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STUDY ON THE NATURAL-HAZARDS VULNERABILITY AND RISK PROFILES IN HOT-SPOT AREAS AS A SUPPORT TO EARLY WARNING, DISASTER PREPAREDNESS AND RISK REDUCTION (EWDPRR) MEASURES IN UGANDA.

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EXECUTIVE SUMMARY

Natural hazards are on the increase at a global scale and Uganda has not been spared either. Since 1990 natural disasters have become more frequent and the most common ones are floods, landslides, droughts, earthquakes/tremors and lightning. This study was aimed at identifying hotspots for natural disasters and also provides more information and recommendations on how they can be reduced. This report provides a detailed account of the methodology, and modalities of how assessment was carried out. The findings reveal that Uganda is mostly impacted on by hydrological and meteorological disasters. These natural hazards and disasters have led to displacement of thousands of residents, claimed lives, devastated homesteads and destroyed livelihoods. A total of 1102 people have been killed and 3,365,380 affected by natural disasters in Uganda since the 1920's. Landslides alone have killed 542 people which is the highest number followed by lightning at 191. Vulnerability to **landslides** is highest in Bududa, Sironko and Bulambuli Districts in the Mount Elgon area. However, the Ruwenzori region also experiences landslides triggered by both rainfall and earthquakes. The eastern side of Bududa is the landslide hotspot for Uganda where most people have died and will continue to die from landslides. For example, 507 people killed by landslides since 1800 - 2013 in Bududa alone whereby 365 of these died in just one landslide that occurred on 1st March 2010 at Nametsi. In Sironko the Zesui area is most affected while in Bulambuli, Namusuni and Lusya are the area's most prone to landslides. Since 1951, 95 landslides have occurred in both Sironko and Bulambuli and 32 people killed. Many sub counties in Sironko and Bulambuli recognize landslides as a major social problem and they have been integrated in their sub-county Development plans, however this is done on individual basis.

Another disaster that creates a lot of strife is drought. 60 districts are prone to droughts however; the Karamoja is the most affected. 41 people have died of starvation and 3,000,000 affected due to **drought** since 1998 and most of the dead are from Karamoja. For example, just this year reports from the Office of the Prime Minister indicate that 41 people have died of starvation in the Karamoja region and

about 300,000 children are malnourished. In Uganda droughts affect more people followed by floods. These droughts normally occur in the months of August to November and they are common in the cattle corridor, which stretches from Karamoja to the south western areas of Mbarara. Droughts lead to water scarcity and sometimes this result in conflicts among pastoralists as they move in such of water for their animals. 2003 to 2006 was a remarkable drought period that caused the Lakes Victoria and Kyoga to drop in their levels. This affected electricity generation and consequently affecting the economy. Therefore, it is recommended that strategies should be put in place to predict droughts and also interventions should aim at improving the food security situation in the drought prone areas.

Floods have killed 40 people and affected 353,333 since 2005. One flood that is still in people's memory is the Kasese flood which occurred on 1st May this year killing eight and displacing 15,000 people. This was caused by an extreme rainfall event and it is believed to have been worsened by increased runoff from the bare areas of the moorland in Mount Ruwenzori National Park where the vegetation was destroyed by wildfires in February 2011. Floods will continue to affect lives unless proper measures are put in place to reduce on the impacts. For example restoration of water catchments and protection of riverbanks can greatly reduce on flood disasters in Uganda. Regulations on management of mountainous areas and river banks already exist and they just need to be enforced. Kasese District and the Teso region are the hotspots for floods in the country. A lot of havoc is caused by floods, but one key finding is that people forget very fast and return to the flood prone areas without any mitigation in place. For example, plans are already underway to resettle people affected recently by floods in Kasese without proper mitigations in some areas such as Kilembe which should have been zoned as flood prone. This undermines the principle of disaster risk reduction. In addition a lot of infrastructure such as roads and bridges country wide have been damaged by floods and the costs of restoration are quite high for a developing nation such as Uganda. Many bridges in most parts of the country are washed away, broken and submerged whenever it rains cutting off most of the routes bringing transport to a stand still for several hours, days or weeks. Karamoja region, Teso region, Butaleja, Bulambuli, Sironko, Kasese and Ntoroko are the areas with high incidents of flash floods. 21 districts in eastern region are prone to floods and the main cause in the heavy run-off from the degraded areas of Mount Elgon catchment. 13 districts in the north are prone to floods while in West Nile 4 districts of Moyo, Adjumani, Arua and Nebbi are prone to flood hazards. The central region has 10 districts that are prone to floods with Kampala being the most affected.

Other disasters that are not prioritized and yet have been identified as a concern in this study are wild and manmade **fires**. 138 people have been killed and 154 injured by fires for the period 2009 to 2012. There is need to sensitize communities about the risk of fires especially those involving highly flammable substance such as fuel. Some of the domestic fires are also due to electrical short circuiting especially those in Kampala which calls for the need to regulate the importation of standard electrical appliances and other materials. Communities should also be sensitized on the risk of living infants alone with naked fires such as candles. 20 districts from the northern region have the highest risk from **Wildfires (bush burning)**, while 13 are at high risk and 17 at medium risk of wildfires. Although bush burning is used as land management practice to clear land for cultivation in northern Uganda and in some other areas such as Rakai it poses a risk to both the environment and the human health.

Another disaster of significance is **lightning**. Lightning has silently killed 191 and affected 727 in 88 districts since 2007. In 2011 alone 48 districts had lightning strikes in some cases resulting into death. Uganda as a country except for the Karamoja region is vulnerable to lightning strikes. Gulu, Lira, Hoima, Kiryandongo, Kibale, Jinja, Kalangala and Kisoro were districts with most occurrences, deaths and also those injured with lightning. In 2011, 19 pupils from Runyaya Primary School in Kiryandongo district were killed by lightning while 70 suffered injuries. Communities need to be sensitized about the safety measures to minimise lightning strikes. Some communities believe in superstition which calls for awareness raising through the media and school programmes. Most disasters in Uganda are weather related. Therefore, it is recommended that the Department of Meteorology increases the number of weather stations and collect timely data and information to inform decisions and also create early warning systems.

Earthquakes that are disastrous are not so frequent but given that in 1966 there was a strong earthquake caution needs to be taken especially in the regions where it was very severe. The 1966 earthquake killed 150 people and injured 1300. Uganda's Earthquakes are linked to faults that are related to the east African rifting. The Fort Portal region and the western are most prone to earthquakes. For example, 259 tremors were felt from 1925 to 1953 and 100 of these were from Fort portal. *Simons 1939* reported that Fort Portal experienced 362 tremors in a period of 12 years which was the highest as compared to 55 in Mubende, 46 in Mbarara, 36 in Hoima. According to the United States Geological Survey, **Hima in Kasese, Pakwach, Bundibugyo, Rukungiri and Hoima** are other areas where epicenters of tremors have been recorded. It should also be considered that earthquakes and volcanism are many times related so they should both be monitored and information used to educate communities about this science. For example in 2004 there was a scare in the Mount Elgon area of an impending volcanic eruption. Also during a recent inspection in the Mount Elgon area with the sub-committee of cabinet on disasters, communities mentioned issues such as rumbling noises in the volcano, dark substances coming out of rocks in some areas with dykes, huge cracks which calls for increased monitoring of this region. It is recommended that the Geological Surveys and Mines Department in Entebbe be equipped with modern equipment and also funds for research so as to better understand this phenomenon and also educate all people on the earthquakes and volcanism, their causes and the consequences in Uganda.

Other findings in this study is the lack of coordination in data collection and storage and use on disasters, It was observed that even the Office of the prime Minister does not have a full database on all disasters although there is an attempt to develop one but the commitment is not adequate. There is also the need to popularize the disaster management policy because some institutions are not aware of it and neither are they aware of their roles as stipulated in the policy. Research on disasters should also be strengthened to improve on the understanding, for example the causes of most fires that occur in households is never known which might require further specialized training of the Uganda Police force. More emphasis has been put on disaster response as compared to disaster reduction.

1. INTRODUCTION.

1.1 Background.

The guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action commonly known as "Yokohama Strategy", adopted in 1994, provided landmark guidance on reducing disaster risk and the impacts of disasters. One of the specific gaps and challenges identified in this strategy was risk identification, assessment, monitoring and early warning. Further still the Hyogo framework of action for the period 2005 to 2015 outlines five priority areas which include:

- Ensuring that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation,
- Identify, assess and monitor disaster risks and enhance early warning.
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthen disaster preparedness for effective response at all levels.

The Mid-Term Review of the Hyogo framework carried out in 2010 - 2011 highlighted the significant progress that has been made over the past five years in disaster risk reduction and the fact that the adoption of the Hyogo Framework for Action in 2005 - 2015 has played a decisive role in promoting this progress across international, regional, and national agendas. The Review confirms that progress achieved in Hyogo framework implementation is uneven across the world, reflecting broad economic and institutional differences among regions and countries. An analysis of government reports, through the Hyogo framework Monitor, for the 2005-2007, 2007-2009, and the on-going 2009-2011 cycles, indicates that progress is indeed taking place in disaster risk reduction, especially from an institutional point of view, in the passing of national legislation, in setting up early warning systems, and in strengthening disaster preparedness and response. Concerns remain about the lack of systematic multi-hazards risk assessments and early warning systems factoring in social and economic vulnerabilities; the integration of disaster risk reduction into sustainable development policies and planning at national and international level, and the still insufficient level of implementation of the Hyogo Framework for Action at the local level. It remains difficult to increase resilience to hazards, especially in the most vulnerable segments of society (Mid-term review 2010 -2011). Recently during the recent global platform on natural disasters held in May 2013 the focus has now shifted on the impact of disasters on business. Disasters, can negatively affect the basic requirements for competitiveness, including sound infrastructure, macroeconomic stability and a healthy and educated workforce (WEF, 2012). As such, countries that are unable to manage their disaster risks are likely to be less competitive in the medium and longer terms (Global Assessment Report on Disaster Risk Reduction, 2013). Many countries have been far less successful, in reducing the vulnerability of their produced capital, including housing, infrastructure and productive assets. Low and middle-income countries which Uganda falls, in particular, report that they are challenged to use tools such as land-use planning, environmental management and building codes to reduce these vulnerabilities (Global Assessment Reports on Disaster Risk Reduction, 2009 and 2011). As a consequence, as mortality risk has decreased in successful economies, economic disaster risk has been increasing in concert with the growth in exposure (Barthel and Neumeyer, 2010). It has been observed that the global economy's transformation over the last 40 years has led to a growing accumulation of disaster risk (Global Assessment Report on Disaster Risk Reduction, 2013). Annually, economic losses already amount to hundreds of billions of dollars and they are projected to double by the year 2030 (Global Assessment Report on Disaster Risk Reduction, 2013). It has been recommended that all parties need access to risk information and scientific and technical methods that are understandable and usable (Global Assessment Report on Disaster Risk Reduction, 2013). Likewise, citizens need to be sensitized and assisted in their use including through information and communication technologies and space-based technologies. This study by UNESCO is a great initiative and it will contribute to the importance of using satellite data in the reduction of disasters in Uganda. The most common natural disasters in Uganda are floods, landslides, droughts, earthquakes/tremors and lightning. The Government of Uganda has a Ministry of Disaster Preparedness and Refugees, under the Office of Prime Minister, charged with overseeing the issues of Disasters and Refugees. The best way to reduce these natural disasters is through preparedness and mitigation. Disaster Preparedness as defined by the United Nations Office for Coordination of Humanitarian Affairs (UNOCHA) would involve pre-disaster activities based on sound risk analysis. This Ministry largely coordinates various relief efforts, which are always a reactive action when disasters have struck and caused untold suffering. The level of preparedness in terms of early warnings and risk maps in Uganda is still low. Therefore this study is to serve as a stimulant for the actors in Government, private sectors and Non-governmental organizations who deal with disasters to enhance preparedness in their work plans and activities by providing risk and vulnerability information in terms of maps, graphics, photographs and video's.

1.2 Objectives.

To develop a database on the geo-hazards vulnerability and risk profiles of the known areas of frequent occurrence of disasters and recommend the establishment of reliable early warning, disaster preparedness and risk reduction (EWDPRR) measures for the affected areas and the entire country.

To institute a best practice and institutional capacity development for national country reports on disaster risks and socio-economic impacts.

2. VULNERABILITY ASSESSMENT TO NATURAL HAZARDS.

2.1 FLOODS

Floods are becoming a more pronounced disaster in many parts of the country costing lives and also damaging property. One observation is that information on floods appears not to be well documented and actually no institution seems to be in charge of these particular disasters. Information is then scattered in various offices including districts, Office of the Prime Minister, media houses, NGO's and some of it was collected from the community. This needs to be harmonized so as to have reliable information to feed into the decision making. Floods occur when we experience above normal rains and rivers burst their banks. This was also observed in a report by UN/ISDR 2011 that flood mortality risk has been growing consistently since 1980 in sub-sahara Africa because the rapid increase in exposure has not been accompanied by a commensurable reduction in vulnerability. Flash floods are also very common especially during seasons of intense rains. The areas with high or severe incidents of flash floods are Karamoja region, Teso region, Butaleja, Bulambuli, Sironko, Kasese and Ntoroko (Table 2.1). A flash flood is typically caused by sudden, excessive rainfall that sends a river, stream or other body of water rapidly out of its banks. Often this occurs in a short amount of time, only several hours or even less. The constant influx of water finally causes a treacherous overflow to begin; powerful enough to sweep vehicles away, roll boulders into roadways, uproot trees, level buildings, and drag bridges off their piers. This was the case that occurred in Kaabong and Amudat districts in August 2011 when a truck and pick-up were swept by floods (Table 2.1). Most frightening is the rapidity with which the water rises the case of what happened in Kasese in May 2013. The force of flash flood waters can be extremely dangerous to motorists who unknowingly drive over flooded roads and the vehicles are sometimes swept away (Plate 2.1).

Year.	District	Parishes.	Number of people killed.	Number of people affected.	Estimated Cost of damage.
2011	Bulambuli	Sisiyi, Lusha, Mabono, Luzi, Kisubi.	3	342	467,000,000
2011	Bulambuli	Bugibologoto, Gidega, Kikuyu, Bumasobo, Buwebele, Bufuni, Bumasare, Bulumela, Buwabwala, Bufumbula, Busiende, Bwikhonge, Busabulo, Namaliro.	0	6805	Not known
2011	Bukwo	Aralam	0	0	Property damaged but cost Not known
2011	Kween	Ngenge,		1320	Not known
2011	Ntoroko	Butungama, Bweramule		1820	Not known.
2011 (August)	Moroto	Lorengdwat, Lopel,			Lorengdwat and Lopel bridges submerged cutting off Nakapiripirit and Kotido.
2011 (August)	Nakapiripirit	Chepskunga	0	0	Chepskunga bridge connecting Mbale - Nakapiripirit cut off
2011 (August)	Kaboong	Karenga	0	0	Karenga bridge connecting Kaabong-Kitgum was at risk of submerging
2011 (August)	Kaboong	Kaboong	0	0	21 tone truck was washed away.
2011 (August)	Amudat		0	0	River Dingidinga washed a brand new pick up land cruiser patrol.
2011 (August)	Abim		0	490	not known.
2011	Mbale	Namasaba	0	225	Not known
2011	Nakapiripirit			1940	Bridges destroyed, cars, trucks and crops.
2011	Nebbi			2040	Not known
2011	Moyo			2570	Not known
2011	Mpigi			492	Not known
2011	Rwengo			1962	Not known
2012 (May)	Kween	Kiriki and Ngenge	5	7498	3,500,000,000
2012 (July)	Kween	Kaptum	2		Roads damaged but cost not known
2012	Sironko	Buwasa, Bukhulo, Bukise, Bumasifa, Bumalimba,			5 fish ponds washed away, 52 acres of land destroyed, 8 bridges

		Busulani.			damaged, 19.7 km of road eroded, 42,000 coffee trees washed away.
2012	Manafwa	Kaato, Buwagogo, Mayenze,	0	0	3 bridges damaged (1,750,000,000).
2012	Ntoroko	Kabimiri, Haibale, Kyapa, Rukora	2	800	Crops destroyed.
2012	Soroti	Awoja	0	0	Awoja bridge section submerged connecting Mbale-Soroti washing more than 200 meters of tarmac road
2013 (May)	Kasese	Kilembe Mines areas,	8	15000	Kilembe mines hospital children and surgical wards closed. Kasese - Fort portal road cut off. Houses along river Nyamwambwa have been submerged.
2013	Ntoroko	Butungama, Bweramale	2	4313	People displaced, bridges swept,
2013 (May)	Bulisa			620	30 families displaced, Road to butyaba health centre was blocked

Table 2.1: Flood occurrences, information collected from the field and reports from districts.

Plate 2.1. A truck swept by a flood and is stuck in the mud in Kasese town.

2.2 Flood hazard mapping.

The national flood hazard map was created using the method below:

Stage 1: Creation of soil Factor Layer.

a). The landuse layer was modified by adding the flood risk soil factors for the respective land use type referring to the value associated with each class.

b). The soil layer was modified by adding the hydrologic class for each soil unit.

c). The modified landuse and soil layers were combined to obtain a "soiluse" layer.

d). Create a risk field and populate its value using the following ranges.

Risk value	Range
3	>70
2	40 - 70
1	< 40

f). Dissolve the common boundaries in the "soiluse" layer using the values in the Risk field.

g). Save the result as **Soil_LU risk_map layer**.

Stage 2: Creation of Rainfall Factor Layer.

a). The rainfall layer was converted into GRID layer.
b). The GRID layer was reclassified using the following rainfall range of values:

Rain risk	Rain value (mm)
3	>60
2	25 – 60
1	<25

c). The reclassified grid was converted into a vector layer

d). Dissolve the common boundaries using the values in the Rain_Risk field (Grid value).

e). Save the result as **Rain_risk_map layer.**

Stage 3: Creation of Slope Factor Layer.

a). The input DEM TIN layer was converted into a GRID slope layer.

b). The GRID slope layer was reclassified using the slope ranges shown in the table following. Note that the weights have been assigned such that slopes of less than 0.1% are favored. This is so as the classification of the hazard is based solely on flood levels not on velocity as well. Under natural conditions, storage is more likely to occur on such flat slopes than ones with the higher values.

Slope risk	Slope range (%)	Slope range (0)
6	<0.1	<0.06
2	0.1 - 0.5	0.06 - 0.3
1	>0.5	>0.3

c. The reclassified grid was converted into a vector layer.

d. The common boundaries were dissolved using the values in the Slope_Risk field (Grid value).

e. Save the result as **Slope_risk_map layer**.

Stage 4: Creation of Flood Risk Layer.

a). The LU_Soil_risk_map was combined with the Rain_risk_map layers and the output as **LU_Soil_Rain_Risk layer**.

b). The Slope_risk_map was combined with the LU_Soil_Rain_Risk layer and save the output as **total_Risk layer**.

c). Create a new field in the resulting layer called **"Total_risk."**

d). Populate this field using the following expression:

Total_risk" = "LU_Soil Risk layer" + "Rain_risk" + "Slope_risk"

e). Dissolve the common boundaries using the values in the Total_risk field.

f). Create a new field called "Risk_Level" and populate this field using the following ranges of total risk values.

Risk _level	Total_risk range
3	>9
2	7-9
1	<7

g). Create a new field called "Flood_Risk" and populate this field as indicated below:

Flood risk	Risk_Level value
High	3
Medium	2
Low	1

h). The result is the Flood_risk_map layer in Figure 2.1.

The flood hazard map in ***Figure 2.1*** indicates that the districts in ***Table 2.2*** are prone to flood hazards. In some of the districts floods have already occurred while others have not been experienced possibly because of vegetation cover. 21 districts in eastern region are prone to floods. 16 of these districts fall under the Lake Kyoga basin an area that runs from Mount Elgon to Tororo down to the Lake Kyoga. Elgon is a high rainfall area at the same time highly degraded with a high population dependent on agriculture for livelihood. Continuous cultivation of steep areas has resulted in increased runoff as observed from the flow curves in most of the rivers from Mount Elgon. The runoff water causes flashfloods in the upper areas and more floods in the low-lying areas with wetlands. 13 districts in the North are prone to floods and 9 have already experienced flood events, while in West Nile four districts of Moyo, Adjumani, Arua and Nebbi are prone to flood hazards and all except Nebbi have experienced floods (Table 2.1). Finally in the central region 10 districts are prone to floods and only five have experienced them. Resilience to floods was low in most affected communities as many always wait for support from Government a practice which needs to be improved by empowering communities to cope through preparedness. There is strong evidence that empowerment of communities and local governments to identify and manage their everyday risks, and to engage in the development of disaster risk reduction strategies, programmes and budgets provides a sound basis for building resilience (Global Platform 2013).

Flood hazard (Eastern region)	Occurrence of floods.	Flood hazard (Northern region)	Occurrence of floods.
Ngora	Observed	Moyo	Some parts
Kumi	Observed	Adjumani	Observed
Pallisa	Observed	Arua	Observed
Bulambuli	Observed	Nebbi	Not yet
Sironko	Observed	Amuru	Observed
Kayunga	No floods yet	Gulu	Not yet
Tororo	Observed	Pader	Observed
Butaleja	Observed	Kole	Not yet
Busia	No floods yet	Otuke	Not yet
Bukedea	Observed	Lira	Not yet
Kween	Observed	Oyam	Observed
Amudat	Observed	Apac	Observed
Bugiri	No floods yet	Amolatar	Observed
Mayuge	No floods yet	Dokolo	Observed
Amuria	Observed	Agago	Observed
Katakwi	Observed	Kitgum	Observed
Soroti	Observed	Kotido	Observed
Serere	Observed		
Napak	Observed		
Abim	No floods		
Kaberamaido	Observed		

Flood hazard (western region)	Floods recorded	Flood hazard (central region)	Floods recorded
Rukungiri	Observed	Kampala	Observed
Kanungu	Observed	Mukono	Observed
Kabaale	Observed	Kiboga	Observed
Mbarara	Observed	Mityana	Observed
Isingiro	Observed	Gomba	Observed
Ntoroko	Observed	Luwero	Not yet
Kibaale	Observed	Nakasongola	Not yet
Kasese	Observed	Nakaseka	Not yet
Kyakwanzi	Observed	Mubende	Not yet
Kiruhura	observed	Masaka	Not yet

Table: 2.2 Flood hazard in the regions.

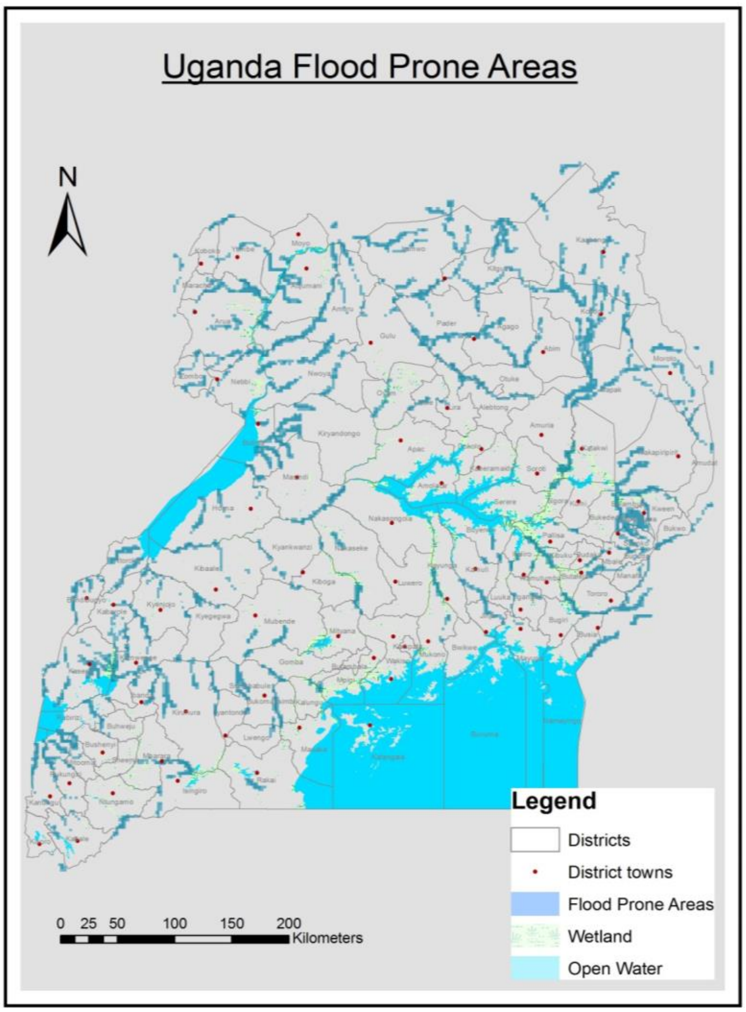


Figure 2.1: Flood prone areas in Uganda.

YEARS	NUMBER OF PEOPLE KILLED	NUMBER OF PEOPLE DISPLACED
2005	0	0
2006	0	0
2007	17	300000
2011	3	19006
2012	9	8298
2013	11	26029
Total	40	353333

Table: 2.3. Number of people killed and affected by floods for period 2005 - 2013. Source: Field work and district reports.

