also go hand in hand with **promoting awareness and building capacity among the Mbale region stakeholders** particularly local governments, technical officers and schools about the need to and the appropriate methods for collecting weather data.

Improve information flow, not only through opening up communication channels between technical people and the local communities but also facilitating the flow of information along those channels for example through ensuring that information is translated so it can be accessed and understood by all members of the community.

Vulnerability to climate change is a function of exposure, sensitivity and adaptive capacity of the environment and society to deal with the risks of climate change. Whereas exposure and sensitivity cannot be easily changed, reducing vulnerability to climate change in the Mbale region will mostly be through enhancing adaptive capacity. **Enhancing climate change adaptive capacity of the environment and the people of Mbale region** requires increase in tree cover coupled with reduction in excessive cutting of trees on farm and clearing of forests, strengthening the banana-coffee system and encouraging minimum tillage crops. The high population of the Mbale region implies that most locations are supporting people beyond the carrying capacity. Establish carrying capacity of the region and enforce regulations respecting that. Regulations are also needed to control settlements on steep slopes because cultivation and house construction on these slopes increases the risk of landslides.

Enhancing climate change adaptive capacity of the people of Mbale region will require that the literacy of the society improved, that the society is aware of how human activities increase vulnerability to climate change, and with viable alternative sources of livelihoods and with opportunities to participate in decision making affecting their region. Multinational companies dealing in coffee could be taken onboard to help local coffee cooperatives plan targeted interventions to dealing with the impacts of climate change.

Developing climate change mitigation and adaptation plans needs to **build upon development interventions that have been or are currently underway** in the Mbale region. This will help in consolidating achievement and build on lessons, making use of information from existing or recent climate change adaptation interventions. A good example is the Mt. Elgon Regional Ecosystem Conservation Programme (MERECP). The goal of MERECP was integrated ecosystem conservation and management of natural resources and biodiversity and enhanced well-being to people and the environment.

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Annexes

Annex 1: Glossary of Climate Change Terminology

Weather:

- Describes the state of the atmosphere. The major weather variables are temperature and precipitation.
- "Weather" refers to the short-term average (trend) and also to the size of the variations around the trend (weather variability).

Climate:

- Climate" refers to the long-term average (trend) and also to the size of the variations around the trend (climate variability).
- Climate can also be described as average of individual weather states, taken over sufficiently long periods of time. While weather impacts our daily lives, climate influences our decisions about where to live, and where and how to grow food. In this way, it directly influences how societies and economies develop and flourish. Changes in climate are associated with more fundamental changes to the global climate system, involving interactions and feedbacks between the atmosphere, the oceans, land and ice surfaces and all living things (the biosphere).

Climate Variability:

- Reflects shorter-term extreme weather events, such as tropical hurricanes and the El Niño Southern Oscillation (ENSO), and North Atlantic Oscillation (NAO). Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Extreme Events:

- Weather events departing markedly from the average values or trends, and that is exceptional. Mostly, the return period substantially exceeds 10 years.

Climate Change:

- the UNFCCC defines climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods"
- the IPCC define climate change as a "statistically significant variation in either the state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings or to persistent anthropogenic change in the composition of the atmosphere or in land use.

Emission scenario:

- A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

Climate Change Adaptation:

- One or more processes by which strategies (policies, actions and other initiatives) to moderate, cope with or take advantage of the consequences of climatic events are enhanced, developed and implemented.

Climate Change Mitigation:

- Response measures that reduce the emission of greenhouse gases into the atmosphere or enhance their sinks, aimed at reducing their atmospheric concentrations and therefore the probability of reaching a given level of climate change.

Climate Risk:

- The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between climate-induced hazards and vulnerable conditions.

Climate Risk Management:

- An approach to systematically manage climate-related risks affecting activities, strategies or investments, by taking account of the risk of current variability and extremes in weather as well as long-term climate change.

Vulnerability to Climate Change:

- Climate change vulnerability refers to the state of susceptibility to harm from exposure to climate hazards, and the ability of the sub-national territory (or other unit of analysis) to cope with, and recover from, such exposure as well as manage incremental and long-term change in climate. In addition, climate change vulnerability encompasses how much the sub-national territory (the environment, society, and economy) will be affected – in other words, how sensitive it is to the change. It also includes the territory's potential to cope with, recover, and adjust to the impacts of climate change, that is, its adaptive capacity. Identifying vulnerability is therefore a necessary prerequisite to developing low-emission climate-resilient plans and strategies, and to ensuring that societies are resilient in the face of climate change.

Adaptive Capacity:

- The ability of a system to adjust its characteristics or behaviour in order to expand its coping capacity under existing climate variability or future climate conditions. Actions that lead to adaptation can enhance a system's coping capacity and increase its coping range thereby reducing its vulnerability to climate hazards. The adaptive capacity inherent in a system represents the set of resources available for adaptation, as well as the ability or capacity of that system to use these resources effectively in the pursuit of adaptation.

Climate Proofing:

- Actions to ensure that development efforts are protected from negative impacts of climate change, climate variability, and extreme weather events and to ensure that climate-friendly development strategies are pursued to delay and reduce damages caused byclimate change.

Climate Resilience:

- The capacity of a system, community or society potentially exposed to climate hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Mainstreaming:

- In the context of addressing climate change and related issues, the term "mainstreaming" is used to describe the integration of policies and measures to address climate change in ongoing and new development policies, plans, and actions. Mainstreaming adaptation aims to enhance the effectiveness, efficiency, and longevity of initiatives directed at reducing climate-related risks, while at the same time contributing to sustainable development and improved quality of life.

National Adaptation Programme of Action:

- National Adaptation Programmes of Action (NAPAs) are intended to communicate priority activities addressing the urgent and immediate needs and concerns of Least Developed Countries (LDCs), relating to adaptation to the adverse effects of climate change.