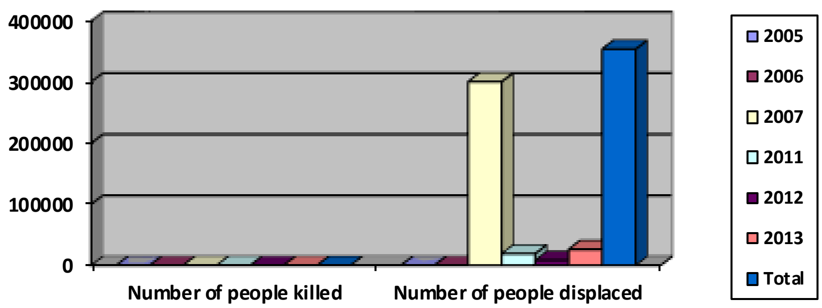


Figure 2. 2. Number of people killed and affected by floods for the period 2005-2013.

Forty people were killed by floods for the period 2005 to 2013 and over three hundred thousand displaced (Table 2.3 and Figure 2.2) The highest number killed and affected was in 2007 when there were extreme high rainfall events in the Mount Elgon and the Karamoja regions a state of emergency was declared. In Karamoja flashfloods have damaged roads and damaged bridges making transport in the region difficult. Most of this damage is not well quantified in monetary terms an area which needs improvement.

2.3 Floods in Kasese District.

On 1st May this year 2013, floods hit Kasese town killing eight people and 15,000 were displaced. The Rivers Mubuku, Nyamwamba and Nyamugasani originate from the Ruwenzori Mountains and empty their waters into Lake George and Edward. Catchments of these rivers have several socio-economic activities being undertaken within, by both the public and the private sectors. These include agriculture;

industry; settlements/urbanization; energy production and wildlife conservation. Despite this use, the water resources in the sub-catchment are threatened by encroachment and unsustainable landuse practices. Some of these activities include cultivation on the river bank and wetland degradation; siltation of water channels. Besides these threats, there are cross cutting issues namely; climate change and variability and vulnerability, high illiteracy rate and rampant poverty and disease that are posing additional threats to the catchment. The cause of the floods was an extreme rainfall event in the Mount Ruwenzori National Park which went on for days causing River Nyamwamba to burst its banks. The river destroyed all the bridges in Kilembe area, and completely wiped out the nurses quarters for Kilembe Mines Hospital. Other rivers such as Mubuku and Rwimi and Nyamugasane also flooded greatly affecting power generation for the Kilembe mines and Kasese Cobalt LTD companies.

The assessment team utilized several tools and instruments to gather an insight of the situation of flooding on the ground. The tools and instruments used included among other approaches;

- Focused discussions of the situation with the District officials together with some lower local Government representatives;
- Physical observation of the situation on ground
- Interviews using some affected community representatives as respondents.
- Report reviews from stakeholders within the area.


Plate: 2.2. Field observations and focus group meetings. Photo credit: Kitutu Goretti

2.3.1. Areas assessed.

These included Kilembe sub-county, Nyamwamba Division-Kasese Municipality, Bugoye, Maliba, Karusandara, and Kyarumba Sub Counties. In all these areas, physical observation of the situation on ground was critical. However some of the areas were not accessible as roads were no passable as they had been damaged beyond crossing. A case in point was Kyarumba-Kising road and Kyanya-Maliba road. The team therefore depended on representative information gathered from the accessible areas.

2.3.2 Characteristics of the watersheds of the Rivers Mubuku, Nyamwamba and Nyamugasani.

The drainage systems of Kasese have 3 main landuse systems; these include:

- The Mountain Ruwenzori National Park which is a protected area.
- The settlement area which has cultivated steep slopes with a high population.
- Settlements practicing subsistence agriculture along rivers.

The rivers Nyamwamba, Mubuku and Nyamugasani and their tributaries originate from the Ruwenzori's Mountains in Western Uganda. River Nyamwamba was diverted from its original course in 1964 by the Kilembe Mines Company that mined copper. The diversion was basically to allow the construction of mine offices and housing estates within the Kilembe valley (Figure 5.3). Downstream the river has a shallow valley making it vulnerable to flooding during rain seasons. There is an illegal irrigation scheme that allows diversion of water at several points along the Nyamwamba river downstream creating lower points where water flows and floods settlements. The drainage channels in the municipality have been silted which worsened the impact of the floods in the municipality.

Similarly river Mubuku has shallow valleys downstream making it vulnerable to flooding even in seasons of light rainfall. This is why settlements and cultivated areas are frequently flooded. River Nkoko a distributary of river Mubuku also flows in a shallow and small valley making it easy for the river to overflow its banks. These are some of the river characteristics that may have greatly contributed to devastating floods in the district.

2.3.2 Climate.

Kasese district experiences a bimodal rainfall pattern. The first rains are short and occur during March- May, and the longer rains from August -November. Annual rainfall ranges from less than 800mm to 1600mm and is greatly influenced by altitude. The temperature and humidity in the watershed vary with altitude, with the high land temperatures ranging from 0 to 25^{o}C and the low land from 8 to 30^{o}C.

2.3.3. Vegetation and land cover.

The watershed has three main belts of vegetation and these include the Ruwenzori Mountains National Park, the Queen Elizabeth National Park (QENP) and the middle belt which has settlements. The Ruwenzori Mountains National Park (RMNP) is located m.a.s.l Republic of Congo (DRC) in the west. The mountain ranges out of which the park has been gazetted run over a hundred kilometers in the north-south direction and fifty Kilometres in the east-west direction. Over 75% of the ranges are in Uganda with the other small fraction falling in the DRC.

2.3.4. Vegetation in Ruwenzori Mountains National Park.

The vegetation of Ruwenzori Mountains National Park is largely influenced by elevation and five distinct zones identified. These include grasslands at an altitude of 1000- 2000 m.a.s.l, Montane forest 2000-3000 m.a.s.l, bamboo/mimolopsis zone at 2,500-3,500, healthier/riparian zone 3,000-4,000 m.a.s.l and the afro-alpine moorland zone 4,000-4,500 m.a.s.l.

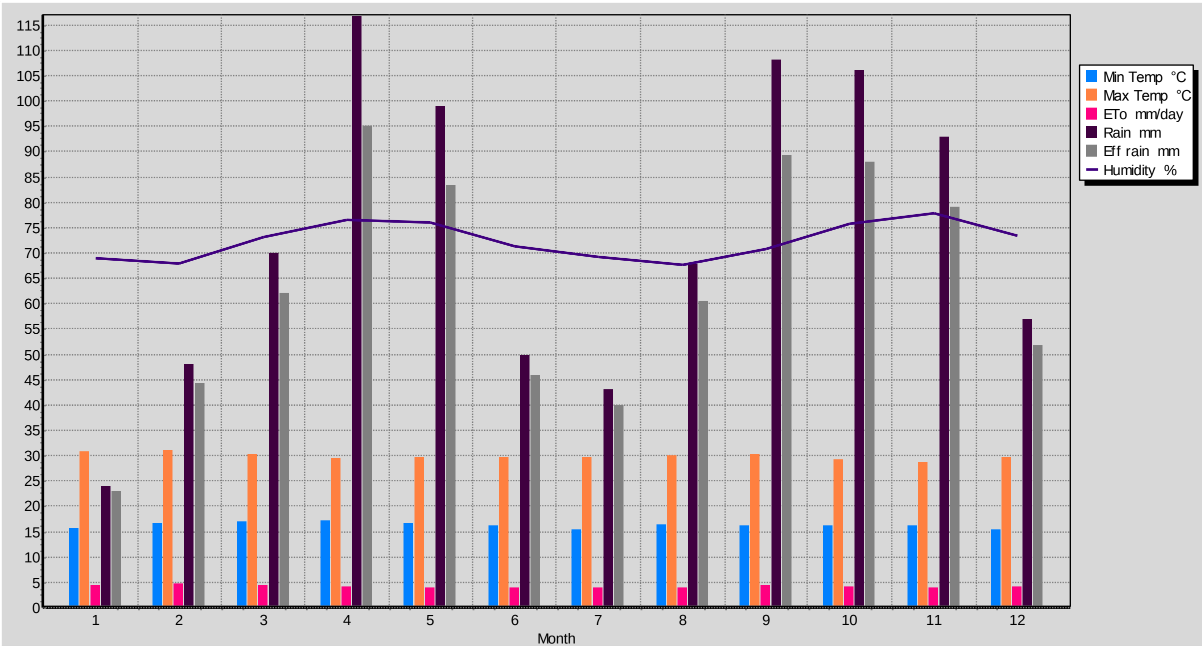


Figure 2.3: Average climatic values for Kasese
(Source: River Mubuku-Nyamwamba Management Plan 2012)

2.3.5. Grassland (1,000-2,000 m.a.s.l).

This zone has tall dense *pennisetum purperum* (elephant grass) in the valleys with shorter grasses and many flowering plants on the hill slopes where the thorny, red-flowered *Erythrina abassinica* is often conspicuous. Flat crowned *Albizia spp*. are abundant in the small valley forests.

2.3.6. Montane forest (2,000-3,000 m.a.s.l).

In the lower lying areas up to about 2,400m the montane forest vegetation is characterized by the tree species such as *symphonia Globulifera*, *prunus Africana*, *Albizia* and *Dombeya spp*. There are very few large trees exceeding 30m in height and a canopy is very broken except in valley bottoms and along ridge tops where gradient are comparatively gentle. Here the trees are very dense and layered with larger tree specimens.

2.3.7. Bamboo/mimulopsis zone (2,500-3,500 m.a.s.l).

On moderate slopes with a deep soil, *Arundinaria alpina* forms a dense stand with few other plants among it. On steep and rocky slopes this is replaced by a frightful tangle of *Mimulopsis ellotii*.

2.3.8. Heather / rapanea zone (3,000-4,000 m.a.s.l)

On poor soil (ridge-tops, rock, or moderately boggy ground) grow dense thickets of tree heathers, *philipia trimera* and *p. kingaensis*.On well drained slopes there is a greater variety of plants, with small trees standing over tangled undergrowth. Bogs in this zone are occupied by various kinds of sedge, chiefly *carex runsorrensis* that forms huge tussocks up to 1m high between which grow sphagnum and other mosses.

2.3.9. Afro-alpine moorland zone (4,000-4500 m.a.s.l).

The most abundant vegetation in the zones is a tangled thicket about 5ft high of *Helichrysum stuhlmanii*, with white flowers that open quickly in any sunny period; at the higher altitudes the same species is only 1ft high, covered with white wooly hairs. Thickets of tree groundsels, *senecio adnivalis* occupy gullies and other sheltered or well watered sites, and scattered individuals occur throughout the zone. *Carex runsorrensis* bogs are abundant in this zone too, and small brilliant yellow or orange moss bogs occur at the highest levels.

2.3.10. Wetlands.

Most of the wetlands in the watershed are related to relief. The majority are found around Lake George. Other swamps are along the river banks with U-shaped valleys. On top of the mountain the bogs occupy depressions. The low land wetlands exist between 800-1,200m above sea level while high up in the Ruwenzori; they are at altitude 2,000-5,100 m above sea level.

2.3.11. Soils.

The soils in Kasese District, are Organic, Podsols/eutrophic, and Hydromorphic. These soils are vulnerable and are degraded because of unwise human activities such as over cultivation, cultivation on steep slopes, poor agronomic practices and over grazing causing soil erosion and fertility loss.

(a). Organic soils.

These soils are found at about 3,000 m.a.s.l up to the summit. The main characteristic is that they are acidic and have an upper layer, which contains slightly more than 20% organic matter. These soils are developed on non-volcanic mass and their pediments. They are called Bujuku complex and Kyansabo series. Kyasabo series moraines while the Bujuku complex has peaty loam and dark sandy clay loam. The Mulinda series has brown gritty clay loams and sandy loams.

(b). Eutrophic Soils.

These soils are developed on the rift valley flat and are recent rift valley deposits at altitude (900-1,200 m). They are in two categories: eutrophic soils developed on volcanic ash referred to as Kasese series, and those developed on non-volcanic material known as Sebwe series. The Kasese series has brown sandy loams and clay sandy loams. The Sebwe series is characterized by the surface (A) horizon being rich in organic matter and sometimes saturated with bases to more than 50% of its exchange capacity. They are generally rich in plant nutrients and contain fairly high reserve of weatherable minerals on alluvial deposits.

(c). Podsolic soils.

They are found at altitude 1,200-2,400m. Podsolic soils are not differentiated and are highly leached soils in which translocation of iron and aluminum has taken place. This produce an ash-colored bleached horizon immediately below a very acidic, peaty top soils and rusty colored B-horizon. These soils are known as Kazo catena. The parent rock is quartzite and granite. The dominant soil is shallow brown and reddish brown sandy loams. These soils are of little agricultural value (potential) being used occasionally for grazing, and any cultivation (coffee growing) is confined to small valleys and pediments.

2.3.12. Geology.

The Ruwenzori watershed and part of the rift basin of Mesozoic and Cenozoic origin straddles the boarder of Uganda and the Democratic Republic of Congo. It developed upon the Precambrian orogenic belts of the African Craton and is bordered by steep normal faults with uplifted flanks composed of Precambrian basement rocks such as gneisses, quartzites and maficintrusions. Geomorphologic development of the region's terrain reflects alternating cycles of mechanical and chemical denudation. There are four geological features in the district: partly granitized and metamorphosed formations, pleistone to recent rock formations, wholly granitized or high to medium grade metamorphosed formations and the rift valley geological features and formations.

Specifically we have:

i) Pre-Cambrian: This comprises of the Kilembe series which is closely associated with the Buganda-Toro system. This system is the most expensive of the cover formations which occupy much of western Uganda.

ii) Cenozoic (Pleistocene to recent): This category covers some district areas such as the plains in Kasese Municipal Council, Muhokya, Karusandara, and Lake Katwe area where rift valley segments are quite evident.

iii) The Crater Lake comprising of volcanic rocks, and parts of Kitholhu and Munkunyu - Lake Katwe area.

iv) The permanent swamp area where sediments, alluvium, black soils and moraines occur.

2.4.1. What caused the floods in Kasese.

On 1st May 2013 most rivers in Kasese flooded causing devastating effects to people and property. High amounts of water flowing in these streams run out of their confines and submerged the surrounding areas as there were virtually no flood control and early flood warning systems.

Possible causes of the flood are believed to be:

- Heavy down pour that was observed in the upper slopes of the Ruwenzori's as early as 5 a.m. in the day break

- Confined river banks that couldn't contain the amount of water flowing down stream consequently bursting the banks and flowing in settlements.

2.4.2. River Diversion and other bank destabilization processes.

There are two principal water diversions on the Nyamwamba River. The major one is at township which diverted the entire river water from its main channel to an artificial one purposely to create an area large enough to cater for construction of the Mine premises ***(Figure 2.4)***. This meant that the river was directed to flow in an area with weak river banks compared to the already hardened banks in its original channel. The strength of the diversion structures is the only hope for those people living in the vulnerable areas.

According to Masereka Alfred the Monitoring and Research Officer for Uganda Wildlife Authority (UWA) in Mount Ruwenzori National Park, who was up in the mountain at an altitude of 2600 m.a.s.l, it rained heavily and continuously for almost one and half days. River Mahoma and Choho the tributaries of River Mubuku started flooding inside the park. The rivers were carrying logs and trees into river Mubuku. The bridges on river Mahoma was swept away. Other rivers Rutara and Kihuma from the Portal peaks also flooded. The logs, trees and ricks dammed the rivers temporarily and when they broke the water was released with high force causing bridges to break. River Ruboni also flooded and it flowed into River Mubuku. This was the reason why river Mubuku flooded greatly almost cutting of Fort portal - Kasese road.

Inside the National Park on the Nyamwamba river side there are a lot of mountain bogs at Samalira, Begata and Mukunda at an altitude of 4,500 m.a.s.l. It was also reported that in February 2011 there was a wildfire at the Samalira catchment in the moorland which is still bare. The cause of the fire is not known although there is suspected arson by the hunters. Samalira is the main catchment for River Nyamwamba. In addition another stream from the Begata catchment that pours in the River Mulyambuli and finally into River Nyamwamba must have also flooded. River Nzwiranja which also pours into river Nyamwamba flooded. The high rainfall coupled with the effects of the bare moorland were the main causes of the flooding in the Kilembe valley. Some community members reported to have seen white flows in the hilly areas of the National Park which were actually flood waters but mistaken to be snow flows. Musana Yoweri the Warden in charge of tourism who had just come from the

national park in few weeks reported that some of the peaks such as Stanley no longer have any snow. The theory of the snow melt was ruled out because the cold temperatures could not cause snow melt and even the amounts of snow cannot cause such huge flows downstream. The rivers carried a lot of boulders from the National Park into the channels below something that might increase floods in the future. The process of formation of the Mount Ruwenzori left some areas with a lot of boulders piled on one another.

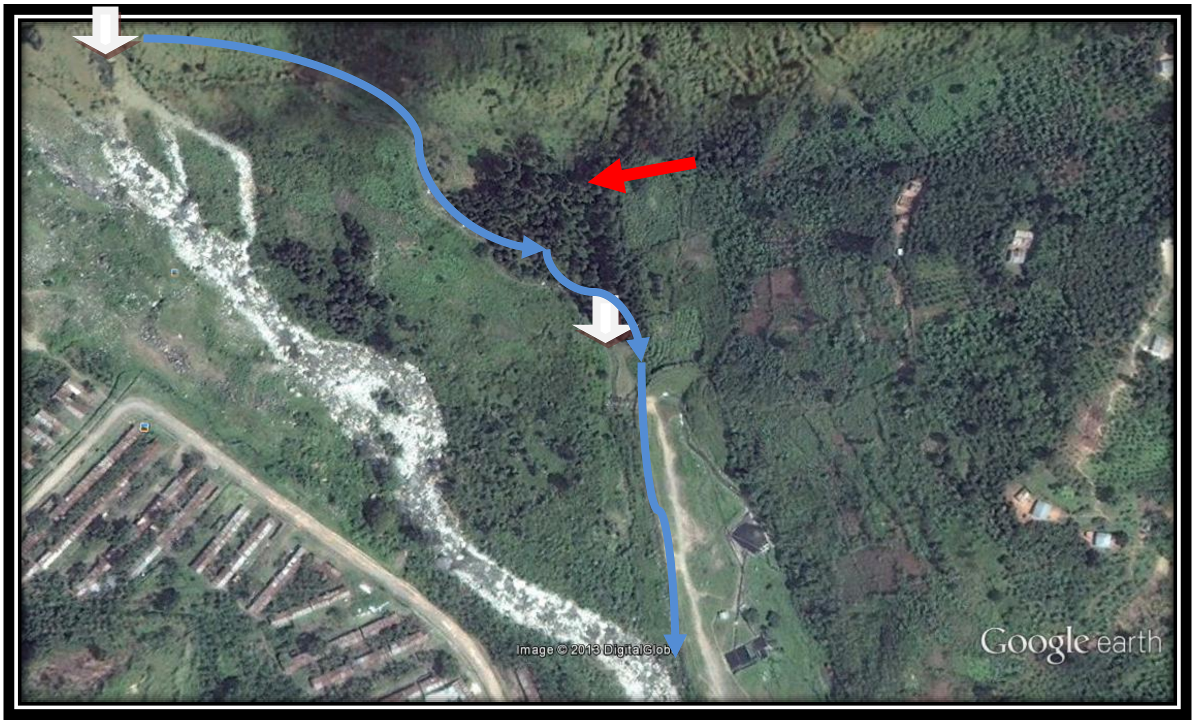


Figure 2.4: White arrows point to points of diversions in the river (36N 0166589, UTM0024041). The red arrow show a forest destroyed by the floods. The blue arrows show the flood channel for waters recently. Source: Google Earth maps

Figure 2.5. White arrows show some of the areas where water is diverted for irrigation. Source: Google Earth maps

The other diversions of significance are along the illegal irrigation points on Nyamwamba River downstream these diversions weaken the banks and make it easy for river water to flow over its banks destroying crops and other nearby structures ***(Figure 2.5)***.

2.4.3 Influence of Bridges.

Bridges have in some instances been seen as structures that constrict the active river channel and sometimes inhibit sediment transportation through the river system. The Kyanjuki and Bulembia bridges were washed away due to this reason. According to some onlookers the debris and rocks blocked the water flow at these bridges causing damming and accumulation of large water volumes. The bridges were eventually forced to break and the water mixed with debris and rocks gushed down at high speeds causing a lot of damage and flooding the Kilembe town.

2.4.4. Clearing of riparian vegetation.

Loss of riparian vegetation increases runoff and subsequent sedimentation to the river. The loss of riparian vegetation also impairs the recruitment of large woody debris for decades, which in turn inhibits the formation of side channels. Mature riverside forests function to help provide structure for the river as the intertwined root systems and large trees line the banks. Key areas where the loss of riparian vegetation is a factor in the Mubuku and Nyamwamba rivers are identified downstream. These are areas that need careful restoration.

2.4.5. Gravel extraction.

Extraction and removal of sand and also removal of stones for crushing was carried out in the lower Nyamwamba and Mubuku valleys ***(Plate 2.3)***. Problems associated with gravel and sand extraction include channel avulsion, head cut erosion in the channel and sedimentation.

Plate 2.3: Crushing stones that were originally removed from the Mubuku river

2.4.6. Channel migration.

This is the natural movement of a river across its floodplain. Mubuku and Nyamwamba rivers, the channels move by eroding the outside of a meander, or through channel avulsion. The channel migration zone (CMZ) is the outermost boundary that the river has historically used or will potentially use through bank erosion or avulsion into new channels. Although the CMZ is usually contained within the boundaries of the floodplain, in some cases the CMZ may extend outside of it. Where vegetation along the river has been removed, the erosion risk is generally greater. River Nyamwamba has an active river channel that moves over time ***(Figure 2.6)***. Houses that are built within or near the channel migration zone are at risk from flood damage, even if the flowing portion of the river is a substantial distance away. Over the past years, communities used to argue that flood damage could be reduced by increasing river channel conveyance by constant dredging and removal of other jam materials like digging out gravel so that the high flows could move unimpeded. However, these actions accelerate the erosive forces of the river and destabilize the river channel. The energy and erosive forces of high flows are actually slowed down by meanders, eroding banks, and the gravel load that the river transports. Location of structures must therefore be carefully done to avoid the potential risk of destruction by flood waters.

Figure 2.6: Channel migration in the Nyamwamba river. Source: Google earth image 2013

2.4.7. Channel aggradations and degradation.

A river not only moves laterally, but the bed also naturally moves up and down. When the riverbed increases in height (relative to a previous height), it is called aggradation, when it decreases in height it is called bed degradation. Pulses of gravel accumulate and decrease in response to the volume of gravel input as well as flood frequency, magnitude, and height. Channel aggradation has left the lower Nyamwamba river valley in a plate-like shape making nearby areas prone to a slight flood that easily runs over its banks.

2.4.8. Avulsion.

An additional hazard to structures in the floodplain and channel migration zone occurs during an avulsion. An avulsion occurs when the river moves to a new channel, either by creating a new channel or reoccupying an old side channel or low area. Generally the river re-enters its channel shortly downstream creating an island in between the banks of the two channels. This was observed on River Mubuku where the river went back to its channel of 1961 causing Mubuku power station without water for power generation.

2.5.7. Damage from floods.

2.51. Damage to bridges and roads.

The Kyarumba, Kilembe, Nyamwamba and Kithakena divisions lost all bridges ***(plate 2.4 and plate 2.5)***. River Mubuku also cut off one of the roads ***(Plate 2.6)***. In Kyarumba, Nyamwamba Division and Maliba roads were destroyed making it had for communities to access markets.

Plate 2.4: Washed away bridge connecting to Kyanzuki and Kilembe SS (36N0166816 UTM0022310).
Photo credit: Kitutu Goretti

Plate 2.5: A bridge damaged at Kilembe town. Photo credit; Kitutu Goretti

Plate 2.6: River Mubuku destroyed the road and went back to the 1961 course.
Photo credit; Kitutu Goretti

2.5.2. Other flood Impacts.

In Kyarumba, Karusanda, Nyamwamba and Maliba Divisions floods destroyed freshly planted fields. The soils were eroded and the gardens fields with rocks. This might lead to lack of food in some families. Kilembe Mines Hospital was closed which affected communities because of disruption in the provision of health services. Some of the houses were completely washed away leaving communities in camps.

Hydro power generation on most of the River Mubuku Power plants stopped because some of the rivers changed course. Generation levels have therefore reduced with the associated negative impacts in the power industry especially on the economic development of the district. The tourism industry is also facing a challenge as bridges, and trails have broken down in Ruwenzori Mountains National Park. Tourists have turned away from the flooded rivers and others cancelled bookings. Numerous small soil slips were observed on some of the slopes in the Kilembe area.

Plate: 2.7. Houses destroyed by floods in Kilembe

Plate 2.8. vehicles stuck in water and mud along the Kasese - Fort

(a) **(b)**

Plate 2.9 (a) shows Kilembe Mines Hospital before the floods and (b) show the same area after the floods. Note that the houses along the river in (a) do not exist in (b). Photo credit; Kasese District and Dr. Kitutu Goretti.

2.6. Recommendations for flood hazard reduction and restoration activities in Kasese.

One of the important steps taken to avert problems of floods and other hazards in the district has been to put in place a District Disaster Management Committee. This committee serves as an advisory body for disaster management in the entire district. The committee in partnership with other District Development Partners needs to be strengthened by building its capacity in order to be better prepared to make informed decisions and long term recommendations on different disaster reduction techniques.

2.6.1 Short term recommendations.

Construction of temporally bridges/ crossing points at all the wash-aways to restore community accessibility to major sources of livelihoods and services e.g. Medical, Marketing, Education and other social services. Taking care of the internally displaced people and facilitate them to resettle in safer areas.

2.6.2. Medium term recommendations.

That people still living in flood prone areas such as the weakened riverbanks and over drainage channels should relocate to avoid further calamities and also to enable river and channel rehabilitation programs run smoothly and as planned.

Demarcation of riverbanks should be carried out after sensitizing the community. These zones can be used for tree planting especially for the Nyamwamba and Mubuku rivers.

2.6.3. Long term recommendations.

Periodic dredging of the Mubuku and Nyamwamba river beds to allow for guided river flow especially towards rainy seasons. Unapproved structures and activities in the riverbanks and flood channels be demolished to allow proper rehabilitation of the flood channels and river banks. Landscape Restoration programs be undertaken to stabilize the hill slopes and protect rivers from further siltation and consequent riverbank and wetland degradation. Community sensitization programs should be undertaken to communicate to them the magnitude of the disaster and pass on agreed resolutions on the management of these degraded areas. Community participation should be emphasized throughout the restoration process to ascertain a sense of ownership and ensure continuity by the community.

Other recommendations for flood hazard reduction emphasize the use of non-structural alternatives because they represent long term solutions and do not negatively impact river processes that exacerbate chances of flood occurrence. These alternatives include land use management, regulations, monitoring, maintenance, emergency response, enforcement, and management plan formulation.

2.7. Flood hazard map for Kasese district.

The flood hazard map of Kasese district is shown below in Figure 2.7. All rivers in Kasese are prone to flooding and all the validated points fall in the river flood plains. The warning from this flood hazard map is settlements in Kasese districts should not be close to rivers.

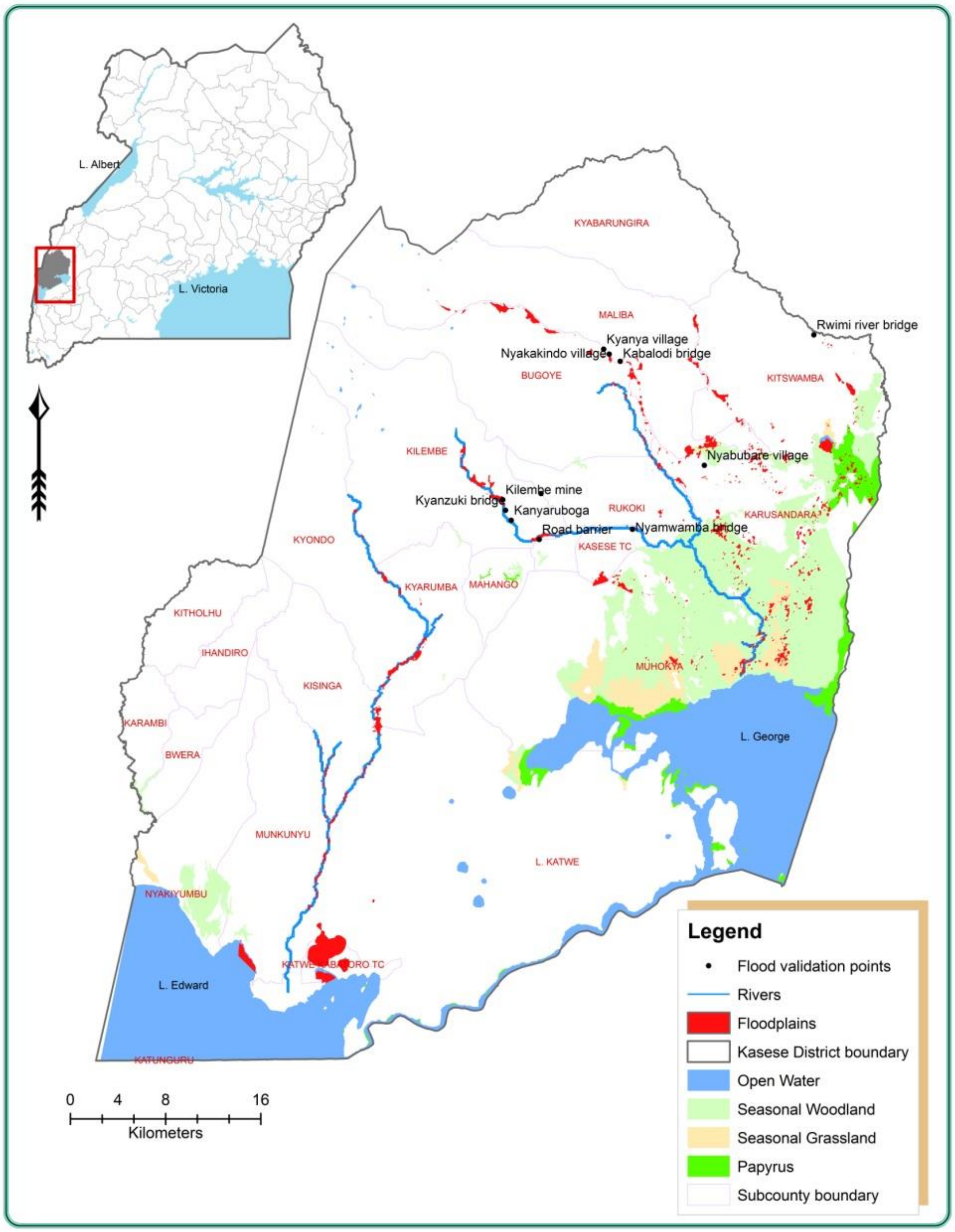


Figure 2.7 Flood hazard map for Kasese District. Map credit: Dr Kitutu Goretti

2.8. Teso floods.

Floods in September 2007 killed 18 people and displaced 300,000 in the Teso region in eastern Uganda. The country was forced to declare the ever first state of emergency. ***Figure 2.9*** shows the Moderate Resolution Imaging Spectroradiometer (MODIS) images of the flood. The image on the left was taken on the September 18th showing the most flooded parts while that one on the right was taken on May 18 th and shows the region under normal conditions. Floods widen the rivers flowing into Lake Bisina in the September image. Water pools in the U-shaped bends of the Kelim River east of the lake, and the Okok and Okere Rivers to the north are swollen. Traces of black define smaller rivers that weren't visible in May. The floods destroyed crops and homesteads. Water supplies were also contaminated putting the region at risk of waterborne diseases. Similarly this year 2013 these areas have been affected by floods.

2.8.1 Kumi district.

In Kumi district the areas which have experienced floods are Akinde and Akuma parishes, Kacharagi, Karapa, Kapoli and Omuyali villages in Ongino Sub County. These areas experience floods during the months of August and September every year. However, since the year 2010, the situation has been more pronounced. Floods have damaged household property, crops such as cassava, potatoes and ground nuts get waterlogged and rot in the ground. This year 2013 from the months of February, March and April ten houses and unknown acreage of crops were destroyed by flood. The areas mentioned are close to Lake Bisina which floods during the rainy season affecting homesteads. The community used to construct houses with unbaked bricks which are weak and make house walls to collapse during floods. Information from the Local council (LC) 1 chairman shows that communities now construct houses using poles which resist floods which is a good coping mechanism. ***(Plate 2.9 and Plate 2.10)***.

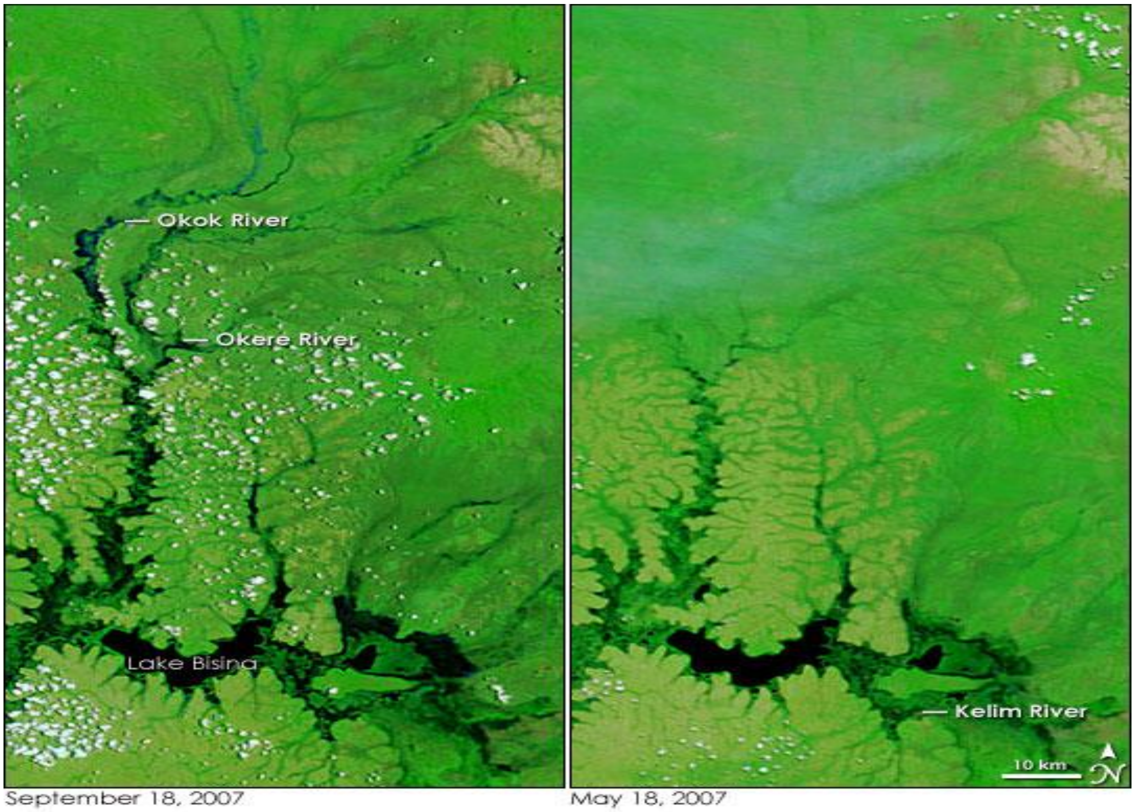


Figure 2.8: Satellite Images of Lake Bisina and River Kelim of Teso region during the flood in 2007. Source: NEMA 2008

Plate 2.10. Akinde LC1 chairman explaining the effects of floods and the new method of constructing houses using poles. Photo credit : Dr. Kitutu Goretti 2013.

Plate 2.11. A house being renovated with poles after the wall was damaged by floods, 2013: Photo credit: Dr. Kitutu Goretti

2.8.2. Bukedea district.

Bukedea is another district affected by floods. The areas affected are: Kombale, Kodike, Kabarwa, Kangole parishes and Aparasi village. According one member in the community, Okwi John Paul who guided us around the flood prone areas, in Aparasi village, Kodike parish and Kabarwa parish in Malea sub county about 50 homesteads were affected. This area is found in the Lake Kyoga catchment is relatively flat with settlements in a drier zones. The areas prone to floods are used for cultivation of crops such as groundnuts, millet, maize, cowpeas, cassava and potatoes. The soil becomes water logged and tuber crops such as cassava and potatoes rot while the cereals and horticultural crops such as maize, groundnuts, millet, cowpeas turn yellow leading to poor harvest and famine. This happens whenever it rains in the months of March, April, May and part of June.

Plate 2 12. Maize and Groundnut garden water logged. Photo credit; Dr. Kitutu Goretti.

Plate 2.13 A lady showing us the extent of damage to her garden. Photo credit: Dr. Kitutu Goretti

Plate 2 .14. Maize and millet turned yellow because of too much water in the soil.

2.8.3. Katakwi district.

The areas in Katakwi affected are Magolo, Ngaramu, Ogongaja, Palam situated in Katakwi sub county in Usuk County. One of the residents' thinks that their area is cursed an indication of the great suffering communities go through during rain seasons. For example the roads become impassable, crops damaged causing famine, and bridges are also damaged. The use of motorbikes which is the common transport in the villages is impossible because of mud and water on roads. This also affects those who earn incomes from motorbike transport.

River Angombo and Lake Bisina destroy households, crops, damage bridges and roads when they flood. The floods happen almost throughout the year and in the whole district although the most affected is Usuk County. All communities visited when asked where floods occur in Katakwi all pointed in the direction of Kodike and Kabarwa parishes.

Plate. 2.15. Mr Isaac Ilelit standing in his garden that is usually affected by floods. Photo credit: Dr. Kitutu Goretti.

2.8.4. Buteleja.

Butaleja is a district with frequent floods and the villages most affected include Doho, Saimbo, Dongo, Namatonke, Lumbembe in Mazimasa Sub County. More villages affected include Nasalangala, Mangoha, Nahaselagala, Nabenganda, Kapisa, Nampolongoma ,Kayite, Buteleja. In 2012 Nasalangala had 50 homes affected by floods. Earlier, in 2005 and 2006 floods destroyed crops and also killed some domestic animals in this village. In Mangoha and Nahaselagala floods displaced people and the area is now used for rice growing . The affected people shifted to Nabenganda, Kapisa, Nampolongoma, Butaleja and Kayite villages in Himutu Sub county, Buteleja County. The villages that suffered from floods also suffered from cholera outbreaks in 2005 because of contamination of water sources. The community when asked about the causes of floods in their area all mentioned the increased run-off from the Mount Elgon catchment. River Manafwa brings in a lot of silt which fills channels reducing the carrying capacity resulting into floods.

Plate 2.16 : Channels built to control flood waters

Plate 2. 17: Women carrying harvested rice. Note the flood waters in the compound.

Plate 2. 18: A home affected by floods with collapsing walls affected . Photo credit: Dr. Kitutu Goretti.

Plate 2.19: The LC1 chairman explaining how the floods occur in Butaleja.

2.8.5. Proposed solutions from the communities.

The communities in Butaleja propose more rice schemes as a control to floods. The schemes must have storage dams and channels that pump water to the rice gardens an interventions greatly control floods, improve income through rice growing. It was also proposed that communities should make small channels on individual plots to divert water. It was also proposed that there should be regular maintenance of these channels by dredging to remove silt brought by rivers from mountainous areas can greatly reduce floods. People are willing to relocate from such waterlogged areas and hence saving lives.

2.9. Tororo district.

The areas of Amurwo, Nkindo and Melikite are most affected by floods. Damage to crops such as maize, rice, cassava and millet usually occurs during the flooding.

Plate 2.20: A lady inspects her flooded garden. Photo credit: Dr. Kitutu Goretti

2.10. Floods in Kampala.

Recent developments have seen the clearing of the buffer zones of forests and open spaces, as well as encroachment on the wetlands. Buildings and other forms of infrastructure have replaced the forests, open spaces and the wetland vegetation. The impacts of this change have been far reaching as most of Kampala's land surface in the built up areas is highly paved leading to reduced water infiltration and hence to generation of high storm waters. The storm water has of late caused flooding in Bwaise and most low-lying areas of Kampala City. In a bid to fight the floods, a lot of drainage channels have been placed and several widened to alleviate the problem. The efforts have hardly solved the problem as the constructed drainage channels have failed to contain the heavy runoff leading to continued floods.

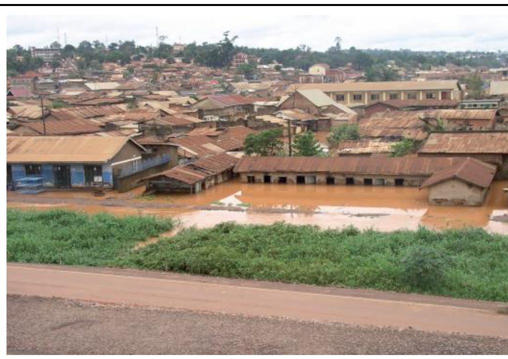


Plate 2.21 Floods in Nsooba - Bwaise zone in the rainy season (2007)

Plate 2..22. Flooding in Bwaise, 2008. Photo credit: NEMA

Plate 2.23: Floods in Nsooba - Kyebando (3/5/2013) Dr. Kitutu Goretti

Plate 2.24: Houses sub-merged in floods in Nsooba -Kalerwe areas (3/5/2013)

2.11. Recommendations to reduce floods in Kampala.

- There should be efforts to promote water harvesting from roofs.
- Dumping of waste and silt in channels should be stopped.
- Construction in water ways should be halted or regulated.
- Construction of standard water channels.

3. LANDSLIDES AND SOIL EROSIVITY IN UGANDA.

3.1 Landslide hazard.

Landslides are common in mountainous areas. Mass wasting on the national scale was assessed by combining the following parameters in ArcGIS model builder;

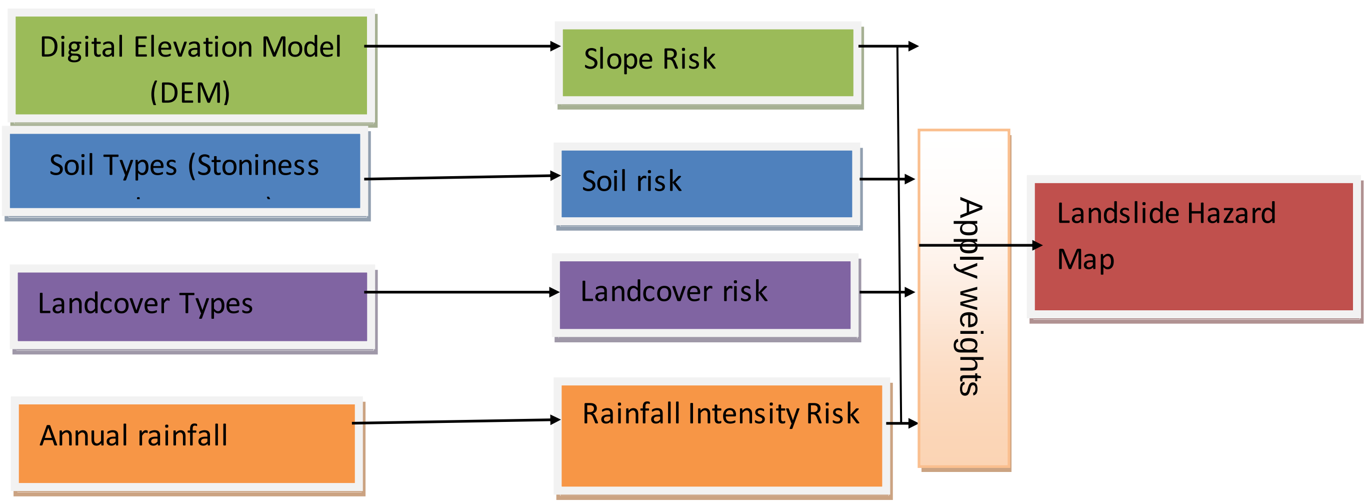


Figure 3.1 Landslide model for landslide assessment.

The Digital Elevation Model was derived from contours obtained from the Department of Surveys and Mapping in Entebbe. The soil types were obtained from the existing soil map prepared by the National Agricultural Research Laboratories at Kawanda. Many areas in the country are prone to mass wasting processes (Figure 3.2). The areas were landslides have occurred are Ruwenzori, Mount Elgon and the Kigezi region. These regions have high populations which makes them high risk areas.

Regulations of landslide prone areas is embedded in the National Environment Act Cap 153, 1998 where the National Environment Management Authority (NEMA) is required to come up with guidelines related to disaster preparedness in landslide prone areas (Section 40 (2d). The same law requires that the local environment committees shall be responsible for ensuring that the guidelines issued and measures prescribed under subsection (2) are implemented. These guidelines do not exist and neither have the local environment committees in the mountainous regions been prepared for this task. NEMA should be urged to expedite this process.

Date	Sub-county	Parish	No. of people killed	No. of people affected	Damage to property	Cost of damage
2011	Buluganya	Sooti	10	316	houses destroyed	376,000,000
2011	Namisuni	Nambeche, Kisekye, Namezi, Namudongo	0	393	latrines washed away and crops destroyed	380,000,000
2011	Buginyanya	Gozi, Tabali, Bunataje, Gidno, Longoli, Kiwali	0	250	Roads blocked, crops swept down the hill	
2011	Masira	Gabugoto	0	0	Roads submerged, destroyed, completely inaccessible by direct route except through Kapchorwa	630,000,000
2011	Gamogo	Kapnarbaba		953	Three (3) houses were buried crops and animals destroyed	
	Chema		1	42	A number of households buried in soil, one old child died and a mother was rescued. Atari and Kaptokwi bridges swept by running water	
	Tegeres	Basar	0	37	4 cows injured and crops destroyed	
	Kapchesombe	Kaplak, Kwoti, Tariet and Kween	0	316	3 cows killed and crops (maize) destroyed	
	Sipi	Chepterich	0	6	5 children were injured and one house hold buried	
July-September 2007	Kortek		3		Three (3) lives lost, Crops destroyed and planted tree destroyed. Main truck road blocked for 3 months latrines sunk	
April to 2012	Riwo	Aralam			crops, animals and houses destroyed. Culverts washed away.	
May-June 2012	Kwosir		0	250	50 acres of land affected. Siltation of bridge on Kere river	
July 31 2012	Bugitimwa		0	0	4 commercial ponds leaving about 18,000 fish destroyed	
2012	Bukiise, Bumasifwa, Bumalimba and Busulani				52 acres of land destroyed, 42,000 trees of coffee washed off along with 20,000 banana stems.	
	Kaabong		7	2	several families resettled in a camp	
	Buhweju			90		
	Kisoro			1,011		
	Kabale		6	6,200		
2013	Kasese				Many soil slips in the Kilembe hills	

1942	Bududa	Bulucheke			Killed very many wild animals such as monkeys, snakes and baboons. A lot of debris was poured blocking roads, When the dam broke Destroyed rice fields and killed people in Bunyole, Tororo District about 20km downstream,destroyed coffee farms	
1922	Bulucheke	Bumwalukana	20		Killed about 20 farmers who were celebrating the end of the harvest season.	
1927	Bulucheke	Busiliwa	1		One man killed and his home and farms swept down slope.	
1997	Bulucheke	Bubita	48		About 48 people killed; houses and bridges destroyed ,Roads were blocked with debris for about one week.	
1970	Bulucheke	Nusu	60		Over 60 circumcision dancers buried alive. Houses were also destroyed.	
1967	Bududa	Bushika			At Buwali valley water was dammed for one day and destroyed many houses downstream. A family of 6 was killed and bodies have never been recovered.	
2010	Nametsi	Bukalasi	365		About 365 missing	
2012	Bumwalukani		8		8 people killed	
1918	Bududa	Busayi	0		0	
2012	Sironko		8			
1900	Bududa	Konokoyi	Not known	Not known	The landslide incised the Konokoyi valley	Not known
1999	Bududa, Bulucheke , Bubita and Bukalasi		5	Not known	5 people killed	Not known

Table 3.1 Landslides that occurred countrywide

About 542 people have been killed and 9866 displaced countrywide by landslides since 1818. The numbers could be more or less but statistics are not documented.

3.2 Landslides in the Mount Elgon area.

Mount Elgon from which the National Park derives its name is an extinct volcano with an age of about 24 million years (Figure 3.3). Eight districts share Mount Elgon and these are Bukwo, Kween, Kapchorwa, Bulambuli, Sironko, Mbale, Manafwa and Bududa. The word Elgon is of Masai origin and believed to have been derived from the word El Gonyi, the name of a tribe who lived on the southern slopes of the mountain (Davies 1957). This name is not used by the greater majority of the native tribes who inhabit the slopes. For the Bagisu tribe on the west it is known as *Masaba*, to the Luo it is *Masawa* and to the Kitosh (Babukusu) on the east *Luteka*. The Elgon massif extends for about 80Km north to south and about 50 Km west to east. The highest point on the crater rim is 4321 meters above sea level making Elgon the eighth highest massif in Africa and the second highest in Uganda after Ruwenzori. The general outline of the mountain is typical of a shield volcano with very gentle slopes in the order of 3^0 to 4^0. The lower part of the mountain is made up of a series of benches separated by prominent cliffs often up to 305m in height. This characteristic terrain is the product of differential weathering of the various volcanic materials resulting in a rugged landscape with cliffs and masses. The rainfall in the Mount Elgon area ranges from 1000 to 2500 mm per year.