For more information see www.ipcc.ch/pdf/assessment- report/ar4/syr/ar4_syr_appendix.pdf

Annex 2: Climate variables generated for Worldclim and downscaled GCM projections

Baseline and future climate for Mbale region covers the following climate variables

- monthly values for maximum, minimum temperature and (tmax to 12 and tmin1 to 12)
- monthly precipitation (prec1 to prec12)
- plus 19 biologically relevant climate variables including:

bio1 - annual mean temperature
bio2 - mean diurnal range (mean of monthly max temp-min temp)
bio3 - isothermality
bio4 - temperature seasonality (SDx100)
bio5 - maximum temperature of warmest month
bio6 - minimum temperature of coldest month
bio7 - temperature annual range (bio5 - bio6)
bio8 - mean temperature of wettest quarter
bio9 - mean temperature of driest quarter
bio10 - mean temperature of warmest quarter
bio11 - mean temperature of coldest quarter
bio12 - annual precipitation
bio13 - precipitation of warmest month
bio14 - precipitation of driest month
bio15 - precipitation seasonality
bio16 - precipitation of wettest quarter
bio17 - precipitation of driest quarter
bio18 - precipitation of warmest quarter
bio19 - precipitation of coldest quarter

In all, 55 climate variables are available for each times slice (1961 - 1990, 2010 - 2039, 2040 - 2069).

Annex 3: List of Global Circulation Models and emission scenarios used

GCM	Emission Scenario
ECHAM	A1b, A2, B1
GFDL	A1b, A2, B1
HADGM	A1b, A2, B1
MEDRES	A1b, A2, B1
PCM	A1b, A2, B1

ANNEXTURE B

"B"

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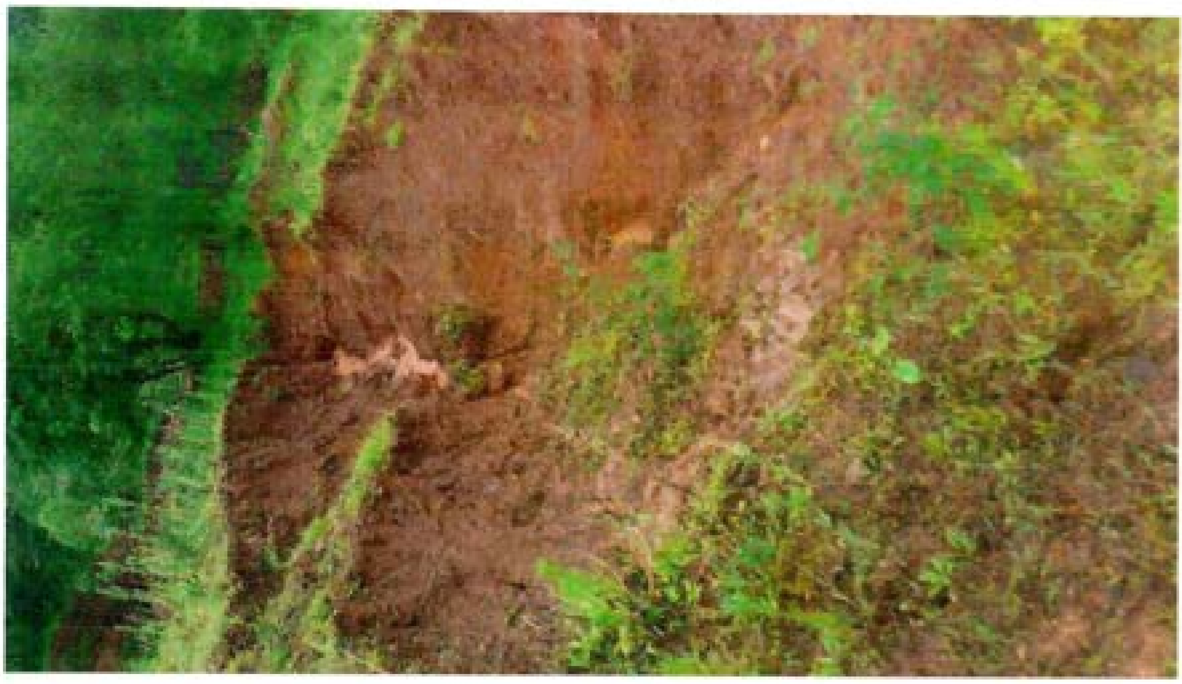
COMMISSIONER FOR OATHS

LANDSLIDE RISK ASSESSMENT, CRACKS IDENTIFICATION & AWARNESS IN MT ELGON SUB REGION



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HIGH COURT OF UGANDA
18 MAY 2021
RECEIVED
EASTERN CIRCUIT - MBALE

June 2015

1.0 Background

Uganda is experiencing signs of climate change as exhibited by the trends in average temperatures and rainfall and is expected to increase the frequency and intensity of floods, landslides and drought which will have significant impacts to livelihoods of local communities.

The Mount Elgon region which covers the districts of Bududa, Manafwa, Mbale, Sironko, Bulambuli, Kapchorwa, Kween and Bukwo has had devastating landslide disasters which have claimed lives and also caused damage to property and infrastructure.

The districts of Bududa, Bulambuli, Manafwa and Sironko experience bimodal type of rainfall with the highest coming in the first season of March to June and the second, which is normally light, in September to November. A short dry spell is between June/July while the December to March spell is longer. In general there are no extreme temperatures ranges; this condition is attributed to closeness to the mount.

The average rainfall is 1800mm per annum. This very high rainfall is very supportive to intensive agriculture, which forms the backbone of the Districts' economy. However, landslides occur during the rain seasons.