3.3. Socio-economic impacts and the perception of communities on landslides in the Mount Elgon region.

This study examines the activities carried out by the population living around Mount Elgon National Park and also assessed the perception of communities on forest conservation. The study further attempts to ascertain the effect of loss of forest cover on the landslide disasters. Six parishes of Sume, Shishendu, Bunamulunyi, Elgon and Buboolo, surrounding Mt. Elgon National Park were selected using simple random sampling. A sample of 180 respondents was analyzed using Statistic package for Social Sciences (SPSS). Data was obtained through household survey. Several questions

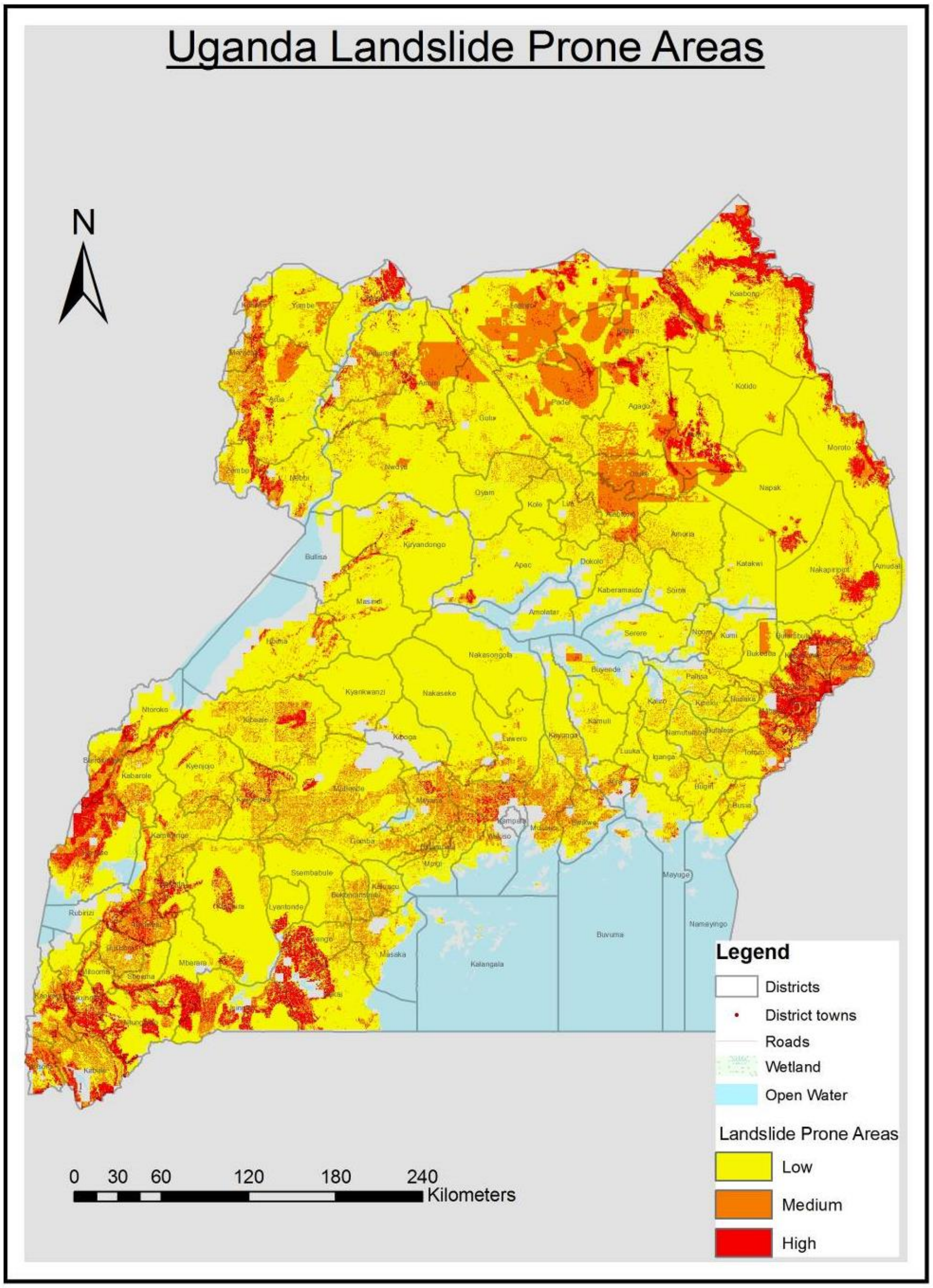


Figure 3.2: Landslide hazard map of Uganda.

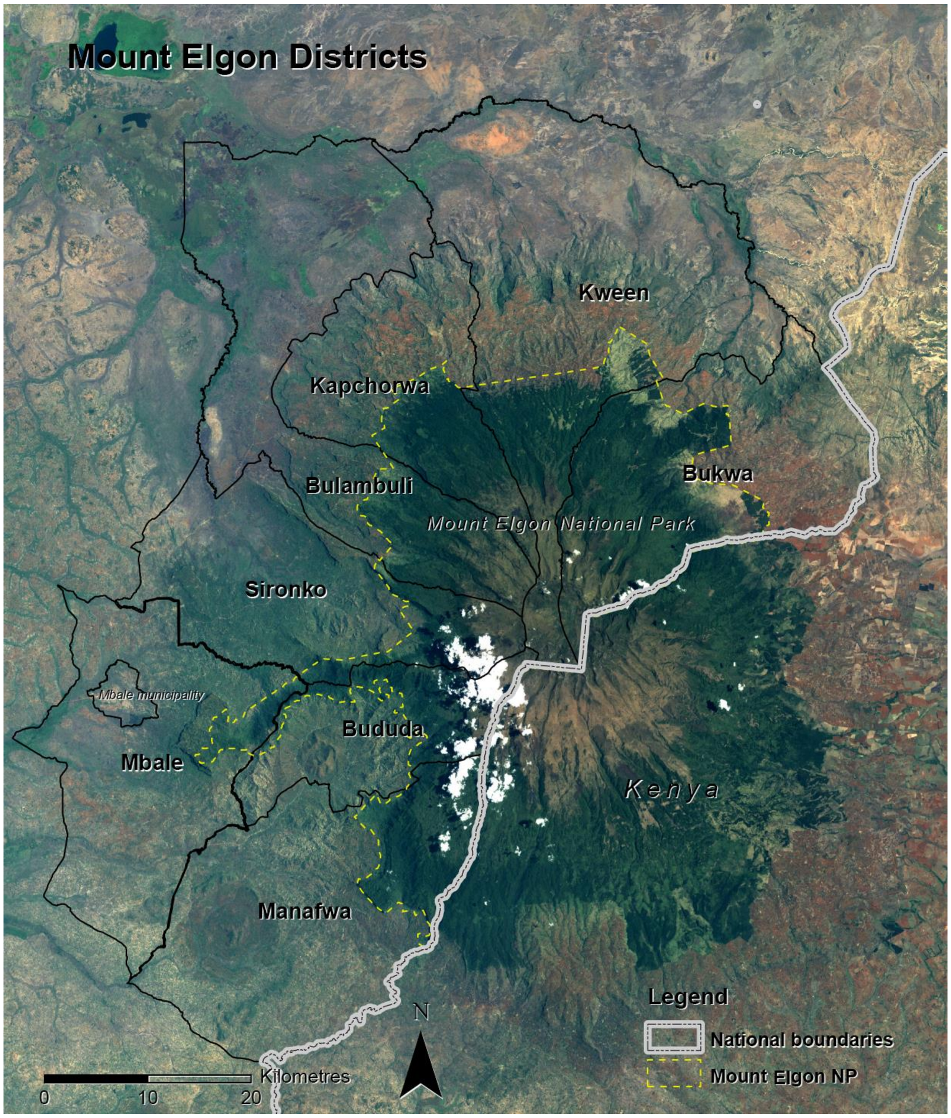


Figure3.3: Boundaries of Mount Elgon districts overlaid on a Landsat TM image. The volcano stands out distinctly. Map credit: United States Geological Surveys.

Focused on the source of livelihood for the people in the area, this topic created some reluctance to give answers with accuracy. More information was obtained through observations and informal discussions with local authorities and elders from the six parishes.

The study revealed that the main economic activity is farming and both cash and food crops are grown. It was further revealed that communities are strongly dependent on forest land for farming, food, firewood, among others. It is therefore important; to change the dependency on land as the only source of livelihood by creating awareness on the importance of forest conservation and finding alternative source of income. The level of education is low and 60% of the communities have attained primary level education and 10% have no formal education. This makes it difficult for many to easily understand the conservation measures that reduce landslide disasters.

All the respondents acknowledged that the forest is of great importance, as it provides them with medicinal plants, food, rainfall, farming source of energy and construction materials. The people have long been depended on the forest for construction materials, food and bamboo shoots. When asked about clearing of the forest, 78.2% of the respondents agreed that there has been forest loss, while 21.8% did say there has been no loss. Those who say no fear the repercussions, if their identity is revealed to the forest authorities. This implied that community is aware of the consequences of forest encroachment and illegal activities carried out in the forest reserve. 167 out of 180 respondents revealed that landslides occurrences are due to clearing of forests. Some of the alternative interventions suggested by the community included, sensitization of the community about the usefulness of afforestation, they further suggested that, the Government should come up with strict rules on those who encroach on forests.

3.4 Landslides in Bududa District.

Bududa district situated in the surroundings of Mount Elgon volcano is the hotspot for landslides in Uganda. Degradation of slopes through soil loss due to landslides in this district is a problem with fatalities, environmental consequences and food shortages in the future. During the period 1997 to 1999, landslides killed 48 people and displaced 10,000 ***(Kitutu et al., 2004)***. Further still in 2010 and 2011 about three hundred and eighty people were killed by landslides in this area.

3.4.1 Causes of landslides in Bududa.

The main triggering factor for landslides in Bududa is rainfall. Rains that go on for days while delivering little amounts of water cause more landslides because of high infiltration of the water into the soils causing stagnation. The preparatory or causal factors are geology, slope shape, slope undercutting and soils texture (***Knapen et. al 2006***). The fenitized basement rocks and dykes are most susceptible to landslides in Bududa ***(Figure 3.3)***. The formation of the Butiriku carbonatite fenitized the basement granites. This process resulted in the partial replacement of the original quartz by sodic amphibole or Hornblende ***(Reedman, 1973)***. The stable minerals such as quartz were replaced by amphibole which is weaker on the stability series of minerals. This weakening resulted in accelerated weathering of the basement rocks forming thick soils rich in clay hence vulnerable to landsliding (***Kitutu et. al. 2010)***.

The influence of vegetation is difficult to assess because almost no natural forest exists in Bududa. It is even difficult to know when the vegetation was cleared because it seems to be a long time ago. Despite this a few hills which had trees in the 1997 rainfall event did not suffer from landslides an indication that vegetation has a lot to play in preventing landslide occurrences ***(Plate 3.1)***.

Plate 3.1: Nusu dyke one of the area with frequent landslides. Photo credit: Knapen 2009

Plate 3.1: Areas with vegetation had no landslides while bare areas had surficial slides in1997.

More research should be carried on the influence of vegetation and also what type of vegetation is suitable. For example the ***Cordia Africana*** an indigenous tree in the Mount Elgon area has been singled out by communities to prevent landslides on slopes. However given the small sizes of farmlands its agro-forestry potential should be well researched. Other countries such as china and India have used the Vetiver grass to stabilize slopes from landslides. This may also be an area where more research is needed. Population is a very significant driver to landslide occurrences and it also increases the risk as many people settle in the steep slopes with high landslide hazard. The communities in this area because of ignorance rarely use family planning methods. Underage marriages have also been identified as a contributing factor to a fast growing population.

4.4.2: Impacts of landslides in Bududa.

About 507 people have been killed by landslides since 1800. The economic damage from these landslides is not well documented which is one of the shortfalls in this process. For example in 1997 all bridges in Bududa were damaged by rivers and roads were completely destroyed by rivers. This was more prominent in Bushiyi, Bukalasi and Bubita areas. Currently these roads have been opened without putting in place measures to reduce the damage if extreme rainfall events occurred.

Year	Sub-Counties affected	Causes of landslides	Losses
1818	Bududa, Bulucheke	Rockslide triggered by rainfall in weathered granite in Bulucheke.	Not known
1900	Bududa,	A landslide that incised the Konokoyi valley. Triggered by heavy rainfall.	Not known
1918	Bududa (Busayi).	A rotational slump	No death.
1922	Bulucheke (Bumwalukana).	Landslides caused by river undercutting by Sakusaku river.	Killed about 20 farmers who were celebrating the end of the harvest season.
1927	Bulucheke (Busiliwa)	Landslide caused by heavy rains	One man killed and his home and farms swept down slope.
1933	Bulucheke, Bubita	Rock slides at Buwali	Not known
1942	Bulucheke	Landslides triggered by rainfall	Killed very many wild animals such as monkeys, snakes and baboons. A lot of debris was poured blocking roads.
1944	Bulucheke	Landslides triggered by rainfall	None
1960	Bulucheke	Triggered by heavy rains	destroyed coffee farms
1967	Bududa, Bulucheke	Landslide dammed river Sakusaku for three days forming a lake of 2km in length.	When the dam broke Destroyed rice fields and killed people in Bunyole, Tororo District about 20km downstream.
1970	Bulucheke (Nusu)	Landslide triggered by rainfall.	Over 60 circumcision dancers buried alive. Houses were also destroyed.
1997	Bududa, Bulucheke, Bubita, Bushika,	Triggered by heavy rains	About 48 people killed; houses and bridges destroyed
			At Buwali valley water was dammed for one day and destroyed many houses downstream. A family of 6 was killed and bodies have never been recovered.
			Roads were blocked with debris for about one week.
1999	Bududa, Bulucheke, Bubita, Bushika,	Triggered by rainfall	About 5 people killed and houses destroyed.
2010	Nametsi, Bukalasi	Triggered by rain	About 365 missing
2012	Bumwalukani	Triggered by rain	8 people killed

Table. 3.2, Records of landslide occurrences in Bududa district.

Period	Number of deaths
1800-1900	0
1900-1950	21
1950-2000	113
2001-2013	373
Total	**507**

Table.3.3: Number of people killed by landslides between 1800 and 2013 in Bududa District.

Plate. 3.2: Communities searching for the dead in the Bumwalukani landslide, 2012. Photo credit; Dr. Kitutu Goretti

Nametsi landslide.

Following continuous rains that started on the 25th February 2010 several soil slips occurred in Bududa. However, the most devastating was the debris flow that occurred on 1st March in Nametsi village killing about 365 people. These particular sites suffered from a landslide in 1997 and 4 people were killed. A huge boulder from this landslide in 1997 narrowly missed the Health Centre built by Care International but completely swept away in the 2010 debris flow. It was also reported that this site again suffered from a small landslides early this year with no damage. This could have been early warning signs for an impending major slope failure. The type of mass movement is a debris flow. Debris flows are one of the most dangerous of all mass wasting events. They can occur suddenly and inundate an entire village in a matter of minutes a case of what should have happened at Nametsi. Debris flows occur when masses of poorly sorted sediment, agitated and saturated with water, move down slopes.

Nametsi landslide, 2010

Bumwalukani landslide

On 25th June 2012 at 2.00pm a landslide occurred at Bumwalukani in Bududa district destroying two villages. About 25 houses were destroyed and 8 people killed. The length of the landslide was 540m, the average width was 130m and the depth of the scar was about 15m. The depletion zone was about 300m of long and the deposition zone was about 240m. The volume of soil displaced was about 700,000m^3 which qualifies it to be a huge landslide. The upper slope of the landslide is about 40^0 and the lower slope 20^0. The type of landslide in an earth slide.

What could have happened?

It was reported that it rained continuously for seven days and rain water infiltrated through a deep crack that formed on this slope in 2009. The water stagnated in the deep soil profiles causing water saturation and slope failure. The crack was as a result of movement of soil block because of water infiltration through the terraces and foot paths across the hill. The water that infiltrated through the cracks was trapped at the interface between the rock and soil which is known as saprolite (i.e. this occurred at an estimated depth of 15m). This water first moved the block of soil of about 300m in length including the trees and houses in the Northwest direction and later turned it in the southwest direction possibly following the flow of water underneath and deposited on a village about 500m downslope. So many questions have been asked why the eucalyptus forest could not stop the landslide. The reason is that the failure plane was deeper than the influence of the roots given that eucalyptus has shallow roots.

Bumwalukani landslide, 2012.Photo credit: Dr Kitutu Goretti

3.5 Landslide hazard and risk assessment in Bududa District.

Assessment was done using existing data more data was collected in the field through interviews. Landslide risk was assessed for Bududa District the areas with high incidents of deaths from landslides. These will then be used to establish the areas of risk from landslides. The landslide risk was prepared by overlying houses location on to the landslide hazard map ***(Figure 3.7)***. The areas with high hazard and have settlements are at high risk of landslides. The eastern part of Bududa district has the highest risk to landslides ***(Figure 3.8)***. In 1997 over 66 landslides occurred in this area killing 48 people. Worse still in 2010, three hundred and sixty five people died in one landslide at Nametsi and in 2012 eight people died. This area is most sensitive to landslides in Uganda.

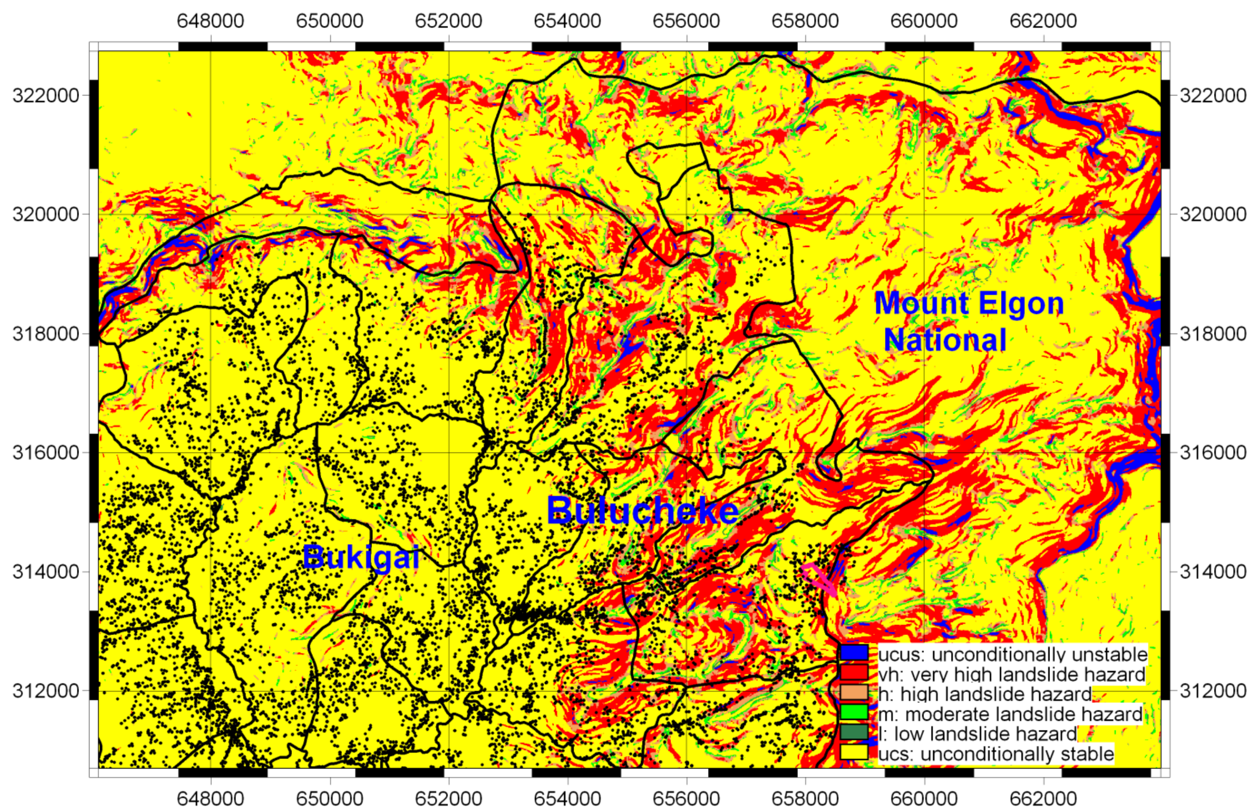


***Figure. 3.4:** Landslide hazard in Bududa overlaid with location of houses. Houses mapped from high resolution satellite images. Courtesy: United States Geological Surveys (USGS).*

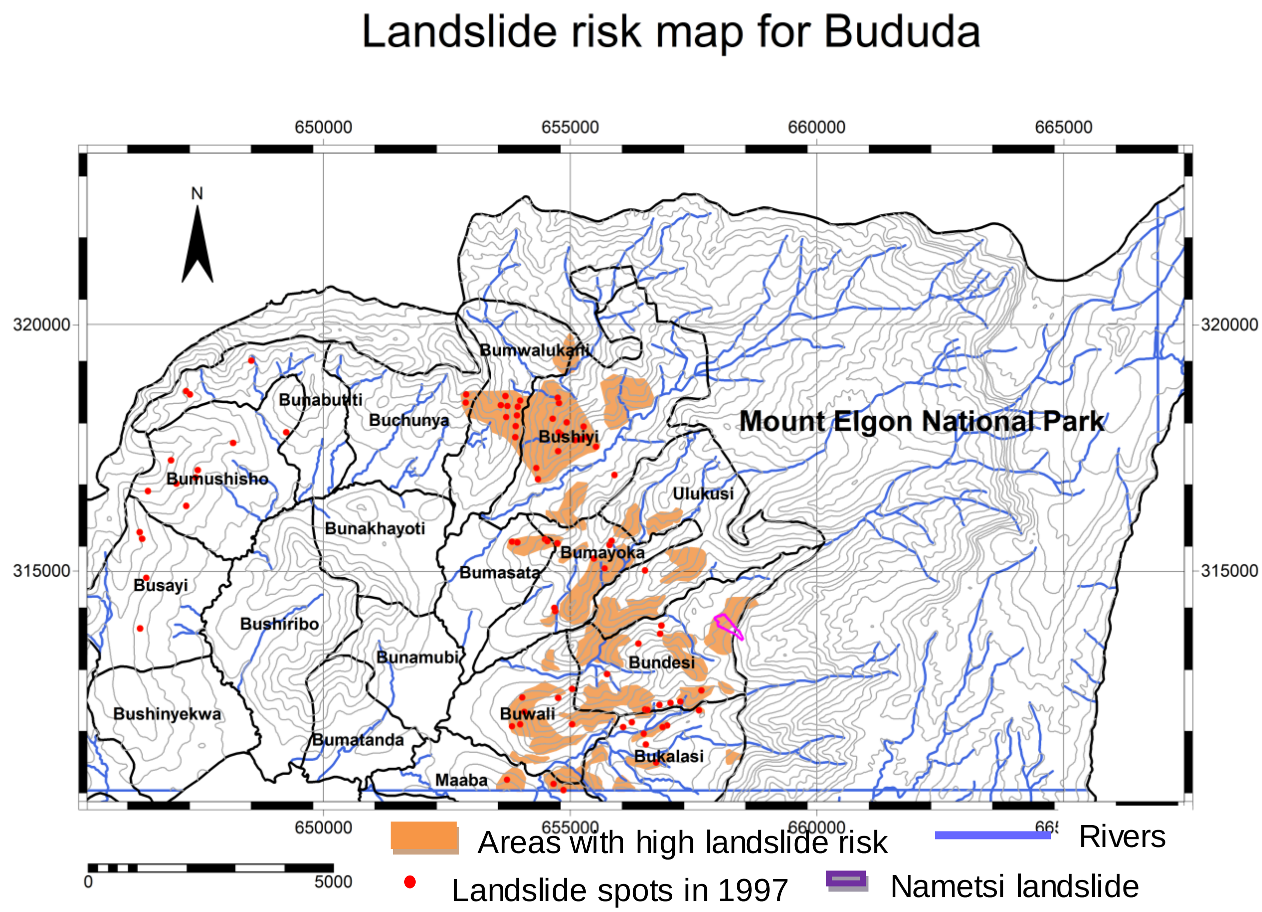


Figure. 3.5: Landslide risk map for Bududa District overlaid with the landslides that occurred in 1997.

3.6. Landslides in Bulambuli and Sironko Districts.

Bulambuli District was curved out of Sironko District in 2010. Part of the district falls within the Mount Elgon volcanics which are known for its environmental sensitivity. On the night of 29th to 30th August landslides devastated the parts of Sisiyi and Buluganya killing 26 people. It was also reported without confirmation that some four people were swept down by flash floods making the number of the dead 30. In addition on the 3rd June 2012 a landslide occurred in Bumasifa in Sironko district destroying 7 houses and killed two people.

Landslides mostly occur in 11 sub-counties and these included Zesui, Buginyanya, Bumasifwa, Buluganya, Masila, Bulago, Buyobo, Buwalasi, Butandiga, Busulani and Sisiyi. In Sironko Zesui area is most affected while in Bulambuli Namusuni and Lusya are the area's most prone to landslides. Since 1951, Ninety five landslides have occurred and 32 people killed. The records for the people killed and affected is very scanty and unreliable because there are no official records for these disasters and people tend to remember those landslides where there is loss of life as compared to those without.

	Period					
	1951-61	1962-71	1972-81	1982-91	1992-2001	2001 - 2013
No of landslides	7	13	6	13	53	3
No. of people killed.	Not known	Not known	Not known	Not known	Not known	32

Table. 3.4: Landslide occurrence between 1951 and 2001

Many sub counties in Sironko and Bulambuli recognize landslides as a major social problem and they have been integrated in their Sub-county Development plans. However, mitigation measures put in place are on individual basis and they are inadequate. Neither the sub-county nor the district local governments had made any effort to mitigate the landslide problem. High population pressure, over-cultivation and deforestation were seen as drivers to landslide occurrence and they are more common on cultivated land. Based on indigenous knowledge, the local population can tell with a high degree of certainty using early warning signs the landslide prone areas. However, very few respond to such warnings because of the costs involved. As an intervention some sub-counties were aided in 2001 through a Germany funded project to begin tree seedling banks for farmers but this has been abandoned since the project ended.

Plate. 3.3: A landslide in Bumasifa which killed one elderly person in 2012.

3.6.1. Recommendations for Bulambuli and Sironko district on how to minimize landslide disasters.

- Areas below agglomerate cliffs should be vacated. This includes areas below the Buginyanya ridge, also those below the Butandiga ridge and also in Buluganya.
- Settlements should not be allowed in areas of 1000m (minimum) from the ridge unless if the ridge has thick forest cover.
- Areas with cracks should be vacated and restored with intensive agro-forestry.
- Areas with known landslide risk (moisture zones) should not be used for settlement. This includes valleys and depressions on hills were water collects.
- More funding should be given to the district especially the environment protection, social development, population control and production units if these landslides are to be minimized.
- Education of the youth should also be taken as priority to reduce the pressure on land. This will enable them get skills and look for alternatives rather depending on land alone.
- Community sensitization on development programmes should be taken as a priority.

Mabono landslide, 2011 (Bulambuli District)

On the night of 29th to 30th August 2011 landslides devastated the parts of Sisiyi and Buluganya killing 26 people. Mabono Parish in Sisiyi sub-county was most affected with over 10 landslides of which three were disastrous. The other sub-county affected was Buluganya where surface water flow from the Butandiga ridge caused many slips. Most of the landslides in Mabono parish were caused by high run-off from the steep cliffs however the most disastrous landslide was a translational slide that ended up in a mild flow. This landslide killed 16 people and was triggered by heavy water flow from the agglomerate cliff in Buginyanya. This water saturated the B horizon of the soils below the cliff that is rich in clay causing the soil block to move for about 300m before it was deposited on the lower area where there were houses. One of the survivors from this landslide narrated her ordeal and how she survived narrowly. It was reported that it rained continuously for about eighteen hours. The length of the landslide was 500m, the depth of the scar was 4m and the volume of debris displaced was 400,000 cubic meters. The main impacts of these landslides are loss of life, loss of farmlands, damage to property, roads and bridges.

Photo credit: Dr. Kitutu Goretti, 2011

4. Drought.

The main drought index in Uganda is precipitation. The old archived data on precipitation was used to assess the drought prone areas. Using satellite technology, additional assessments was carried out through modeling to further assess the drought effects. This method used is based on NDVI (Normalized different vegetation index) for 10 years that was downloaded from the e-station and processed using spatial analysis in the ArcGIS software. The drought severity index is based on maximum NDVI (MNDVI). The drought severity index was calculated as the deviation of current MNDVI values from their corresponding long-term mean MNDVI values for the every pixel for the last 10 years. The final drought susceptibility layer was classified using natural breaks method into five classes.

Classes	Values
No drought	>0.4
Mild drought	<0.4
Moderate drought	<0.3
Severe drought	<0.2
Extreme drought	<0.1

These classes were further reduced to three classes since the ranges were not showing significant differences from each class.

Classes	value
No drought	>0.4
Low drought risk	<0.4 - <0.3
High drought	<0.2 - <0.1

The final three classes presented the drought risk situation in Uganda on long-term.

60 districts in the cattle corridor or rangelands are prone to drought (***Figure 4.1***). However, among all these the Karamoja region is the one most affected by drought in Uganda. Drought is one climatological factor that greatly affects Uganda's agricultural and water sectors. Drought also leads to drying up of water sources leading to conflicts among the nomadic pastoralists. A drought is often the result of many complex factors such that it often has no well-defined starting or end point. It may take time to manifest itself. According to information from the Office of the

Prime Minister, in 1998 126,000 were affected by drought and in 1999 the number rose to 700,000 (***table 4.2***). In 2002 those affected were 655,000 and in 2005 the number was 600,000. In another report released by OCHA in 2010, the Karamoja region had persistent drought since 2006. In 2006 the districts of Kotido, Abim, Moroto and Nakapiripirit were affected. In 2007 Moroto and Nakapiripirit were again affected and these continuous effects from drought is what has made the Karamoja region highly vulnerable with acute food shortages. In 2009 the districts of Kotido, Abim, Moroto and Nakapiripirit were hit by drought (OCHA 2010). Drought in this region causes acute food shortage and sometimes death. In 2012 Kaabong district experienced food shortage because of drought. Food shortages were also reported in northern and eastern Uganda. The Karamoja region and the Bulambuli district, in particular, were among the worst hit areas, with an estimated 1.2 million Ugandans affected. The Ugandan government also indicated that as of September 2011, acute deficits in foodstuffs were expected in 35 of the country's districts.

1. Ntoronko	16. Kyegegwa	31. Kole	46. Budaka
2. Hoima	17. Gomba	32. Lira	47. Bulambuli
3. Bullisa	18. Kiboga	33. Apac	48. Katakwi
4. Kasese	19. Kyankwanzi	34. Dokolo	49. Otuke
5. Buhwenju	20. Nakaseke	35. Amolatar	50. Nakapiripirit
6. Sheema	21. Luwero	36. Buyende	51. Amudat
7. Ntungamo	22. Mityana	37. Serere	52. Napak
8. Mbarara	23. Kibaale	38. Kaberamaido	53. Kotido
9. Isingiro	24. Ssembabule	39. Soroti	54. Kaabong
10. Lyantonde	25. Kiruhura	40. Amuria	55. Kitgum
11. Lwengo	26. Rubirizi	41. Ngora	56. Lamwo
12. Bukomansimbi	27. Nakasongola	42. Kumi	57. Agago
13. Ibanda	28. Masindi	43. Bukedea	58. Abim
14. Kamwnge	29. Kiryandongo	44. Pallisa	59. Amuru
15. Mubende	30. Oyam	45. Kibuku	60. Gulu

Table4.1. Districts prone to drought in Uganda.

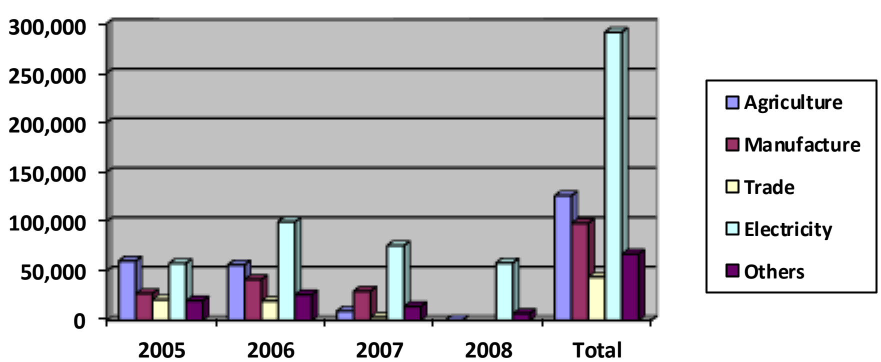
The Teso region is also prone to these droughts. For example, according to the Uganda Humanitarian Update for May 2009, there was increased food shortage in the northern and eastern Uganda caused by the prolonged dry spell. The districts most affected were Pader, Soroti, Amuria, Katakwi and Kaberamaido. A survey of communities in some districts revealed that drought conditions occur during the month of August in Bukedea and Butaleja. In Kumi district it occurs in October and November and in Katakwi it is experienced in July, August and September. Drought also affects the countries manufacturing sectors because some are dependent on agricultural products. Table shows the performance of some sectors for 2005-2008. Electricity supply was greatly affected because of the drop in the water levels in Lake Victoria.

Year	Number of people affected.	Number of people dead
1998	126,000	0
1999	700,000	0
2002	655,000	0
2005	600,000	0
2010 - 2011	10,000 pastoralists from Kenya crossed into Uganda.	0
2012	1.2 million , 35 district with acute food shortage.	0
2013	300,000 children malnourished, about 3 subcounties migrate.	41

Table. 4.2. People affected by droughts during years 1998 - 2013

Sector	2005	2006	2007	2008	Total
Agriculture	60,204	56,177	9,465	344.2	126,190.7
Manufacture	27,207.4	41,469.8	29,561.6		98,238.8
Trade	21,071.6	19,661.9	3,312.8		44,046.3
Electricity	57,723.2	99,705.7	75,678.1	58,213.9	291,321.0
Others	19,944.8	26,041.7	14,162.1	7,027	67,175.6

Table.4 3 Impacts of drought on different sectors from 2005 -2008. Source: OPM,



This year 2013 Karamoja region has been hit by a severe food shortage (OPM 2013). According to a report from the Office of the Prime Minister, Kaabong district is the one most affected where 41 people are said to have died and 59 elderly rescued. The causes of this food shortage are floods that destroyed crops in the early months of the year and then subsequent drought conditions. About 300,000 children in the region are malnourished and some have turned to gold mining to earn a living and abandoned school. The report cited the sub-counties of Kamion, Lodiko, Kapedo, Kaabong and Lolelia as the most affected areas. About 8,000 people have migrated from their homes to Didiit, Kalokosi, Nakapei, and Loolam (OPM 2013). "The districts had poor harvest in 2012 due to flooding of gardens that led to the rotting of crops. Among the interventions, the Government is proposing is planting of fast maturing sorghum and beans given the changing weather patterns in the district. Also it is proposed that 10,000 hectares of land around the lakes of Opeta and Bisinia are gazette for an irrigation scheme that can act as strategic food reserve for the region. Source: OPM 2103

4.1. Recommendations:

It's all very evident that drought is one disaster that affects many people and can lead to conflicts as communities struggle for scarce resources such as water therefore there is a great need for more attention and monitoring in Uganda. Section 47 of the National Environment Act CAP 153, 1998, NEMA in consultation with the lead agency, issue guidelines and prescribe measures for the sustainable management and utilization of rangelands. In issuing the guidelines and prescribing measures under subsection (1), NEMA shall be guided by the risk to desertification faced by any rangelands. Some efforts have been done under the Sustainable Land Management project in the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) but only targeting two districts of Nakasongola and Kamuli. This project has identified hotspots for land degradation by use of satellite data and worked with communities to come up with strategies for sustainable land management to enhance food security. These efforts should be rolled out to other districts in the rangelands or cattle corridor. For example irrigation in Karamoja should be more prioritized and make this region food secure. Efforts by the Famine Early Warning Systems Network (FEWS NET) funded by USAID-in providing timely, early warning and vulnerability information to international, regional and national partners on emerging and evolving food security issues have been commended. Despite this information the situation in Karamoja is still worrying. It has also been found that the capacity in the use of the space technologies in key institutions such as MAAIF is limited and needs to be improved.

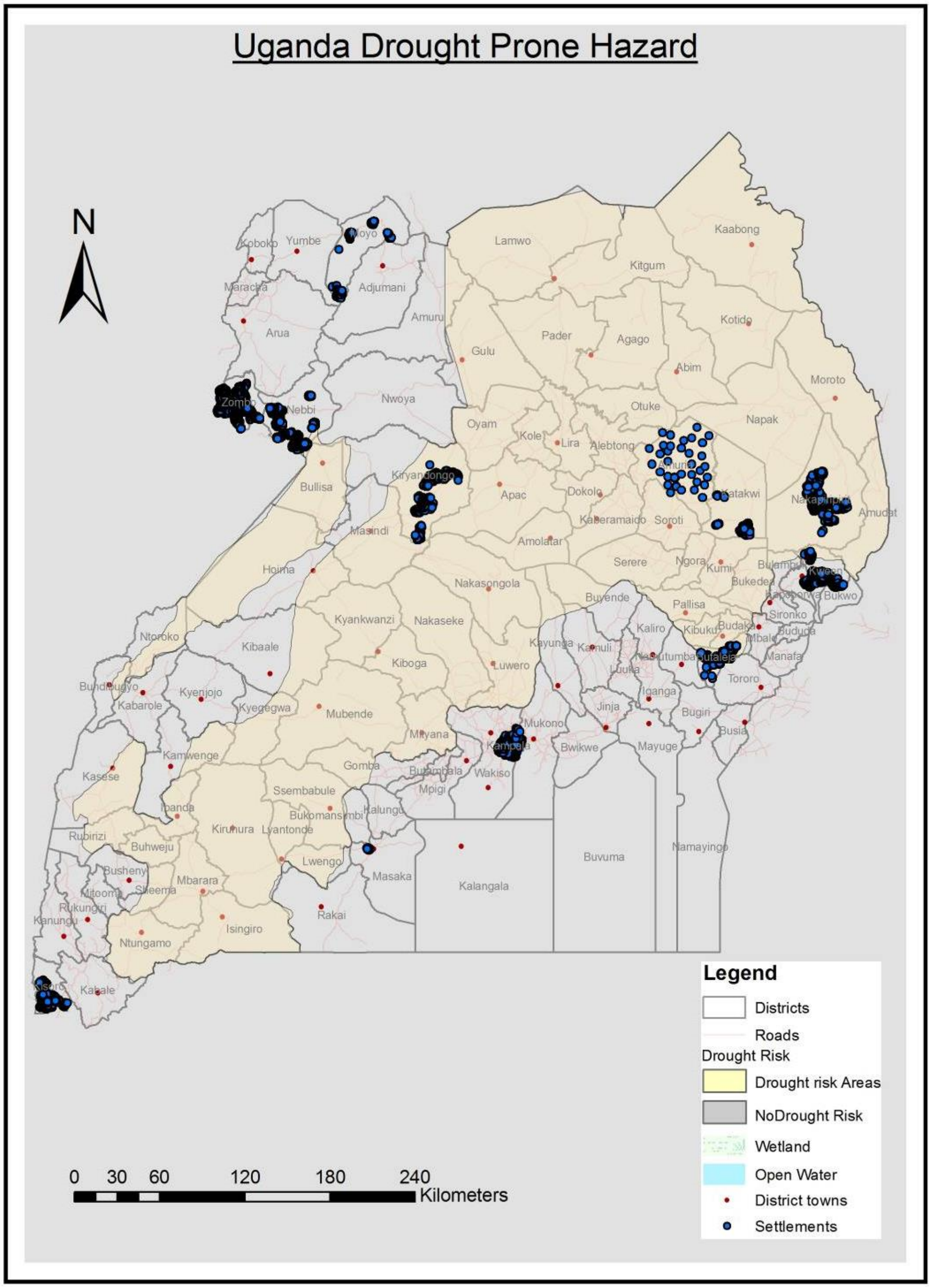


Figure. 4.1. Drought prone areas in Uganda.

5. LIGHTNING.

5.1 Introduction:

Lightning is a massive electrostatic discharge between electrically charged regions within clouds, or between a cloud and the Earth's surface (http://en.wikipedia.org/wiki/Lightning). The charged regions within the atmosphere temporarily equalize themselves through a lightning flash, commonly referred to as a *strike* if it hits an object on the ground (http://en.wikipedia.org/wiki/Lightning). There are three types of lightning flashes and these include that one from a cloud to itself (intra-cloud or IC); from one cloud to another cloud (CC) and finally between a cloud and the ground (CG). Lightning occurs approximately 40–50 times a second worldwide, resulting in nearly 1.4 billion flashes per year (Oliver, 2005). Ground elevation, latitude, prevailing wind currents, relative humidity, proximity to warm and cold bodies of water are the factors that affect the frequency, distribution, strength, and physical properties of a "typical" lightning flash to a particular region of the world. (http://en.wikipedia.org/wiki/Lightning). The most studied lightning flash is the cloud to ground because this is the one that affects man although the cloud to cloud and the intra cloud are the most common. Lightning's relative unpredictability limits a complete explanation of how or why it occurs, even after hundreds of years of scientific investigation. A typical cloud to ground lightning flash culminates in the formation of an electrically conducting plasma channel through the air in excess of 5 km tall, from within the cloud to the ground's surface. The actual discharge is the final stage of a very complex process (Uman 1986). A typical thunderstorm has three or more *strikes* to the Earth per minute at its peak (Uman 1986). Lightning primarily occurs when warm air is mixed with colder air masses resulting in atmospheric disturbances necessary for polarizing the atmosphere.

About 70% of lightning occurs over land in the tropics where atmospheric convection is the greatest. This occurs from both the mixture of warmer and colder air masses, as well as differences in moisture concentrations, and it generally happens at the boundaries between them (http://en.wikipedia.org/wiki/Lightning). Because the influence of small or absent land masses in the vast stretches of the world's oceans limits the differences between these variants in the atmosphere, lightning is notably less frequent there than over larger landforms(http://en.wikipedia.org/wiki/Lightning). The North and South Poles are limited in their coverage of thunderstorms and therefore result in areas with the least amount of lightning (http://en.wikipedia.org/wiki/Lightning). Lightning is usually produced by cumulonimbus clouds whose bottoms are 5–6 km (3–4 miles) above the ground and that are themselves up to 15 km (9.3 mi) in height.

On Earth, the place where lightning occurs most often is near the small village of Kifuka in the mountains of the eastern Democratic Republic of the Congo (Wondermondo, 2010), where the elevation is around 975 m (3,200 ft). On average, this region receives 158 lightning strikes per 1 square kilometer (0.39 sq mi) per year (National Oceanic and Atmospheric Administration, 2008)· Other lightning hotspots include Catatumbo in Venezuela and also in Singapore (National Environmental Agency. 2002). According to United States National Lightning Safety Institute, an estimated 24,000 people are killed by lightning strikes around the world each year and about 240,000 are injured.

5.2. Lightning in Uganda.

Since 2007 lightning has killed 191 people and injured 727 in Uganda (table 5.1). Gulu, Lira, Hoima, Jinja, Kalangala and Kisoro were districts with most occurrences, deaths and also those injured. 98 people were killed and 494 injured in 43 districts across the country in 2011. In 2012 38 people were killed and 38 injured in 19 districts and in 2010 23 people were killed and 109 injured in 10 districts. On 28th June 2011 lightning killed 19 school children and injured 70 in a Primary School in Kiryandongo District. The locations were most people were killed or injured include classrooms, taking shelter under trees, grazing cattle in the field, walking in the open and inside houses. Most of the people were struck in the afternoon during storms.

Year	No of people killed	No of people affected	No of districts
2004	3		1
2007	10	20	3
2008	15	62	8
2009	7	4	5
2010	23	109	10
2011	98	494	43
2012	38	38	19
	191	**727**	**88**

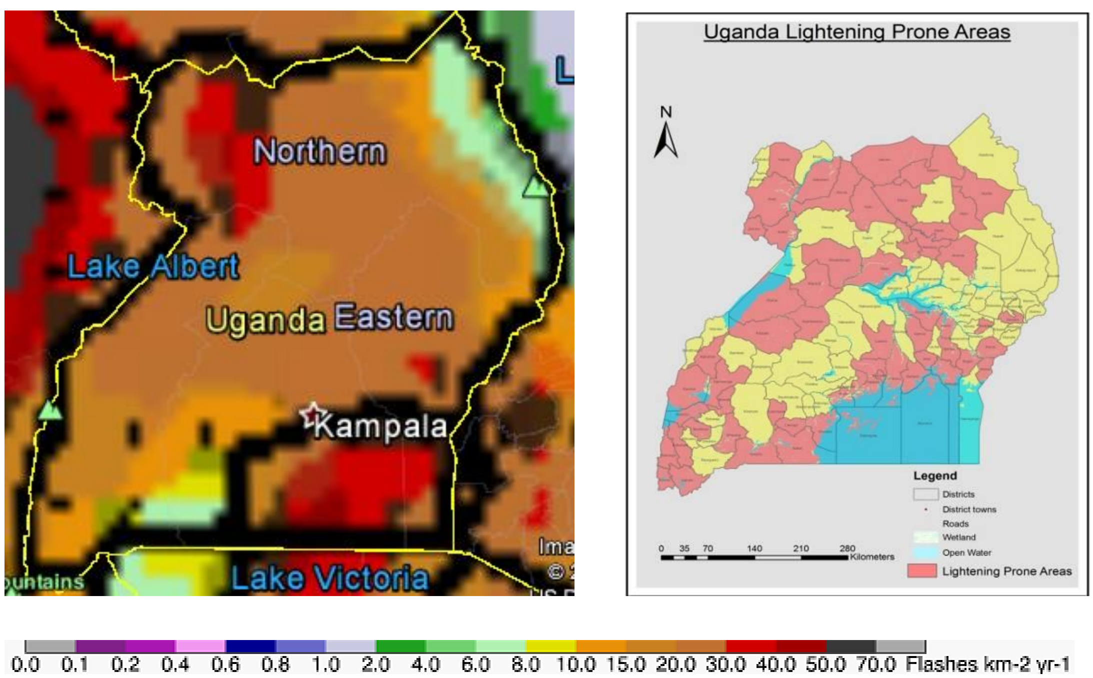
Table. 5.1 Lightning incidents in Uganda. Source: Analyzed from data from Department of Meteorology.

Some communities in Uganda associate lightning with superstition and witchcraft. However, the science of lightning begins with rain clouds which contain water drops and ice particles. When the water and ice rub on one another they become charged and the top of the cloud becomes positive (+ve) and the bottom negative (-ve). These positive and negative charges get attracted to each other causing lightning between the cloud and cloud (Intra cloud lightning) (**Figure 5.1).** The negative charges below the cloud create a positive charge in the ground and as these negative charges grow stronger it jumps into the ground causing lightning spark seen during storms. This spark can strike anything that stands high above the ground or mountains (**Plate 5.2**). These can be people, animals, buildings and trees.

Plate 5.1: Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. (NASA).

Plate 5.2 Cloud-to-ground lightning is the most damaging and dangerous form of lightning. Although not the most common type, it is the one which is best understood. (NASA)

NASA has pursued lightning research because it has a direct effect on day to day of many activities. Lightning strikes have also struck their spacecrafts during their launch. The Lightning Imaging Sensor (LIS) is a space based instrument used to detect the distribution and variability of total lightning (cloud-to-cloud, intra-cloud, and cloud-to-ground lightning) that occurs in the tropical regions of the globe. This lightning sensor consists of a staring imager which is optimized to locate and detect lightning with storm-scale resolution (4 to 7 km) over a large region (600 x 600 km) of the Earth's surface. The TRMM Satellite travels a distance of 7 kilometers every second (nearly 16,000 miles per hour) as it orbits the Earth, thus allowing the LIS to observe a point on the Earth or a cloud for almost 90 seconds as it passes overhead. Despite the brief duration of an observation, it is long enough to estimate the flashing rate of most storms. The instrument records the time of occurrence, measures the radiant energy, and determines the location of lightning events within its field-of-view.



(a) (b)

Figure: 5.1 a) Lightning flashes map for Uganda from the Lightning image sensor (NASA) (b) Lightening map from the actual lightening strikes in Uganda. Note: the scale bar is for map (a).

The satellite map in figure 6.3 (a) shows that the Lake Victoria area, Adjumani, Amuru, Nwoya, Moyo and Kiryandongo have very high risk to lightning within a range of 30 to 40 flashes km^{-1} yr^{-1}. This is in agreement with map (b) showing areas were lightning has killed people around the Lake Victoria, Kiryandongo, Adjumani, and Amuru. The rest of the country is still at high risk to lightning with a range of 15-30 flashes km^{-1} yr^{-1}. Karamoja region has the lowest risk from lightning with range of 6-15 flashes km^{-1} yr^{-1}. The whole country except for the Karamoja is very vulnerable to lightning strikes. The strong recommendation is sensitization of all communities on lightning safety.

5.3 Confirmation of lightning strikes in communities.

Lightning in Bukedea district usually affects trees, animals and houses. In 2011 at Malera trading centre three people were killed and five cows at Kabarwa Primary school were also killed. Lightning conductors have not been installed as yet (Plates 5.3 and 5.4). Kumi District is also prone to lightning strikes. In May 2013 lightning killed two cows. In 2005 one cow was killed and the tree on which it was tied was also burnt (Plate 5.5). In Karapa one person was struck by lightning and admitted in hospital. Also in Akinde one person was struck but the date not known. In Butaleja three children were killed by lightning about ten years ago while on the way from school near the bridge. In 2012 one person was struck by lightning in Kapisa and died. Still in the same district the year 2013 at Nanjale two people were struck and injured by lightning.

In 2011 lightning struck Runyanya Primary School in Kiryandongo, killing 19 pupils and 70 were hospitalized. The school is in the open so vulnerable to lightning strikes Overlooking Murchison National park. According to one of the teachers in the school it happened in the afternoon and most of the children affected were girls. Some had taken shelter in the church and classrooms when they were struck. Almost every corner of this school was prone to lightning even the toilets because some pupils who were there where not spared by the spark. Lightning conductors have been installed on the roofs of the school by a charity organization (***Plate 5.8 - 5. 9***). This should be done for all the other schools in this region.