1.1 Purpose

In Eastern Uganda the rainy season is peaking up and landslides cracks are beginning to appear in several places in Mt Elgon sub region (OPM) which are signs of impending landslides.

Therefore to guide and prepare for possible interventions by relevant stakeholders in case of landslide occurrence and as well inform the communities in these areas of the existing situation and prepare them for the likely disasters, NEMA team visited the Mt Elgon region from 7th – 12th June 2015 to assess, identify and map cracks that are widening in the districts of Bulambuli, Bududa, Sironko and Manafwa and carry out community awareness as well.

1.2 Activities carried out:-

- Identification and Mapping of Cracks widening in Mt Elgon districts of Bulambuli, Sironko, Bududa and Manafwa
- Integrated Assessment of the identified vulnerable areas (Environmental, Social, Economic, Land use and Public Infrastructure)
- Community awareness about the land slide cracks appearance in the identified areas and possible measures for preparedness
- Radio talk show in the Elgon sub region for information dissemination on emerging conditions, widening cracks and possible measures

2.0 Methodology

- Mapping Identified landslide risk areas.
- GPS Mapping of identified cracks
- Observations and Interviews for information gathering on environmental, social, economic, land use and public infrastructure in the identified areas
- Satellite/Google Earth data for land cover
- Field meetings for community awareness in the Elgon sub region about the land slide cracks appearance and possible measures for preparedness
- GIS for analysis and output generation

3.0 Findings

3.1 The economy

The areas visited have high population density for example the population density in Bududa District stood at 516 people per square km in 2012 and there is intensive subsistence agriculture practiced. Like many Ugandan districts, the economies of Bududa, Manafwa, Bulambuli and Sironko are dependent on agriculture and employs over 80% of the total population. Fertile soils and suitable climate combine to support the cultivation of a number of crops in most parts of the districts. Agriculture is mainly carried at subsistence level and takes place on smallholdings of approximately one and half acres fragmented in many places. Mainly, simple farming tools (hoes, pangas and harrowing sticks) are used.

Both food and cash crops are grown. The major food crops include bananas, beans, yams, sweet potatoes and maize. Coffee is the major cash crop and is the main source of livelihood for the majority of the population in the districts. The major livestock found in the districts are cattle in zero grazing units, goats, chickens and pigs. Some people derive la livelihood by collecting Kamalea (bamboo shoots) as a local delicacy.

3.2 Areas visited

The NEMA team visited several areas which are prone to landslides with the aim of identifying widening cracks and mapping these areas and informing the community on the likely occurrence of these landslides and good environment management practices in general. It was also observed that areas have dangerous rock falls which roll and threaten lives.

These areas are as indicated in the table below:

Village	Sub county/District	Cause of Land Slide Risks
Soobi, Bunabutsale Parish	Kaato, **Manafwa District**	Poor cultivation practices Vegetation clearance Settlements on steep slopes
Butoto, Zion	Wesswa, **Manafwa District**	Poor cultivation practices Vegetation clearance Settlements on steep slopes
Bugobilo, Bulujewa Parish	Zesui, **Sironko District**	Poor cultivation practices Vegetation clearance Settlements on steep slopes
Masiyopo, Bulujewa Parish	Zesui, **Sironko District**	Poor cultivation practices Vegetation clearance Settlements on steep slopes
Bunakasala, Bunamuhembwa, Wahwanyi, Mabaya, Nametsi	Bulucheke, Nametsi, ***Bududa District***	Poor cultivation practices Vegetation clearance Settlements on steep slopes
Kajere, Tabale, Nakidibwo, Kikolo, Seswata	Simu, Sisiyi, Bulago, Buluganya ***Bulambuli District***	Poor cultivation practices Vegetation clearance Settlements on steep slopes

3.3 Identified Causes of landslides in the Elgon Region

The main triggering factor is rainfall and goes for days while delivering little amounts of water thus high infiltration of water into soils causing stagnation.

The causal factors are also aggravated by human activities:-

- Poor agricultural practices
- Vegetation clearance
- Loose soils due to cultivation
- Construction

Figure 1: Soil block that is creeping (slow movement that results into a landslide) in Bulambuli District

Figure 2; Showing cultivation practices on steep slopes in Bulambuli

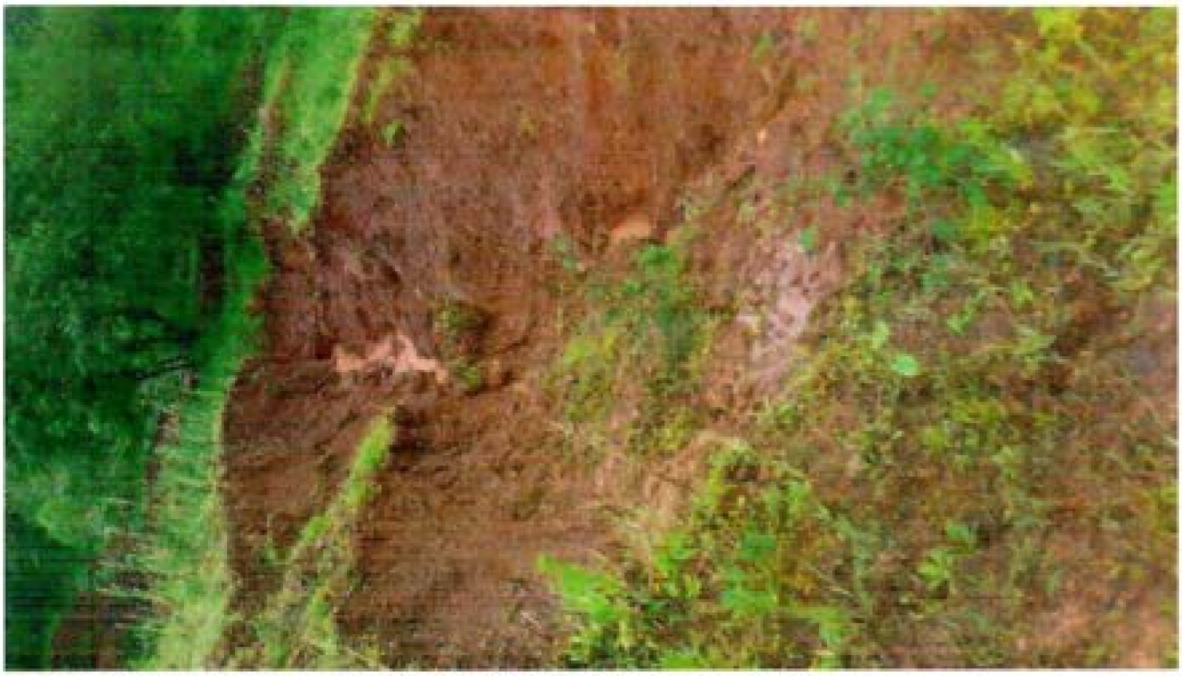

Figure 3; Showing showing cracks widening in Bududa

3.4 Local knowledge of causes of Landslides by the community

In the course of trying to gauge the knowledge of the local community members on the causes of landslides in the districts they attribute the cause of landslides to heavy rains and slope aspect as the only factors. Whereas these are necessary conditions, a whole host of other factors such as deforestation, cultivation and construction aggravate the situation.

4.0 Awareness programme

As part of the activity community environmental awareness was undertaken. This involved a call in radio talk show and community meetings (barazas).

4.1 Radio talk show

A call in Radio talk show was held on Open Gate FM on 11th June 2015 from 8.00-9:00 pm. The call in talk show was in both English and the Lumasaba Language (Lugishu). This was to benefit mainly the local communities and also others.

The focus of the talk show was:

- Landslides, their causes,
- Conservation agriculture (bunding, terracing, agro forestry, etc)
- Landslides precautionary measures
- Hill and mountainous areas protection,
- Observation of the riverbanks protection zones,
- Kavera –the dangers and the ban
- Tree planting as an enterprise

4.2 Community meetings (barazas)

Community awareness meetings were held. The participants of the meetings numbering about 90 per meeting consisted of Local Councilors, Local Community members, opinion leaders and other community members

- Landslides, their causes,
- Landslides precautionary measures

- Conservation agriculture (bunding, terracing, agro forestry, etc)
- Hill and mountainous areas protection,
- Observation of the riverbanks protection zones,
- Kavera –the dangers and the ban enforcement
- Tree planting as an enterprise
- Education for better management of Environment and natural resources

Figure 4; Community Awareness in Bududa Landslide prone area

Issues that arose at the community meetings

S/No	Issue/Question	Response/Answer
	A tree farmer in Manafwa earns more money than crop farmer and tree planting can mitigate landslide effects. Where can they get the seedlings from?	Farmers can come into groups of raise their own seedlings and an enterprise. Sale of seedlings can also earn them income. The District authorities should plan for Sub county level tree nursery raising.
	Which species of trees are environmentally friendly?	Environmentally friendly tree species are normally agroforestry tree species (nitrogen fixing, offer less competition to crops, are multi-purpose and are deep rooted (gravillea, calliandra, fruit trees), etc.)
	Most Households own very small pieces of land. In case of landslides can the owners be offered land in other areas?	No, the most important thing is life. Protect your life and the lives of the family members by moving to safer areas.

5.0 Way forward/Recommendations

Natural disasters are a dramatic example of people living in conflict with the environment. Early predictions and warnings are essential for the reduction of property damage and loss of life. Because landslides occur frequently and can represent some of the most destructive forces on earth, it is imperative to have a good understanding as to what causes them and how people can either help prevent them from occurring or simply avoid them when they do occur.

a) Steep slopes should be left unsettled and under vegetative cover.

b) Tree planting should be undertaken by all households as part of agricultural system.

c) Enforcement of environmental laws should be done by all authorities such as The National Environment Hilly and Mountainous areas regulations which facilitate sustainable utilization and conservation of resources in mountainous and hilly area and promote soil conservation and restrict the use of these areas.

d) Families on land with developed cracks should move to safer places such as trading/urban centers which are generally on lower areas or flatter areas.

e) The districts should identify and provide land for government Long-term urbanization strategy

f) Public facilities such as schools, water facilities, health centers /clinics etc should not be constructed in condemned places or places clearly prone to landslides