Plate 5.3 Houses that were struck by lightning killing three persons in Bukedea District.

Plate 5.4. Kabarwa Primary school where cows were hit by lightening in Bukedea District.

Plate 5.5. A tree that was struck by lightning and killed a cow in 2005 in Kumi.

Plate5.6. Classroom where children were killed,

Plate 5.7. Iron sheets destroyed by lightning at Runyanya Primary school.

Plate 5.8. Installed lightning conductor at one of the roofs at the school.

Plate 5.9. The commissioning of the lightning conductors at the school.

5.4. Safety precautions against lightning.

Information on effects of lightning is compiled by the department of meteorology and it is a commendable effort because all the data and information required is with them. There has also been an effort to give the early warning on lightning during the seasonal outlook. However, because the limitations in the accuracy of predicting weather in some seasons there is bias in the use of information in the seasonal outlook. More should be done to correct this attitude.

There are three ways in which lightning may strike you: direct strike where the lightning hits you and goes to earth through you, jumped is where the lightning hits another object and jumps sideways to hit you and the ground strike where the lightning strikes the ground then travels through it hitting you on the way.

5.5. The safety tips:

- Install lightning protection conductors on buildings.
- Get inside motor vehicles during strong storms (avoiding soft top convertibles). Cars are safer than standing outside due to the metal body of the car.
- Move away from wide open spaces or exposed hilltops.
- Move away from water.

- Move away from the open space of the shore or beach. Studies have shown that proximity to water is a common factor in lightning strikes.
- Do not take shelter under tall trees.
- If you are exposed to the elements with nowhere to shelter try to make yourself as small as possible by crouching down with your feet together, hands on knees and head tucked in. This technique keeps as much of you off the ground as possible as lightning will not necessary target the highest object in an area, but the object providing a path with the least resistant to ground.
- When camping, avoid placing your tent at the highest point in the area, especially if thunderstorms are expected over night. If you are in a tent during a storm avoid touching or being close to tent poles if possible.
- Avoid using objects that can attract or conduct a lightning strike, if possible avoid touching or using such items and move away if necessary. These include bathroom taps, central heating radiators, light switches, telephones, televisions, computer systems or any mains powered appliance, umbrellas, metal fences, golf clubs, bikes, fishing rods, sailing boat masts, antennas, metal objects.
- Avoid using mobile phones during storms.

6. WILDFIRES.

Wildfires or bush burning in Uganda is an old practice but not regulated. Many parts of the country especially the north go into flames because of bush burning during the dry seasons. Using satellite data from the MODIS satellite ***(Figure 6.1)***, old data from this satellite was used to zone areas prone to wildfires. MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days. MODIS data is available in shape files for areas with active fires and also burnt areas. Data in form of images for wildfires for the period 1/4/2000 to 1/1/2013 was obtained from the Regional Center for Mapping of Resources for Development (RCMRD) in Nairobi and used to generate the fire hazard map in figure 6.1. More information was obtained from media archives.

HIGH RISK	HIGH	MEDIUM
Kaboongo	Ntoronko	Gomba
Kitgum	Kiryandongo	Sembabule
Pader	Oyam	Kalungu
Lamur	Kole	Bukomansimbi
Kotido	Lira	Masaka
Agago	Alebtong	Rakai
Abim	Amuria	Isingiro
Adjumani	Katakwi	Kiruhura
Amuru	Apac	Lyantonde
Gulu	Amolatar	Lwengo
Nwoya	Kaberamaido	Moyo
Otuke	Kanungu	Yumbe
Napak	Rukungiri	Koboko
Moroto		Maracha
Nakapiripirit		Arua
Kiryandongo		Nebbi
Bullisa		Zombo
Kween		
Bulambuli		
Amudat		

Table: 6.1 District with high incidence of wildfires.

Twenty districts are at very high risk of wildfires, thirteen districts are at high risk and seventeen are at medium risk. The northern region is ranked with the highest risk in wildfires followed by parts of Teso and finally Rakai district and West Nile regions ***(Figure 6.1 and table 6.1)***. Wildfires and scars for burnt areas can also be captured live from satellites such as Landsat TM ***(Figure 6.2 and 6.3)***. Wildfires are used to control grazing fields in some cattle keeping communities however; these have turned out to be disasters. For example on 2/4/2012 a fire destroyed pasturelands in Karamoja region. Similarly another fire on 17/1/2012 destroyed many acres of vegetation in the Piane Upe game reserve. Further still on 14/2/2012 a fire displaced 24 families in Moyo.

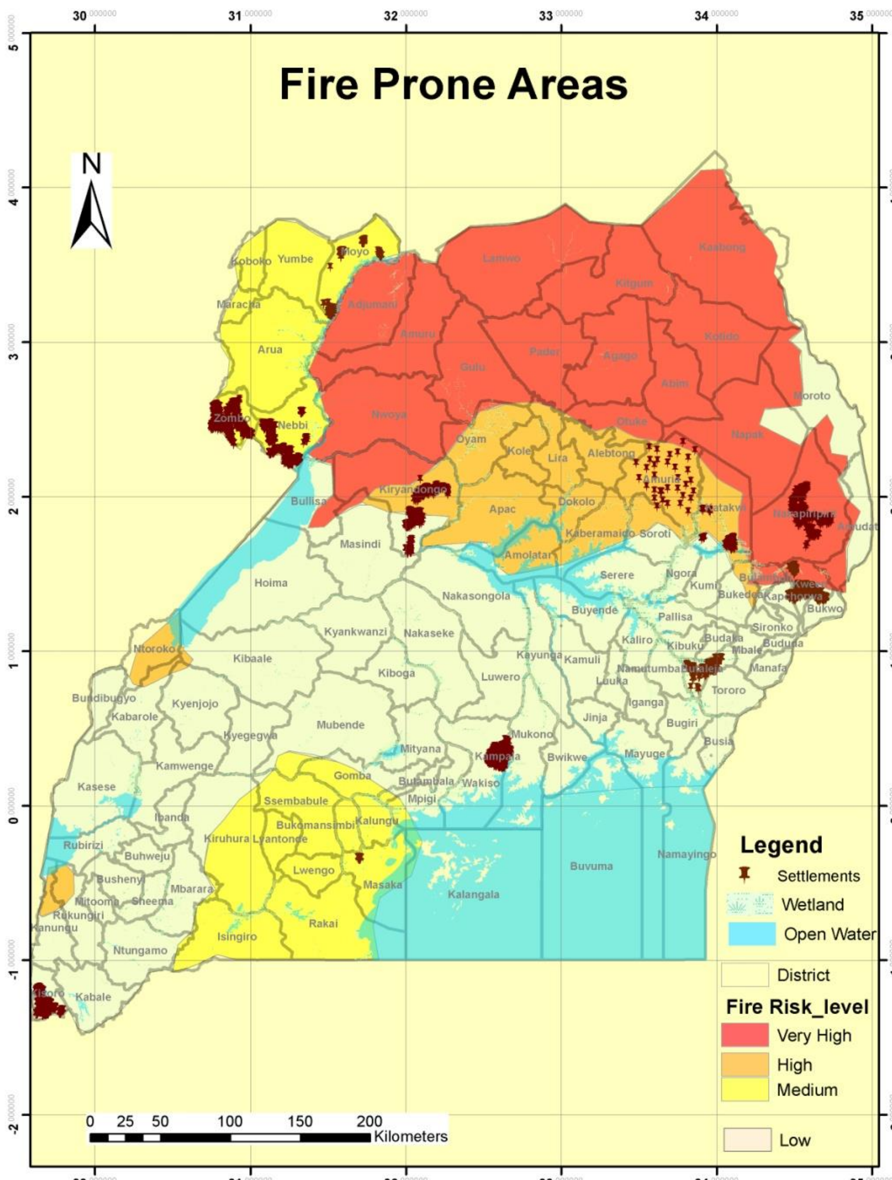


Figure 6.1 Areas prone to wildfires.

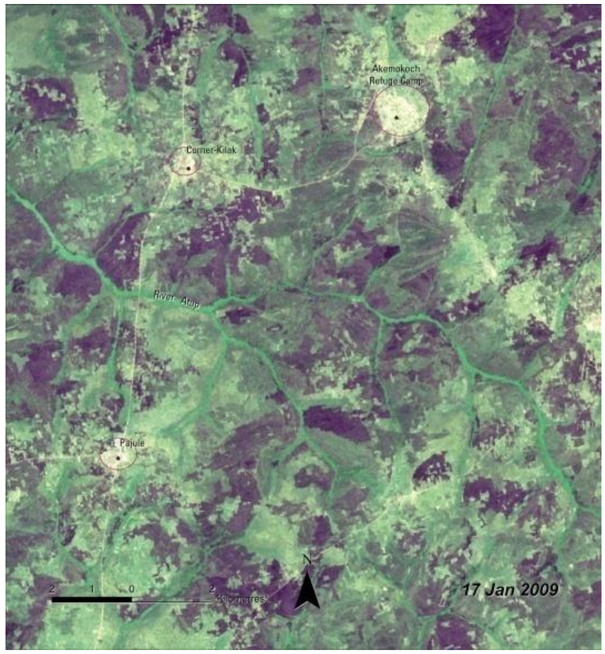


Figure 6.2: Scars from bush burning as seen on the Landsat TM satellite image for the year of 2009 for Gulu and Pader areas.

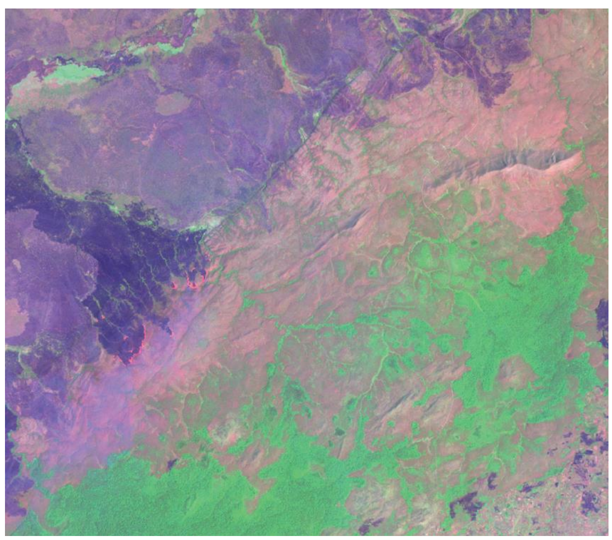


Figure 6.3 Live fire fronts in Budongo Forest captured by a satellite in 2009

6.2. Effects of bush burning on human health and also the environment.

Bush burning in the northern Uganda is used as land management practice to clear land for cultivation. In the cattle corridor such as Rakai district bush burning is used to clear grazing lands to control ticks and also allow new grass to sprout from the burnt scars when the rains begin. The Uganda Wildlife Authority (UWA) also uses controlled bush burning to reduce risk of small animals from other predators such as lions. Bush burning produces smoke into the atmosphere and this is where it becomes dangerous to the environment and human health. Smoke particles are composed of gases such as Carbon dioxide, Carbon monoxide, hydrocarbons, nitrogen oxides and thousands other compounds. The composition of smoke depends on the type of wood and vegetation being burnt, the temperature of the fire and the wind conditions. Cabondioxide is one of those gases known for causing global warming and the consequence of climate change. Carbon monoxide is a colorless gas, it is highly poisonous and when inhaled it combines with the blood to form carboxyhemoglobin and the person dies of suffocations because of lack of oxygen. Communities are not aware of these dangers therefore an awareness strategy is proposed. Further still it was observed that wildfires have no direct institution to regulate it. Although it is assumed that UWA should regulate fires in the protected areas. Areas outside protected areas are left to communities who have limited knowledge on the dangers of bushburning.

6.3. Impacts of bush burning in Rakai.

Kooki hills are located in the relatively dry zone of Uganda (the cattle corridor) with climatic conditions classified as dry sub-humid to semi-arid. Rainfall records at Kibanda indicate that the area receives about 880 mm annually (Climatology Statistics for East Africa Part II- Uganda; East Africa Meteorological Department, Nairobi 1975). This rainfall station is no longer functional and so the most current rainfall data is not available. Occasionally, the area experiences periods of prolonged droughts which sometimes lead to severe moisture deficit. During this dry season, extensive and uncontrolled bush burning, a traditional practice mainly used as a means of land clearing for agriculture and for rejuvenation of young and tender grasses for livestock grazing ***(Figure 6.4)***. A combination of low soil fertility and poor structure, steep slopes, low available plant moisture, as well as poor grazing and crop growing practices, is thought to be the main cause of extensive occurrence of patches of bare ground on the Kooki hills ***(Figure 6.5)***. The rate of expansion of these bare patches is reported to have recently increased dramatically, which indicates rapid environmental change in the area. Consequences of this process are far reaching, especially with regard to reduction of grazing land, increased runoff and erosion and, increased sedimentation problems in the valleys below and in water systems. With increased degradation to bare ground in upland areas, people are turning to the valley bottoms and dry plains, wetlands, river banks, and fragile ecosystems for both crop cultivation and grazing, leading to yet new threats of degradation and environmental change.

Plate 6.1. Scars of burnt areas in Kooki hills in Kacheera sub county, Rakai District.
Photo credit: NEMA.

Plate 6.2. Bare hills as a result of bush burning.
Photo credit: NEMA.

7.5 Other Fires.

Fire is an emerging risk which should not be ignored and it contributes the biggest percentage of all the emergency calls received by the Fire Brigade section of the Uganda police since 2006.

Year	Fires
2009	1011
2010	931
2011	1203
2012	1126

Table. 6.2 Fire incidents in Uganda

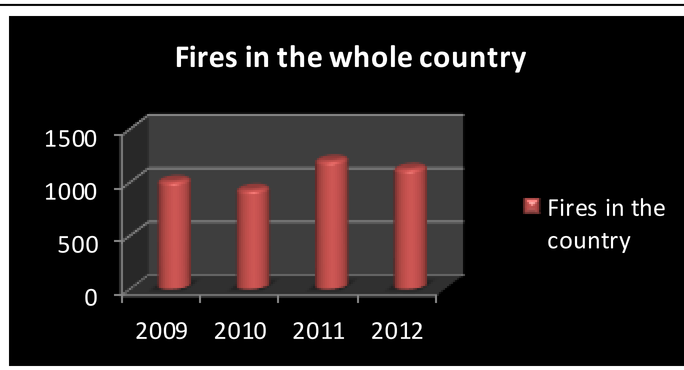


Figure 6.4. Fires incidents in the whole country
Source: Uganda Police records.

Kampala City has had the highest number of fires in the whole country since 2006. Electrical short-circuits are the single most identified cause of fire outbreaks in Uganda due to habits such as overloading power supplies, poor wiring, using poor quality electrical materials, structures not protected from power upsurges and fluctuations along with outright theft of power. Wax & paraffin candles also cause a significant (about 14%) number of fire emergencies. However, many fire incidents caused by candles result into injuries or death of mainly young children who are left alone in houses of concern is the upsurge of incidents caused by charcoal stoves left unattended to totaling to over 12%. This is normally witnessed in markets, single/double room residences and structures of mixed occupancy (retail shop & residence) Arson is also prominently growing in society with people resorting to fire to settle their grievances whether real or imagined. Most of the fires occurred in residential structures however, incidents in commercial structures have increased in the Kampala Metropolitan area 138 people have been killed and 138 injured by fires since 2009. The highest number being in 2009.

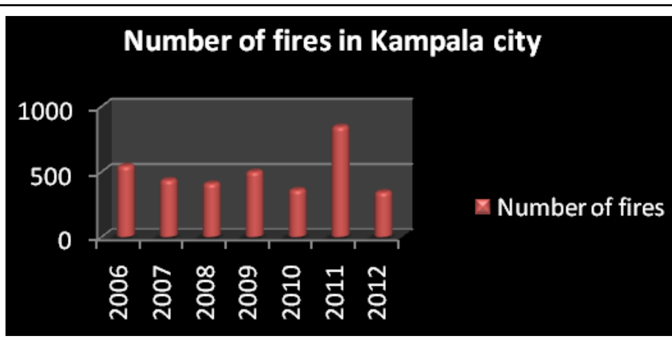


Figure 6.5. Fires in Kampala. Source: Uganda Police.

Year	Dead	injured
2009	63	46
2010	22	43
2011	31	37
2012	22	28

Table 6.3 Number of people killed by fires from 2009-2012. Source: Uganda Police.

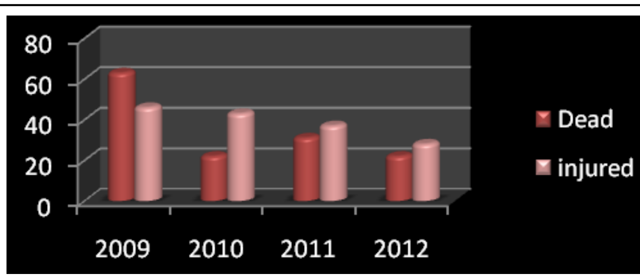


Figure 6.6. Number of people killed and injured in fires from 2009 - 2012.

Some of the most devastating fires in the country were the Budo Junior and the Kasubi tombs fires. The Budo junior fire occurred in April 2008 and 19 children were burnt. The fire for the Kasubi tombs which was a UNESCO World heritage site occurred on 16th March 2010 and plans are underway to rebuild the tombs. Another recent fire is the one involving a petrol tanker at Namungona a Kampala suburb were about 40 people lost their lives.

7. Earthquakes.

7.1: Introduction.

An earthquake or a tremor is the result of a sudden release of energy in the earth's crust that creates seismic waves (*http://en.wikipedia.org/wiki/Earthquake*). Seismicity, of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale (*http://en.wikipedia.org/wiki/Earthquake*). Magnitude 3 or lower earthquakes are weak and those of magnitude 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 (as of October 2012), and it was the largest Japanese earthquake since records began (*http://en.wikipedia.org/wiki/Earthquake*).

At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. Earthquakes can also trigger landslides, and occasionally volcanic activity. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter. The epicenter is the point at ground level directly above the hypocenter (*http://en.wikipedia.org/wiki/Earthquake*). Tectonic earthquakes occur anywhere in the earth where there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. The sides of a fault move past each other smoothly only if there are no irregularities along the fault surface that increase the frictional resistance. Most fault surfaces do have such irregularities and this leads to a form of stick-slip behavior (*http://en.wikipedia.org/wiki/Earthquake*). Once the fault has locked, continued relative motion between the plates leads to increasing stress and therefore, stored strain energy in the volume around the fault surface. This continues until the stress has risen sufficiently to break through the irregularity, suddenly allowing sliding over the locked portion of the fault, releasing the stored energy (http://en.wikipedia.org/wiki/Earthquake). This energy is released as a combination of radiated elastic strain seismic waves, frictional heating of the fault surface, and cracking of the rock, thus causing an earthquake (http://en.wikipedia.org/wiki/Earthquake). Most of the earthquake's energy is used to power the earthquake fracture growth or is converted into heat generated by friction. Therefore, earthquakes lower the Earth's available elastic potential energy and raise its temperature, though these changes are negligible compared to the conductive and convective flow of heat out from the Earth's deep interior (Spence and Sipkin 1989). There are three main types of fault, all of which may cause an earthquake namely normal, reverse (thrust) and strike-slip (Figure 7.1). Normal faults occur mainly in areas where the crust is being extended such as a divergent boundary. Reverse faults occur in areas where the crust is being shortened such as at a convergent boundary. Strike-slip faults are steep structures where the two sides of the fault slip horizontally past each other. Many earthquakes are caused by movement on faults that have components of both dip-slip and strike-slip; this is known as oblique slip (http://en.wikipedia.org/wiki/Earthquake).

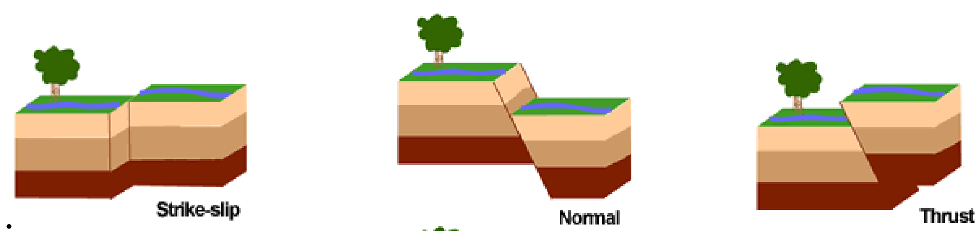


Figure.7.1 Types of faults that cause earthquakes Source :(http://en.wikipedia.org/wiki/Earthquake).

Reverse faults, particularly those along convergent plate boundaries are associated with the most powerful earthquakes, including almost all of those of magnitude 8 or more. Strike-slip faults, particularly continental transforms can produce major earthquakes up to about magnitude 8. Earthquakes associated with normal faults are generally less than magnitude 7 (http://en.wikipedia.org/wiki/Earthquake). This is so because the energy released in an earthquake, and thus its magnitude, is proportional to the area of the fault that ruptures and the stress drop (Wyss (1979). Therefore, the longer the length and the wider the width of the faulted area, the larger the resulting magnitude. Earthquakes occurring at a depth of less than 70 km are classified as 'shallow-focus' earthquakes, while those with a focal-depth between 70 and 300 km are commonly termed 'mid-focus' or 'intermediate-depth' earthquakes. In subduction zones, where older and colder oceanic crust descends beneath another tectonic plate, deep-focus earthquakes may occur at much greater depths ranging from 300 up to 700 kilometers (National Earthquake Information Center, 2005).

It is estimated that around 500,000 earthquakes occur each year, detectable with current instrumentation. About 100,000 of these can be felt (USGS 2010). The number of seismic stations has increased from about 350 in 1931 to many thousands today. As a result, many more earthquakes are reported than in the past, but this is because of the vast improvement in instrumentation, rather than an increase in the number of earthquakes. It is estimated that, since 1900, there have been an average of 18 major earthquakes (magnitude 7.0–7.9) and one great earthquake (magnitude 8.0 or greater) per year, and that this average has been relatively stable (USGS, 2006).

In Uganda several authors and researchers in the 1910's to 1960's all mention that Fort Portal is the area with the highest number of earthquake tremors ***(table7.1)***. *Simons 1939* reported that Fort Portal experienced 362 tremors in a period of 12 years as compared to 55 in Mubende, 46 in Mbarara, 36 in Hoima, 30 in Entebbe, 23 in Kabale, 10 in Butiaba, 13 in Masaka, 6 in Kampala, 5 in Gulu, 2 in Kitgum, 2 in Jinja, 2 in Lira, 1 in Bombo and 1 in Serere ***(Figure7.2)***. He also mentioned that among the tremors experienced those which were strong are from Fort Portal. Furthermore, *Krenkel in 1921 and 1922* made a significant study of earthquakes in East Africa. His findings showed that the western rift was the most seismically active zone in Africa with a frequency of 100 tremors per year on average. Others who concluded the same findings included *Sieberg (1923), Willis (1936), Henderson (1953), King (1956), Gorshkov (1963), De Bremacker (1956), Sutton and berg (1958), Herrinck (1959) and Shimozuru (1960)*. Furthermore, ***Henderson in 1953*** reported that 259 tremors were felt from 1925 to 1953 and 100 of these were from Fort portal. The Uganda geological Surveys and Mines Department in Entebbe recorded 588 felt shocks during the period 1907 – 1942 of which 418 came from Fort portal. According to *K.A Davies in 1949*, Fort Portal has numerous tremors of which very few are recorded. He further reports that between 1920 to 1955 seventeen serious tremors were recorded in Fort Portal. These cracked houses and caused landslides in the Ruwenzori Mountains. Other areas which experience tremors are **Hima in Kasese, Pakwach, Bundibugyo, Rukungiri and Hoima** (United States Geological Surveys).

One major earthquake which is remembered occurred on 20th March in 1966 at 4.42 pm Uganda local time (Engdahl and Villaseñor, 1900-1999) lasting 3–5 minutes (Loupekine,1966). Some sources put the epicenter in Uganda while some put it in the Democratic Republic of the Congo (Loupekine, 1966). The earthquake had a magnitude of 6.8 (Mavonga and Durrheim, 2009), and a maximum perceived intensity of VIII (*destructive*) on the Mercalli intensity scale (Loupekine, 1966). This earthquake killed 150 people in Uganda and the Democratic Republic of Congo, injured 1,300 and damaged property worth 1million US dollars. According to one witness in Rukungiri who was still a child their house shook vigorously forcing them to run outside in the night. He further mentions that they experience some tremors today but not so frequently and also not to the magnitude of the one for 1966. The 1966 earthquake damaged the Virika Cathedral and it had to be reconstructed ***(Plate 7.1)***. The Mt. Ruwenzori region is the most seismically active region in Uganda and the East Africa Rift System and is bounded by steep active normal faults (Maasha) (Twesigomwe, 1997). The calculated focal mechanism for the earthquake was normal faulting in type, (Foster, and Jackson 1998) although the focal mechanisms of three of the aftershocks were dominantly strike-slip in type (Zana, and Tanaka 1981). The earthquake was associated with 20 km of surface faulting showing a down throw of about 1.8 m to the southeast, consistent with one of the two possible fault planes from the focal mechanism (Foster, and Jackson 1998).