g) No cultivation on very steep hill slopes

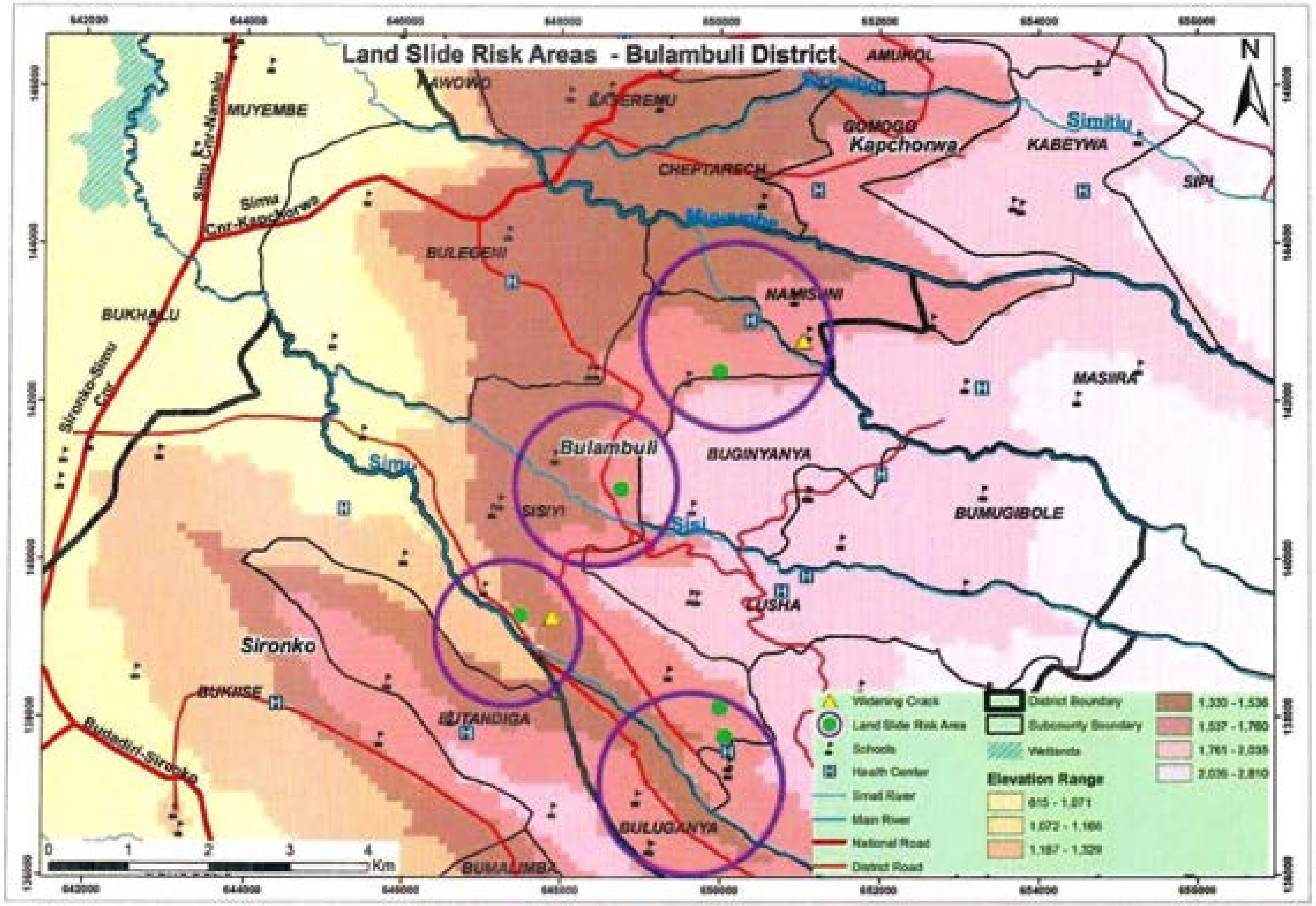

Figure 5: Map showing Land Slide Risk Areas in Bulambuli District

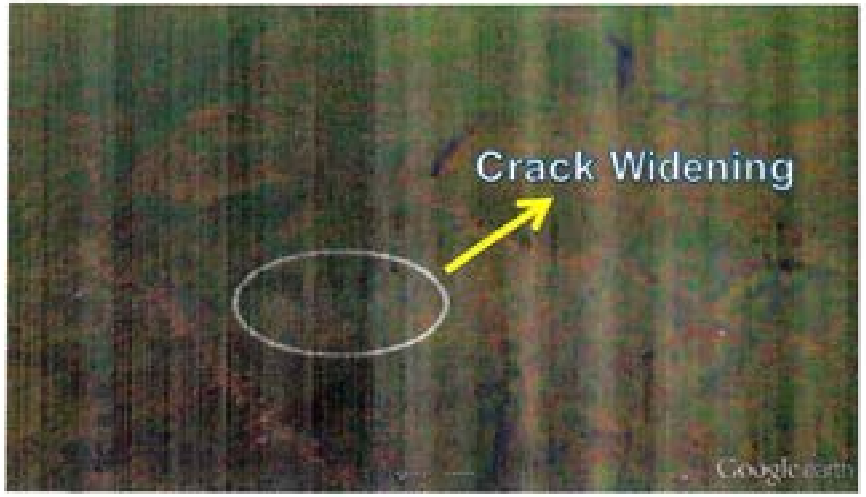

Figure 6: Widening Crack in Sisiyi Subcounty, Bulambuli District

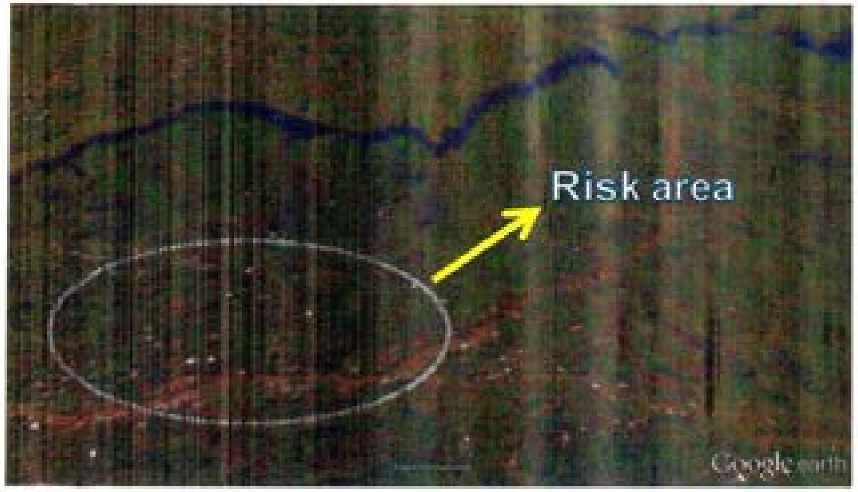

Figure 7: Land Slide Risk area in Simu Subcounty, Bulambuli District

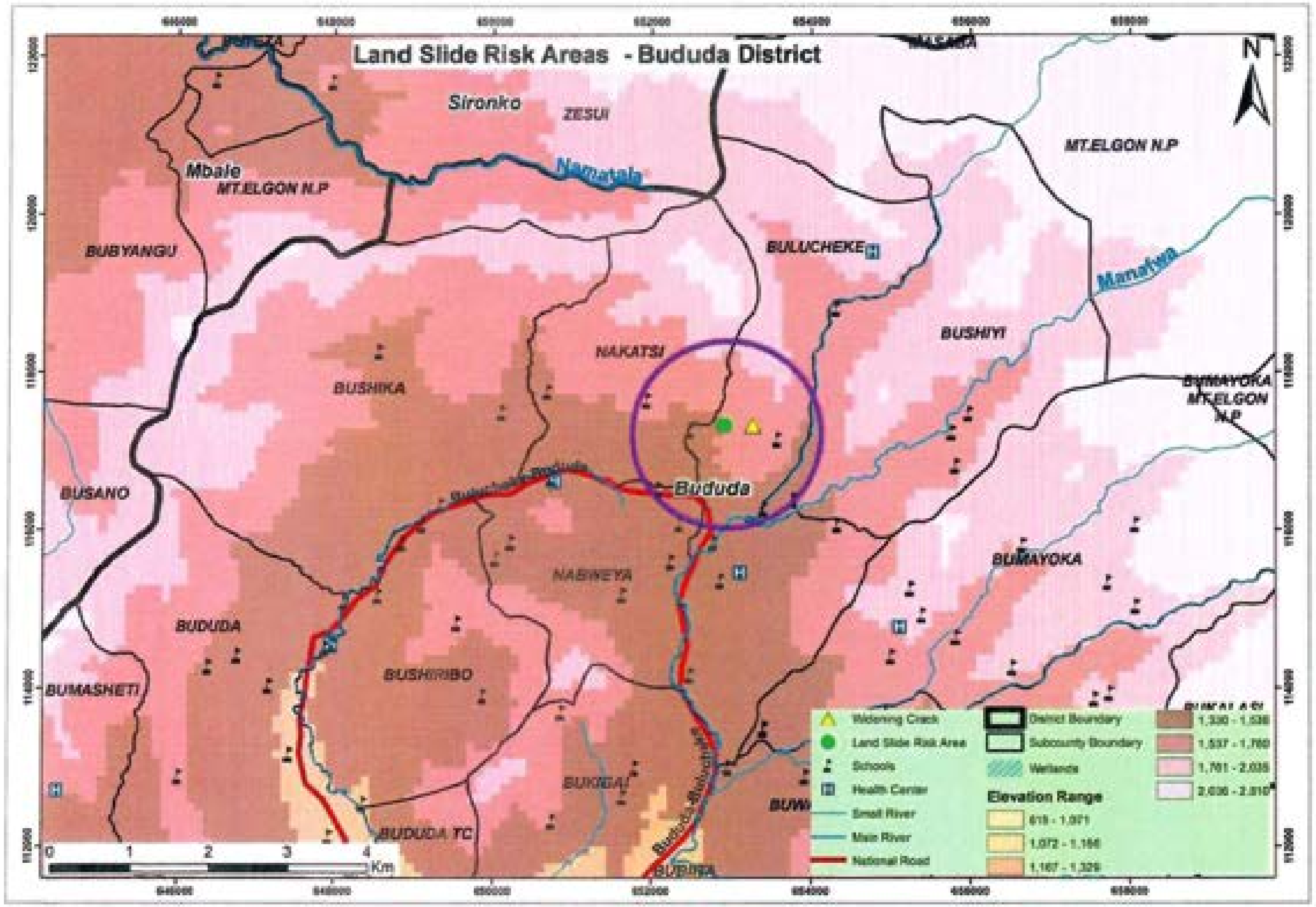