The earthquake was preceded by numerous foreshocks on March 18th and 19th, 1966 and was followed by many aftershocks during the next two months, nine of them with a magnitude of 5.0 or greater (Loupekine, 1966). The energy release of the main shock was about 2×10^{17} Nm. The energy release associated with aftershocks after April 18 was also significant. The sum of energy release from the aftershocks up to 45 days after the main shock was also about 2×10^{17} Nm (Loupekine, 1966).

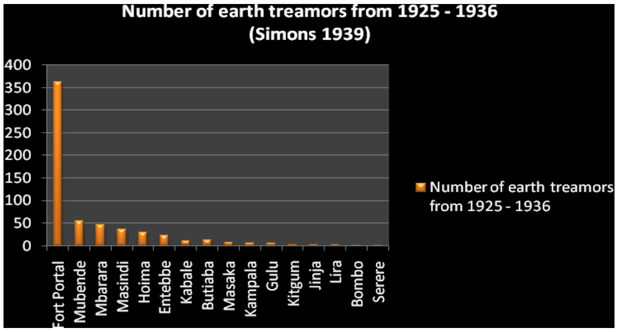


Figure 7.2: Number of earth tremors from 1925 - 1936 in 16 different areas of Uganda.

DATE	LOCATION
9/1/1925	Fort Portal
2/7/1925	Fort Portal
6/12/1925	Fort Portal
21/3/1926	Fort Portal
6/1/1928	Subukia, Kenya
10/2/1929	Fort Portal
12/2/1929	Fort Portal
11/12/1929	Lake Albert
21/1/1930	Fort Portal
22/11/1930	Lake Albert
3/9/1932	Fort Portal
24/9/1932	Fort Portal
21/1/1935	Fort Portal
23/3/1935	Fort Portal
11/9/1935	Fort Portal
21/4/1936	Lake Albert

Table 7.1: Dates of strong tremors that occurred in Fort Portal from 1925 - 1936.

Plate. 7.1: Virika Cathedral in Fort Portal which had to be rebuilt after damage from the 1966 earthquake. Photo credit: Dr. Kitutu

Plate. 7.2 The Mount Ruwenzori ranges in the vicinity of Fortportal town. Photo credit: Dr Kitutu

This year 2013, on 20th April residents along the eastern coast of Lake Albert (Uganda) were frightened by a tremor and rushed out of their houses. One resident in Hoima felt the shaking of his semi-permanent house which lasted for about one minute. Again on 2nd to 4th July a series of earthquakes were felt in the country. According to Dr. Fred Mugume a Principal Geophysicist at the Geological Survey and Mines Department, in the Ministry of Energy and Mineral Development, the first of the three quakes - with a magnitude of 5.2 - occurred on the afternoon of 2 July, while a second, measuring 5.4 occurred late in the evening on 3 July. A third, measuring 5.7 and described by seismologists as "dangerous", took place at 01:22 am on 4th July. The epicenters of all these earthquakes were in the Lake Albertine region an area known for earthquakes.

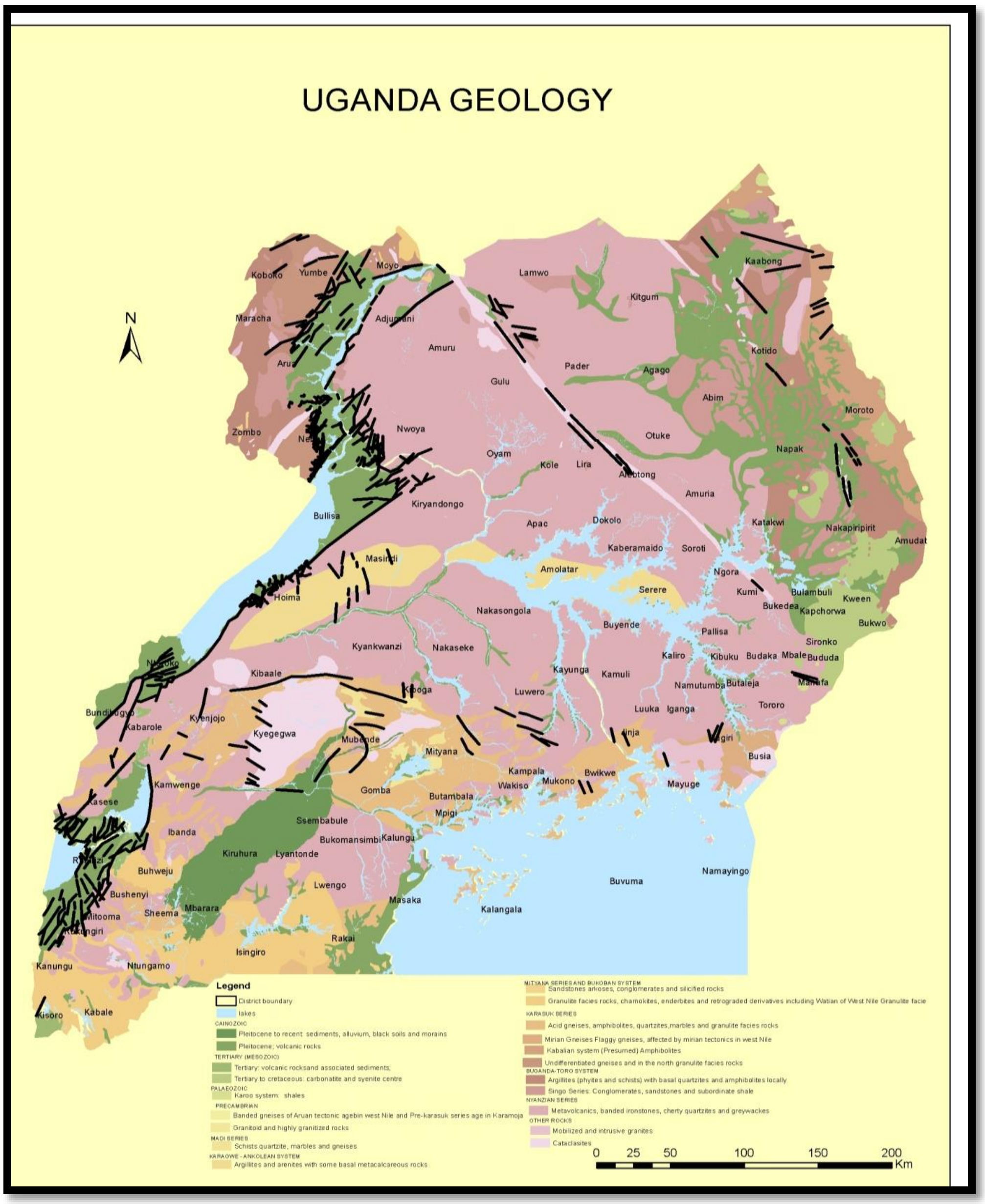


Figure 7.3 Geology map of Uganda, Source: Prepared from shape files from PEPD.

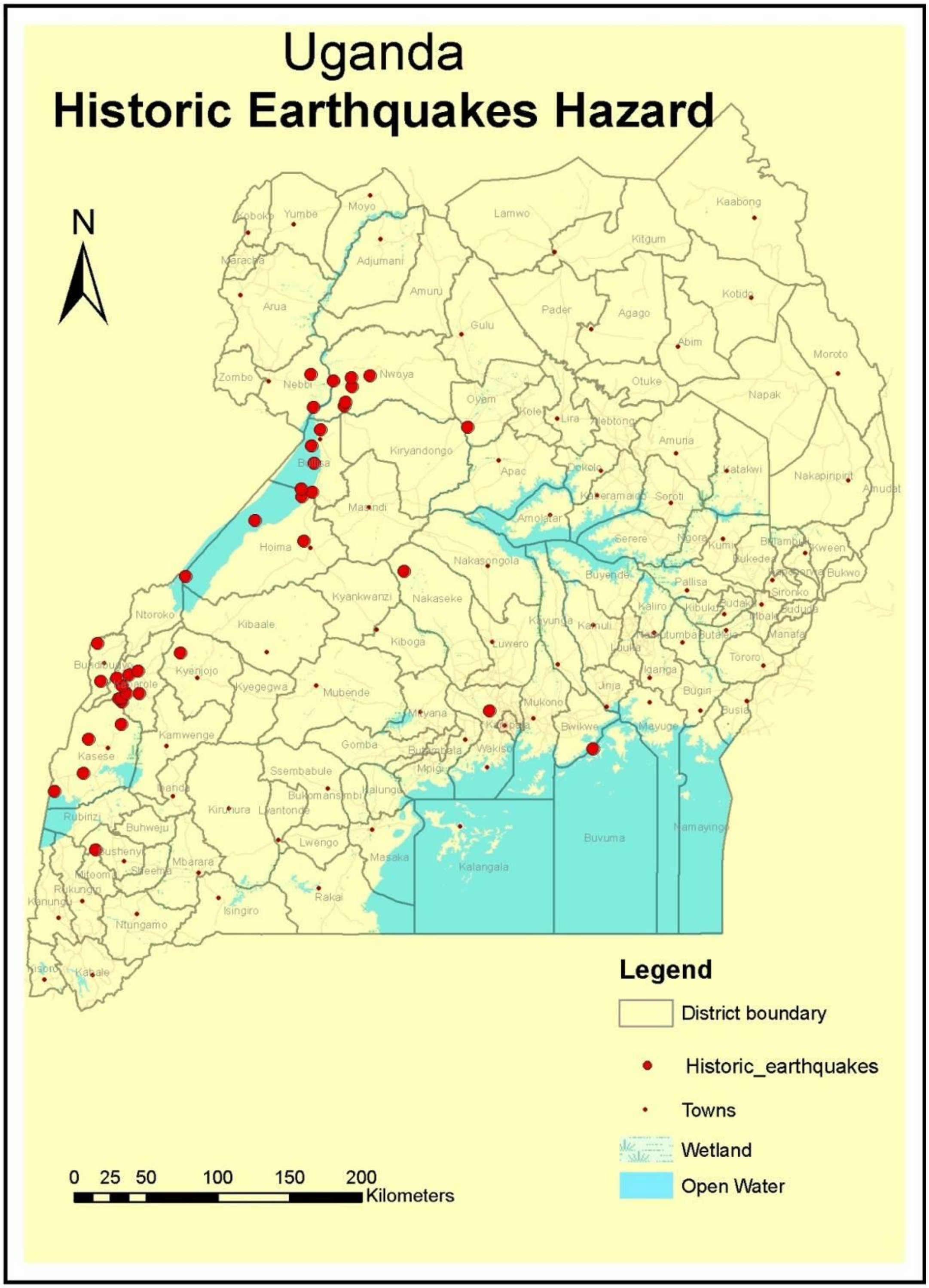


Figure. 7.4: Locations of epicenters of earthquakes in Uganda.

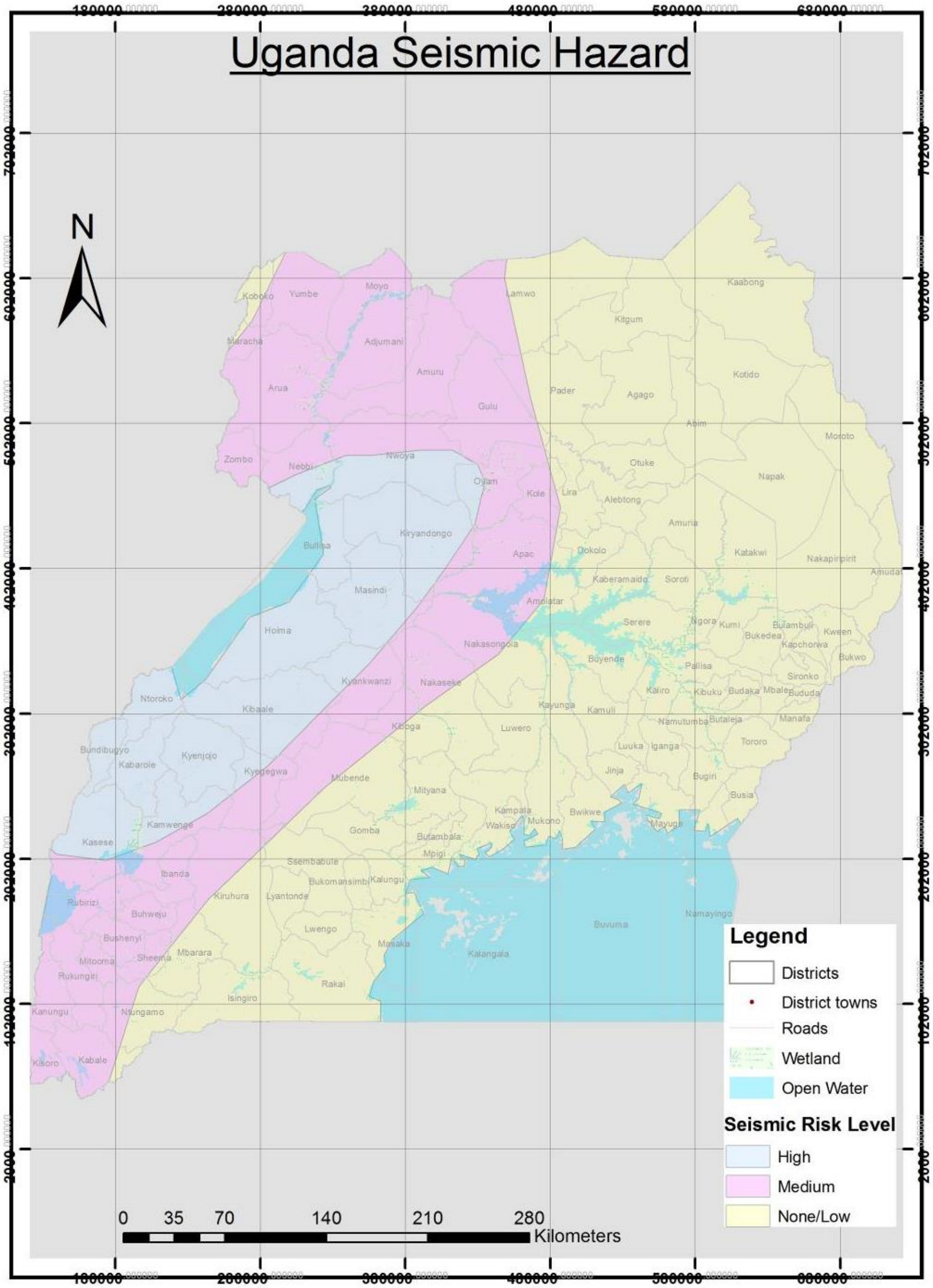


Figure. 7.5: Seismicity map in Uganda. Source: Office of the Prime Minister.

No	DATE	LOCATION	LATITUDE	LONGITUDE	DEPTH (Km)	MAGNITUDE	DAMAGE
1	25/04/1974	Bundibugyo	0.995	30.091	33	5	Not known
2	28/12/1977	Paidha,Nebbi	2.03	31.55	33	5.2	Not known
3	29/12/1977	Kasese	0.013	29.683	33	5.4	Not known
4	26/2/1979	Paidha, Nebbi	1.858	30.936	10	4.9	Not known
5	4/12/1979	Hoima	1.754	34.294	33	5	Not known
6	10/2/1980	Rukungiri	-1.151	29.241	33	0	Not known
7	22/2/1982	Rukungiri	-0.495	29.648	10	0	Not known
8	22/7/1982	Rukungiri	-0.495	29.648	10	0	Not known
9	15/1/1983	Hima, Kasese	0.513	30.199	10	5.2	Not known
10	15/01/1983	Hima, Kasese	0.513	30.199	10	5.2	Not known
11	17/7/1984	Kasese	-0.19	29.698	5	4.7	Not known
12	17/7/1984	Kasese	-0.19	29.698	10	5.2	Not known
13	3/9/1985	Ntungamo	-0.966	29.17	33	0	Not known
14	23/3/1986	Fort Portal	0.515	30.28	10	4.7	Not known
15	20/7/1986	Bundibugyo	1.077	29.896	10	4.4	Not known
16	2/1/1988	Hima, Kasese	0.482	30.148	10	4.6	Not known
17	7/5/1988	Bushenyi	-0.467	30.006	10	4.5	Not known
18	5/1/1989	Kasese	0.209	29.962	10	4.8	Not known
19	3/6/1990	Apac	2.193	32.335	10	4.3	Not known
20	29/7/1990	Kiboga	1.285	31.937	10	4.3	Not known
21	11/8/1990	Njeru/Mukono	0.165	33.18	33	4.6	Not known

22	16/7/1991	Bundibugyo	0.644	29.887	33	4.4	Not known
23	9/10/1991	Hoima	1.804	31.293	33	5.7	Not known
24	18/10/1993	Fort Portal	0.633	30.125	33	4.9	Not known
25	20/3/1994	Hima, Kasese	0.462	30.17	19	4.9	Not known
26	29/3/1994	Hima, Kasese	0.487	30.166	10	4.5	Not known
27	5/2/1994	Bundibugyo	0.593	30.037	14	6.2	Not known
28	22/5/1994	Kasese	0.011	29.928	10	4.6	Not known
29	7/2/1994	Fort Portal	0.611	30.136	10	4.3	Not known
30	8/2/1994	Fort Portal	0.655	30.22	33	4.4	Not known
31	31/8/1994	Hoima	1.603	31.002	10	5	Not known
32	26/5/1995	Kyenjojo	0.769	30.538	10	4.5	Not known
33	26/8/1995	Pakwach	2.073	31.354	33	4	Not known
34	24/3/1996	Fort Portal	0.565	30.169	10	5.4	Not known
35	9/2/1996	Kasese	-0.101	29.749	10	3.9	Not known
36	27/5/1997	Masindi	1.967	31.373	10	0	Not known
37	27/5/1997	Pakwach	2.504	31.604	10	4.8	Not known
38	27/5/1997	Pakwach	2.523	31.35	10	0	Not known
39	28/5/1997	Hoima	1.782	31.361	10	0	Not known
40	31/5/1997	Hoima	1.475	31.31	33	0	Not known
41	16/6/1997	Pakwach	2.317	31.369	10	4.5	Not known
42	18/7/1997	Pakwach	2.349	31.57	10	4.8	Not known
43	18/7/1997	Pakwach	2.484	34.491	10	4.7	Not known
44	18/7/1997	Pakwach	2.516	31.723	10	4.6	Not known
45	18/7/1997	Pakwach	2.448	31.609	10	4.7	Not known
46	19/7/1997	Pakwach	2.177	31.412	33	4.6	Not known

47	19/7/1997	Pakwach	2.516	31.723	33	4.7	Not known
48	15/8/1998	Bundibugyo	0.752	29.956	10	4.8	Not known
49	15/8/1998	Hima, Kasese	0.321	30.168	10	4.4	Not known
50	15/8/1998	Bundibugyo	0.752	29.956	10	4.7	Not known
51	15/8/1998	Bundibugyo	0.946	30.048	10	4.7	Not known
52	16/8/1998	Bundibugyo	0.875	29.899	10	4.7	Not known
53	18/10/1998	Bundibugyo	0.832	30.017	10	4.3	Not known
54	29/6/2001	Kasese	0.292	29.972	10	5.3	Not known
55	27/1/2002	Bundibugyo	0.775	29.716	10	4.7	Not known
56	4/1/2002	Kasese	-0.136	29.758	10	4.8	Not known
57	10/8/2002	Kitgum	3.322	32.358	10	4	Not known
58	19/1/2003	Bundibugyo	0.919	29.947	10	4.5	Not known
59	2/11/2003	Hima, Kasese	0.473	30.168	10	3.8	Not known
60	5/8/2003	Rukungiri	-0.521	29.446	10	5.2	Not known
61	25/8/2003	Rukungiri	-0.512	29.309	10	4.6	Not known
62	18/3/2004	Pakwach	2.904	31.401	30	4.7	Not known
63	5/2/2004	Fort Portal	0.957	30.451	10	4.8	Not known
64	24/5/2004	Kasese	0.116	30.054	10	4.4	Not known
65	7/6/2004	Yumbe	3.411	31.522	4	3.7	Not known
66	13/12/2004	Fort Portal	0.775	30.169	18	4.8	Not known
67	13/12/2004	Fort Portal	0.65	30.171	20	4.3	Not known
68	3/9/2005	Kasese	0.06	29.903	10	4.4	Not known
69	13/3/2005	Kasese	0.19	29.883	10	4.5	Not known
70	3/11/2006	Rukungiri	-0.382	29.493	10	3.7	Not known
71	27/4/2006	Hima,	0.333	30.058	10	4.4	Not known

		Kasese					
72	27/4/2006	Hima, Kasese	0.338	30.078	10	5.2	Not known
73	29/5/2006	Hima, Kasese	0.343	30.114	23	4.9	Not known
74	29/4/2007	Paidha, Nebbi	1.883	30.791	10	4.5	Not known
75	15/6/2007	Hoima	1.719	30.834	24	5.9	Not known
76	26/8/2008	Paidha, Nebbi	2.273	30.911	10	4.4	Not known
77	23/12/2008	Rukungiri	-0.437	29.643	10	0	Not known
78	18/10/2009	Fort Portal	0.563	30.145	10	4.9	Not known
79	9/7/2010	Rukungiri	-0.437	29.643	10	4.4	Not known
80	27/12/2010	Jinja	0.175	33.334	10	4.5	Not known
81	15/3/2011	Hoima	1.746	31.231	10	5.1	Not known
82	2/10/2012	Hima, Kasese	0.468	30.006	20	4.3	Not known
83	20/11/2012	Bushenyi	-0.77	30.108	10	4.8	Not known
84	20/4/2013	Hoima				4.0	
85	2/7/2013	Hoima, Kasese				5.2	
86	2/7/2013	Whole country				5.4	
87	3/7/2013	Whole country				5.7	
88	4/7/2013	Whole country				5.0	

Table. 7.2. Earthquake information from Uganda. Source: United States Geological Survey (USGS)

Period	No of tremors felt.	No of districts	Range in magnitude
1974 – 1989	18	8	4 – 5
1990 -1999	35	11	4 – 6
2000 – 2013	34	11	3 – 6

Table. 7.3. Summary of earthquake occurrence in the period 1974 - 2013.

Locations/districts	No. of occurrences
Bundibugyo	11
Kasese	22
Hoima	7
Runkungiri	8
Paidha, Nebbi	4
Ntungamo	1
Fort Portal	9
Bushenyi	2
Apac	1
Kiboga	1
Njeru/Mukono	1
Kyenjojo	1
Masindi	1
Kitgum	1
Pakwach	11
Jinja	1
Yumbe	1
Total	**87**

Table.7.4: Earthquake prone districts.

Observation from the table above shows that the highest earthquake measured 6.2 magnitude in 1994 and the epicenter was in Bundibugyo. The total number of earthquake occurrences in Uganda during the period 1974 – 2013 was 87 and the epicenters were in western and Northern. Kasese had the highest number 22, followed by Bundibugyo and Pakwach at 11, Fort Portal with 9, Runkungiri with 8, Paidha/Nebbi 4 while the rest experienced 1 (Apac, Kiboga, Njeru/Mukono, Ntungamo, Masindi, Kyenjojo, Jinja, Kitgum and Yumbe.

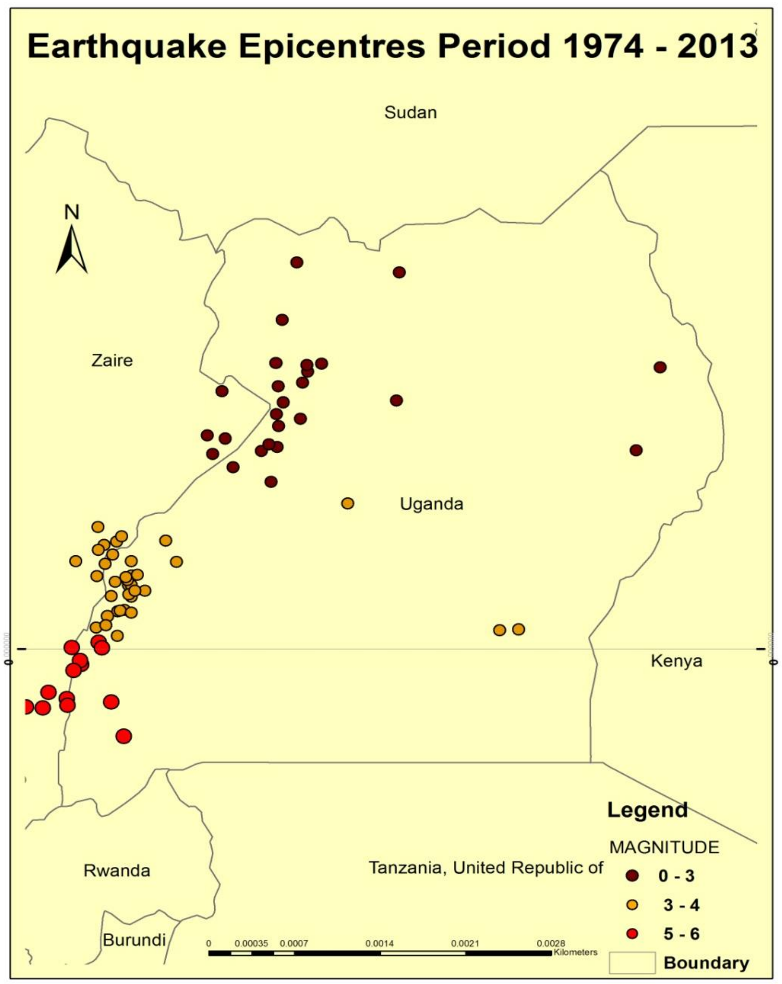


Figure 7.6. Location of Epicenters map source: United States Geological Survey (USGS)

8. Volcanism

There are six volcanic fields in western Uganda namely Fort Portal, Kyatwa, Katwe – Kikorongo, Bunyaruguru and Katunga near the Ruwenzori Mountain (John seach). The Muhavura, Gahinga and Mufumbira Volcanoes are located down in the Kigezi region. Mount Elgon is located in the east of the country at the border with Kenya.