Figure 8: Map showing Land Slide Risk Areas in Bududa District

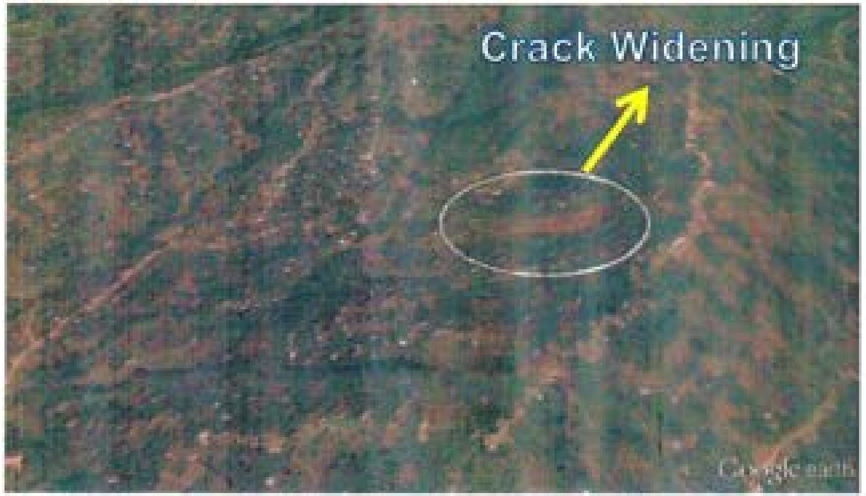

Figure 9: Widening Crack and Land Slide Risk Area in Buluchake Subcounty, Bududa District

Figure 10: Showing the location of a Crack and Land Slide Risk Area in Zesui Subcounty, Sironko District

Figure 11: Cracks in Masiyopo village, Bulujewa Parish, Zesui Sub County in Sironko district

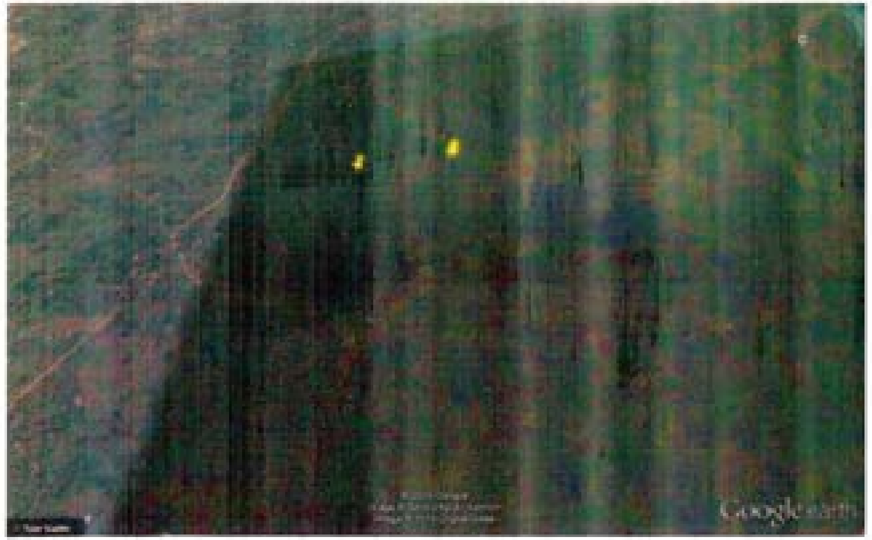

Figure 12: Land slide in Soobi village Kaato, Mansfwa District 10 house holdes affected

Figure 12: Land slide in Zion village, Manafwa District

ANNEXTURE C

THE EXHIBIT MARKED "......C......"
REFERRED TO IN THE ANNEXED AFFIDAVIT OF
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DAY OF....................................20..............

COMMISSIONER FOR OATHS

National Environment Management Authority (NEMA)

Rapid Landslides & Disaster Assessment Report Manafwa & Namisindwa Districts

Prepared by:

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NEMA

June 2018

1. INTRODUCTION

1.1 Background

The Mount Elgon region which covers the districts of Bududa, Manafwa, Mbale, Sironko, Bulambuli, Kapchorwa, Namisindwa, Kween and Bukwo has had devastating landslide disasters which have claimed lives and also caused damage to property and infrastructure.

From 30th May– 01st June 2018, the Hon. State Minister of Water and Environment accompanied by the technical staff from the National Environment Management Authority (NEMA) conducted a rapid landslides and disaster assessment in the Elgon districts of Manafwa and Namisindwa.

During the inspections, areas affected by the May 2018 landslides were visited which included Namisindwa Town Council, Bupoto and Bumbo Subcounties in Namisindwa District and Kaato and Wesswa Subcounties in Manafwa District. The team further mapped out the May 2018 landslide occurrences in those areas and assessed the disaster caused by the hazard.

1.2 Objectives of the Inspections

(i) To assess the damage caused by the landslides in the affected communities of Manafwa and Namisindwa districts.

(ii) To assess and map out landslides scars in the affected areas.

1.3 Methodology

(i) Field visits to observe areas of landslide occurrence
(ii) Interviews from the affected persons
(iii) Photography
(iv) Use of a GPS to capture location of landslide scars

1.4 Findings

Namisindwa District

Namisindwa District is composed of 14 Sub Counties, 4 Town Councils, 72 Parishes, 31 Wards, 699 Villages, 238 cells. The Sub County of Bupoto and Namisindwa Town Council have been greatly affected by the recent landslides throughout the communities. The affected area is one Kilometre away from the District headquarters on the eastern part.

On 20th May 2018, due heavy rains in the area this season, the cracks were infiltrated by water which triggered landslides in the villages of Buwandyambi, Matibo, Musaayi, Kimundu, Bowere, Bukibumbi and Buyaka. As a result, people were displaced, crops and trees destroyed, houses developed cracks and some destroyed.

Land slide scars in Bumbo Subcounty

Land slide scars in Namisindwa Town Council

General effects

- 200 families displaced
- 150 houses cracked
- 69 houses broken
- 10 households are sinking
- Acres of crops destroyed (Matoke, Maize, Beans)
- 04 bridges destroyed
- A section of 2km UNRA road damaged
- A total of 500 families affected
- Buwandyambi Primary school affected with cracks
- Graves cut and opened

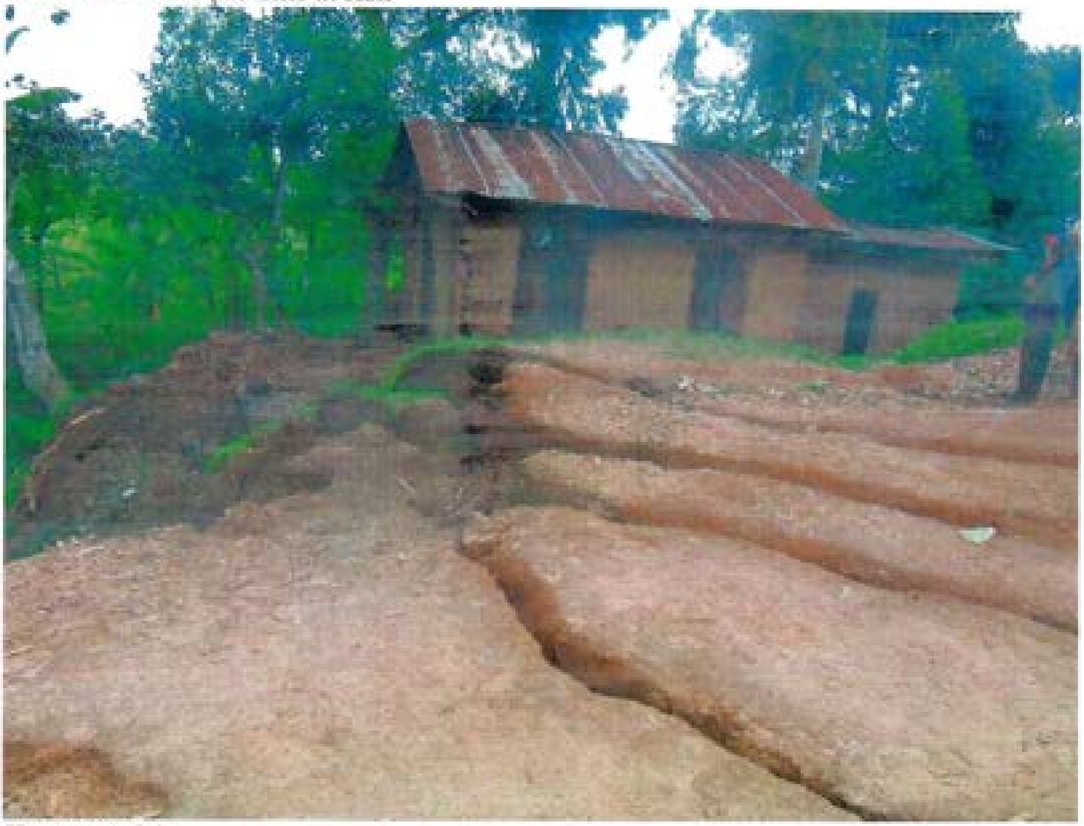
Landslide Scar 1

The landslide scar is 80 m by 50m , 5m deep and located at GPS coordinate UTM, WGS 84 (36 N 651170 98825). Matibo Village, Namisindwa Town Council. Crops were destroyed, houses were destroyed, developed cracks and shifted, trees were destroyed and people were displaced.

Landslide Scar 1


Trees were destroyed


Houses destroyed


Houses and People still at risk

House at risk


Bridge destroyed

Buputo to Magale road destroyed

House abandoned

Crops destroyed

Landslide Scar 2

The landslide scar is 30 m by 15m, 7m deep and located at GPS coordinate UTM, WGS 84 (36 N 654922 98565). Bukimatya Village, Bumbo Subcounty. Houses at risk and developed cracks, Trees and crops were destroyed.

Landslide Scar 2

Trees destroyed

House at risk

Landslide Scar 3

The landslide scar is 50 m by 15m, 15m deep and located at GPS coordinate UTM, WGS 84 (36 N 654455 98912). Bumwali Village, Bumbo Subcounty. Houses at risk and developed cracks, Trees and crops were destroyed.

Landslide scar 3

Houses at risk and developed cracks, Trees and crops were destroyed.

Manafwa District

The District is composed of 22 Sub Counties, 3 Town Councils and 1129 Villages. The Sub Counties of Kaato, Wesswa, Butta and Bunabutsale have been greatly affected by the recent landslides which occurred on 16th and 18th May 2018.

In Kaato Subcounty, the landslide affected the following villages Bunamungoma, Sibanga, Bunamalwa West, Bunamalwa East, Namoso, Bumukari West, Bumukari East, Bumukari Central. In Wesswa Sub County the village affected is Bunashirwe Village in and Sobbi Village in Bunabutsale Sub County

As a result, affected people were displaced, crops, livestock and trees destroyed, houses developed cracks and 20 houses were destroyed. The main road in Kaato Sub County from Buwangani to Shikunga was cut off by the recent landslides.

Land slide scars and where Buwangani to Shikunga road was cut off in Kaato Subcounty

Land slide scars in Butta Subcounty

Landslide Scar 4

The landslide scar is 300 m by 50m, 15m deep and located at GPS coordinate UTM, WGS 84 (36 N 649934 108647). Bunamungoma, and Sibanga Villages, Kaato Subcounty. Houses at risk and developed cracks, crops, livestock and Trees were destroyed.

Landslide Scar 4


Crops washed away


Buwangani to Shikunga road was cut off


Houses at Risk

Landslide Scar 5

The landslide scar is 50 m by 20m, 10m deep and located at GPS coordinate UTM, WGS 84 (36 N 649556 109424). Sobbi Village in Bunabutsale Sub County. The landslide first occurred in December 2014 and resurfaced in May 2018. Houses at risk and developed cracks, crops, livestock and trees were destroyed. The landslide has affected 32 households leaving them homeless.


An old scar imminent

Landslide Scar 6

The landslide scar is 80 m by 10m, 7m deep and located at GPS coordinate UTM, WGS 84 (34.2550 0.9256). Bufumbula IV Village in Butta Sub County. The landslide occurred on 12th May 2018. Rocks fall, crops, livestock and trees were destroyed

Landslide scar

Water emerges from people's houses after landslide occurrence

Stones brought by water after landslide occurrence destroying people's houses and crops

Mudslide

Recommendations

- Relief assistance to affected communities of the recent landslides
- The households need to be resettled as more cracks are still visible and more rains are expected that might trigger more landslides
- Sustainable interventions need to be done on resettlement of all households out of risk areas
- Landslide risk areas should be zoned and not inhabited
- Public facilities such as schools, water facilities, health centers /clinics etc should not be constructed in landslide prone areas
- Proper farming [illegible]
- Sensitization to communities the dangers in staying in such risk areas, conservation of highlands of Mt Elgon, good farming practices.
- Restoration of degraded highlands
- Soil and Water conservation efforts should be [illegible]
- Urbanization and communities given alternative livelihood to reduce on the dependence on highlands