Mount Elgon is a caldera eruption which is the most powerful and catastrophic type of volcano because of the unique way in which they form. A caldera is huge bowl-shaped crater usually formed by volcanic activity. Calderas are formed because eruptions of huge volumes of pyroclastic materials had left the roof of the magma chamber unsupported, causing it to fracture and fall downwards into the chambers (http://en.wikipedia.org/wiki/Caldera). Collapse of the cone occurs, as it becomes a jumble of enormous blocks, some of which sink through the magma. This process is termed cauldron subsidence. This process may take a very long time to complete and often happens in an extinct volcano. It is believed that Mount Elgon may have been higher than Mount Kilimanjaro but the summit of Elgon collapsed into the chamber from which volcanic material had been expelled resulting in a caldera of 8 Km in diameter (Davies, 1957). The caldera lies 800m below the highest point on the crater rim. The western and northern boundaries of the volcano are characterized by magnificent step-like cliffs up to 305m (1000ft) towards the almost unbroken plain of eastern Uganda. These ridges of granitoid rocks (granite, gneiss, schist) existed before the volcanic activity took place (Davies, 1957). Some of them got covered with volcanic material, which gives rise to the variegated geology. The area covered by the volcanic rocks is about 3237 Km^2 although it appears that the lava and agglomarates seem to have covered a larger area. Tuffs and agglomerates form the greatest portion of the mountain. The agglomerates are dark blue or grey in color and carry blocks of lava up to one meter or more across. Agglomerates are igneous rocks that consist almost wholly of angular or rounded lava fragments of varying size and shape (Davies, 1957). The threat of volcanic eruption from Mount Elgon is not anticpated and communities have settled in most of the areas covered by the volcanic material. However, given that Mount Pinatubo erupted when it was thought to be extinct needs to be taken cautiously (http://www.livescience.com/14603-pinatubo-eruption-20-anniversary.html). For example communities in Bududa during a recent inspection in the Mount Elgon area with the sub-committee of cabinet on disasters, mentioned issues such as rumbling noises in the volcano, dark substances coming out of rocks in some areas with dykes, huge cracks which calls for increased monitoring of this region. The communities declined to disclose the site because they thought the substance was oil. This calls for the empowerment of the Geological Surveys and mines Department to carry out continuous research and monitoring of these areas. For example monitoring of seismicity should be done for the Mount Elgon area just as it is being done in the western.

Fort Portal Volcanic filed is located in western Uganda between Lake Albert and Lake Edward. It is situated at the North East end of the Rwenzori Mountains. The volcanic field contained the first recognized example of calciocarbonatite lava. It contains about 50 vents, and has erupted in three stages. Two NE–SW lines of carbonatite tuff cones were erupted in the first stage. A blanket of tuffs formed the major deposit, defining the Fort Portal field. The final phase involved eruption of lava flows at the SW end of the main line of tuff cones. Kyatwa volcano field is located in western Uganda, east of the Ruwenzori Mountains.
The volcano is located halfway between Lake Edward and Lake Albert, and consists of tuff cones and lake-filled maars. Katwe-Kikorongo volcano field is located on the NE shore of Lake Edward. It is part of a kamafugite-carbonatite province of southwest Uganda in the western rift valley branch. It has eight explosive crater lakes some of which are Murumuli and Katwe. Volcanic rocks in the field cover 180 sq km, and are separated by the Kazinga Channel from Bunyaruguru volcano 15 km SE. There is a hot spring in Katwe kirorongo with sulpahet an indication that it is magmatic and hydrothermal. Bunyaruguru volcano is located 20 km east of Lake Edward. Bunyaruguru volcanic field was possibly created as the result of downwarping between two major rift faults. The main type of activity was gas explosions. Only four

of 152 craters have lava associated with them. Volcanic activity follows fracture patterns and lines of weakness. The field is elongated along the line of the main fault. Two main systems are identified at Bunyaruguru volcanic field - A north to northeasterly one, and an east to southeasterly one. Within each and between them are a number of smaller peaks that are not significant in relation to the field as a whole. Local people have legends of volcanic eruptions, which indicates eruptions may have occurred in the past few centuries. Katunga volcano is located 40 km SE of Lake Edward. Flows of katungite are only found at Katunga volcano. Katungite contains mainly biotite and augite. The rock known as katungite was originally described as melilite-basalt or olivine-melilitite.

Gahinga (Mgahinga) volcano is located in the eastern Virunga ranges. There is a swamp crater on the summit of Mt Gahinga. The plains at the foot of the volcano are characterised by deep volcanic ash, and run-off from the mountains rapidly disappears underground. Muhavura volcano is located at NE end of the Virunga Range on the Uganda/ Rwanda border. Muhabura lies in Volcanoes National Park, Rwanda and Mgahinga Gorilla National Park, Uganda. Muhavura, has a very youthful morphology and appears to be intermediate in age between the currently active volcanoes of the Virunga range and the more deeply eroded Sabinyo. Bufumbira volcano is located in SW Uganda. The volcano consists of 40 cinder cones and lava flows. The Bufumbira depression is bounded by high and deeply dissected mountains. A prominent feature of the Bufumbira lava field are several long ridges, formed almost entirely of ash and scoria. The most prominent of the ridges are Bunagana, Ndakilye-Migeshe, and Karambe. The ash ridges follow lines of weakness coinciding with steeply dipping sedimentary rocks. Most of the smaller eruption centers are composed of ash, scoria, and pumice.

The volcanic centers in the western need to be monitored given that we have hot springs and frequent earth tremors. More attention needs to be given to equipping the Geological Survey and Mines Department to continuously monitor both earthquakes and volcanism in Uganda.

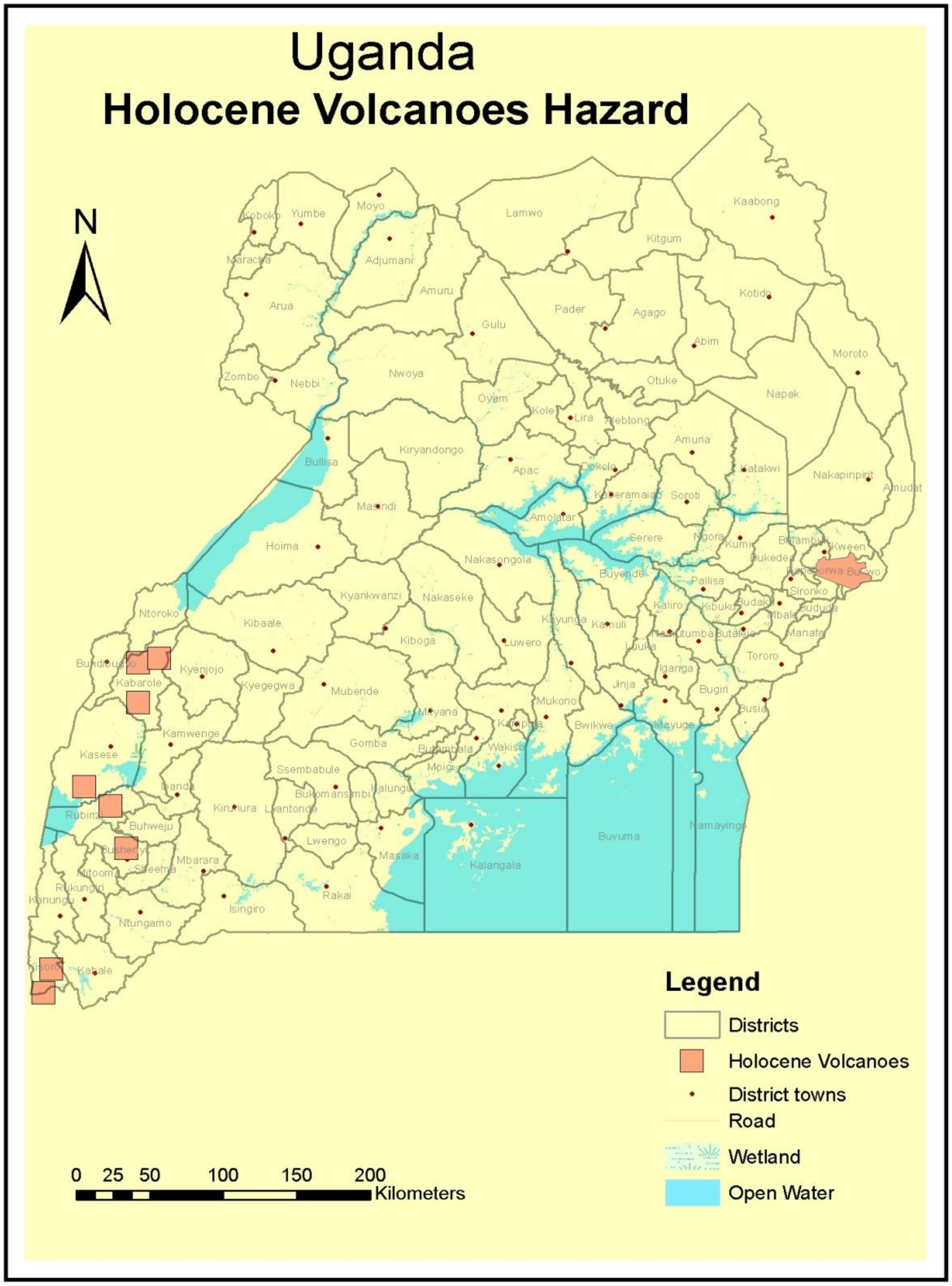


Figure 8.1: Volcanic centers in Uganda.

9. General Findings and recommendations.

This study has revealed that a total of 1102 people have been killed and 3,365,380 affected by natural disasters in Uganda **(table 9.1**). Out of these the hydro-meteorological disasters namely landslides, floods and drought were the most devastating killing 622 people and affecting 3,363,199. Landslides have killed 542 people which is the highest number followed by lightning then earthquakes and fires. Droughts affect more people followed by floods (**table 9.1**).

Disaster type	Number of people killed	Number of people affected
Floods	40	353,333
Landslides	542	9866
Drought	41	3,000,000
Fires	138	154
Earthquakes	150	1300
Lightning	191	727
Total	**1102**	**3,365,380**

Table 9.1. Summary of people killed and affected by different disasters

This study also revealed that the cost of damage and loss from these disasters in monetary terms is not usually assessed and where it has been done the reliability of the data is questionable. This need to be improved because knowing the cost of damage informs decision makers the importance of disaster risk reduction in promoting development and sustainable livelihoods.

Floods, drought, lightning, fires and landslides are more frequent but landslides and floods cause great damage to infrastructure such as roads and bridges. About 542 people have been killed and 9866 displaced countrywide by landslides since 1818. This number of people killed is highest in Bududa with a number of 507, followed by Bulambuli and Sironko. These numbers are likely to increase as the population in these sensitive regions continues to grow and more people settle on steep slopes and also encroach on the forests in the National Park. To reduce on landslide occurrences areas prone to hazards should not be used for settlement. For example areas below agglomerate cliffs in Bulambuli and Sironko districts should be vacated. This includes areas below the Buginyanya ridge, also those below the Butandiga ridge and also in Buluganya. In addition settlements should not be allowed in areas of 1000m (minimum) from the cliff unless if the cliff has a thick forest cover which is never the case. Areas with cracks should be vacated and restored with intensive agro-forestry. Areas with known landslide risk (moisture zones) should not be used for settlement. This includes valleys and depressions on hills were water collects. This mainly applies to the eastern side of Bududa district. More funding should be given to the district especially the environment protection, social development, population control and production units if these landslides are to be minimized. Education of the youth should also be taken as priority to reduce the pressure on land. This will enable them get skills and look for alternatives rather depending on land alone. Community sensitization on development programmes should be taken as a priority.

Floods.

Morestill, about 40 people have been killed and 353,333 affected by floods since 2005. 58 districts in the country are prone to flooding during seasons of intense rainfall. In some of these areas such as Teso region, Ntoroko districts and Kasese districts the floods were very devastating. The year 2007 had 17 people killed and 300,000 displaced. Crops were also washed away and infrastructure such as bridges and roads was greatly damaged. Also in 2011 the Karamoja region was greatly affected by floods which cut off roads and bridges. This year in Kasese floods killed 8 people and damaged bridges, and flooded houses in the Kilembe mines and Kasese town. Most of the floods are associated with rivers bursting their banks and others are in lowlands and wetlands. The damage and impacts from floods have been increasing and unfortunately they have not been well documented and also costed in monetary terms. In Kasese district it was proposed that river banks should be demarcated and be used for tree planting. It was also propose in Kasese and Butaleja that rivers be dredged to allow guided flows. Channels were also to be constructed to reduce floods. Degraded catchment areas and hilltops should be restored through tree planting to reduce on the runoff. Community sensitization programs should be key; not only to restore the hopes of the affected communities and the general public but also to communicate to them the magnitude of the disaster and pass on agreed resolutions on the management of these degraded areas. Community participation should be emphasized throughout the restoration process to ascertain a sense of ownership and ensure continuity by the community. In Butaleja communities were willing to be resettled to other areas without floods. For Kampala it is recommended that the following be done to control floods:

- There should be efforts to promote water harvesting from roofs.
- Dumping of waste and silt in channels should be stopped.
- Construction in water ways should be halted or regulated.
- Construction of standard water channels.

This year 41 people have died of starvation and about 300,000 children malnourished in the Karamoja region alone. In addition over 3,000,000 million are affected by famine due to drought countrywide since 1998. It's all very evident that drought is a disaster that affects many people and can lead to conflicts as communities struggle for scarce resources such as water therefore there is a great need for more attention and monitoring in Uganda. Section 47 of the National Environment Act CAP 153, 1998, requires NEMA in consultation with the lead agency to issue guidelines and prescribe measures for the sustainable management and utilization of rangelands. In issuing the guidelines and prescribing measures under subsection (1), NEMA shall be guided by the risk to desertification faced by any rangelands. Some efforts have been done under the Sustainable Land Management project in the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) but only targeting two districts of Nakasongola and Kamuli. This project has identified hotspots for land degradation by use of satellite data and worked with communities to come up with strategies for sustainable land management to enhance food security. These efforts should be rolled out to other districts in the rangelands or cattle corridor. For example irrigation in Karamoja should be more prioritized and make this region food secure. Efforts by the Famine Early Warning Systems Network (FEWS NET) funded by USAID-in providing timely, early warning and vulnerability information to international, regional and national partners on emerging and evolving food security issues have been commended. Despite this information the situation in Karamoja is still worrying. It has also been found that the capacity in the use of the space technologies in key institutions such as MAAIF is limited and needs to be improved

Lightning

Lightning has silently killed 191 and affected 727 in 88 districts since 2007. In 2011 alone 48 districts had lightning strikes in some cases resulting into death. According to a press release from the Department of Meteorology (2011) this effect was due to unusual serge of the moist air from the Atlantic Ocean and Congo air mass. Most parts of the country in that year received outbreaks of showers and thunderstorms accompanied by lightning. Information on effects of lightning is compiled by the Department of Meteorology and it is a commendable effort because all the data and information required is with them. There has also been an effort to give the early warning on lightning during the seasonal outlooks. However, because of the limitations in the accuracy of predicting weather in some seasons there is bias in the use of information in the seasonal outlook. More should be done to correct this attitude in the users of the information. The following recommendations should be popularized:

- If you are in a group, each person must stand at least 50 feet apart, in order to minimize group injuries.
- Sit on the heels of your feet with toes touching the ground so as to lower your height.
- Tuck your head between your knees; doing this will minimize any chance of a strike on your head, so that your chances of survival are better.
- Keep your ears covered to protect against hearing damage and close your eyes to minimize blindness due to close strikes.
- Remove your jewelry, watches and other metal items as these might cause severe burns if you are struck by a lightning.

- You should stand on a plastic sheet, sleeping pad, rubber soles, saddles or any such thing which will help you isolate from the wet ground. This should be done to minimize the conductivity.
- Try to hold your position till the storm passes.
- Install lightning protection conductors on buildings.
- Get inside motor vehicles during strong storms. Cars are safer than standing outside due to the metal body of the car.
- Move away from wide open spaces or exposed hilltops.
- Move away from water.
- Move away from the open space of the shore or beach. Studies have shown that proximity to water is a common factor in lightning strikes.
- Do not take shelter under tall trees.
- If you are exposed to the elements with nowhere to shelter try to make yourself as small as possible by crouching down with your feet together, hands on knees and head tucked in.
- When camping, avoid placing your tent at the highest point in the area, especially if thunderstorms are expected over night. If you are in a tent during a storm avoid touching or being close to tent poles if possible.
- Avoid using mobile phones during storms.

Earthquakes and volcanism.

Earthquakes although not taken as a potential disaster in Uganda, killed 150 people in Uganda and the Democratic Republic of Congo, injured 1,300 and damaged property worth 1million US dollars in 1966. The epicenters are usually in the Lake Albert region and this region is where there is the discovery of oil and gas. Given the recent earthquake occurrences there has been a general concern on the inadequacy of technical capacity and also preparedness in case a damaging earthquake occurred. According to Dr. Fred Tugume of the Geological Surveys and Mines Department "Earthquakes have been there and we live with them". However, he stressed that the repeated occurrence is worrying. He promises to analyze the phenomena and find out why." This lamentation instead of reassuring from an institution with the mandate causes concern given that media reports have indicated vandalisation of some of the equipment at this very important center. It has also been reported in the media that little effort has been made to educate the population on proper actions to take in the event of an earthquake, despite experiencing some two dozen moderate earthquakes over the last decade. This was very evident in the responses given by communities on the causes. Some people especially in the Bunyoro region attributed the earthquakes to the coming of the rain season. Others were anticipating the oil drilling activities to be the cause and some were even saying the construction of the Bujagali hydro power dam in Jinja could be the cause. The United Nations International Search and Rescue Advisory Group (INSARAG) has standardized guidelines for search and rescue missions following disasters that may cause buildings to collapse and has hosts awareness training courses for disaster manager's at all administrative levels, this should be pursued and have Ugandan officials trained. The Hon Minister of State Minister for relief, disaster preparedness accepts that there are gaps in preparedness and stresses the need for construction to take the potential for earthquakes into consideration. He further promises that the US Government had agreed to train two Ugandan army and police battalions in search and rescue operations and promises that some equipment will be purchased. All this interventions only address disaster response but more should be done on the technical side by equipping the Geological Surveys and Mines Department in Entebbe with modern equipment and also fund research so as to better understand this phenomenon and also educate all people on the earthquakes causes and their consequences in Uganda. Volcanism although not considered a threat to communities in Uganda needs to be monitored and also more research carried out. Mount Elgon is believed to be extinct but this area needs to be monitored given that Mount Pinatubo erupted when it was least expected to erupt. For example the numerous tremors in the western gives an indication of an unstable crust and both earthquakes and volcanism should be monitored. The Geological Surveys and Mines Surveys should be prioritized as a key institution which provides important information on many aspects of earth. Many times they are only consulted when there is a scare, for example in August 2004 gases and molten substances were coming out of caves on the Mount Elgon volcano. It was reported that temperatures rose up to 170ºC in the cave. Of course there was panic that the dormant volcano was to erupt but since then everything went silent and neither is there any research and monitoring done on this volcano.

Fires

138 people have been killed and 154 injured by fires for the period 2009 to 2012. Fires both domestic and wild pause a great risk to the population. There is need to sensitise communities about the risk of fires especially those involving highly flammable substance such as fuel. Such fires occurred at Busesa and this year at Namungona and yet the public has not learnt any lessons. Some of the domestic fires are also due to electrical short circuiting especially those in Kampala which calls for the need to regulate the importation of standard electrical appliances and other materials. Communities should also be sensitized on the risk of living infants alone with naked fires such as candles. Quantification of losses from fires should also be initiated as this gives an insight to decision makers to understand the gravity of the matter. It was also observed that wildfires cause a lot of havoc especially in northern Uganda and the cattle corridor yet no institution regulates these wildfires. The Office of the Prime Minister should appoint an institution to regulate wildfires.

Other observations and findings in this study is that data and information about natural hazards is not well coordinated. For example the Office of the Prime Minister (OPM) should be a one stop center for all data and information on natural hazards but this is not the case. An attempt has been made at OPM to create a web portal for natural disasters but not all the information is uploaded and also it's not easily accessible. It is recommended that OPM should streamline data collection with the mandated institutions to avoid release of wrong information on disasters. A visit to institutions that deal with management of certain natural hazards was done and it was observed that the Uganda Police has good records on manmade fires and an attempt has been made to carry out analysis to produce annual reports but this only goes back to 2009. The period earlier than that, the records were handed to the

Office of the Prime Minister and these could not be easily accessed. It is suggested that the Uganda Police should be supported to have these records published within their websites and a copy is given to the Office of the Prime Minister for the national database. More efforts are commended for the Department of Meteorology for collecting data on lightning. This was readily available and very useful in the analysis made in this report. Uganda falls within the lightning hazard zone and so information on safety from lightning should be widely distributed. Safety measures such as lightning conductors on major institutions such as schools, hospitals should be enforced by OPM and other mandated institutions.

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APPENDIX 1: TECHNICAL TERMS RELATED TO NATURAL DISASTERS AND DISASTER RISK REDUCTION.

A **natural disaster** is a major adverse event resulting from natural processes of the Earth; examples include floods, volcanic eruptions, earthquakes, landslides, drought.

An **earthquake** is the result of a sudden release of energy in the Earth's crust that creates seismic waves which manifest as vibrations, shaking and sometimes displacement of the ground. The vibrations may vary in magnitude. Earthquakes are caused mostly by slippage within geological faults.

Focus: The underground point of origin of the earthquake.

Epicenter: is the point above the focus on the surface is called the *epicenter*.

A **volcano** is an explosive event where lava from the depth of the earth escapes through fault to the surface.

A **flood** is an overflow of an expanse of water that submerges land.

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

Wildfires are large fires which often start in wild land areas. Common causes include human negligence or arson.

Lightning is a massive electrostatic discharge between electrically charged regions within clouds, or between a cloud and the Earth's surface. The charged regions within the atmosphere temporarily equalize themselves through a lightning flash, commonly referred to as a **strike** if it hits an object on the ground. Lightning primarily occurs when warm air is mixed with colder air masses resulting in atmospheric disturbances necessary for polarizing the atmosphere

A **Disaster** is a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

An Early warning system is a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.

El Niño-southern oscillation; A complex interaction of the tropical Pacific Ocean and the global atmosphere that results in irregularly occurring episodes of changed ocean and weather patterns in many parts of the world, often with significant impacts over many months, such as altered marine habitats, rainfall changes, floods, droughts, and changes in storm patterns.

Hazard: A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Natural hazard: Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Vulnerability: The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

Risk: The combination of the probability of an event and its negative consequences.

Intensive risk: The risk associated with the exposure of large concentrations of people and economic activities to intense hazard events, which can lead to potentially catastrophic disaster impacts involving high mortality and asset loss.

Extensive risk: The widespread risk associated with the exposure of dispersed populations to repeated or persistent hazard conditions of low or moderate intensity, often of a highly localized nature, which can lead to debilitating cumulative disaster impacts.

Exposure: People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Appendix 2: Photo archives for disasters in Uganda. Credit: Dr Kitutu M.G. 2013.

Floods

Inspecting areas affected by floods in Butaleja.

A channel made between gardens to control floods in Butaleja.

A bridge that is always submerged by floods in

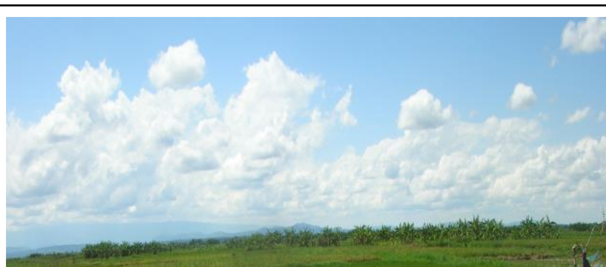
Crops in Marera sub county affected by floods

Channels used to control floods in Doho rice

Banana plantation always at affected by floods in

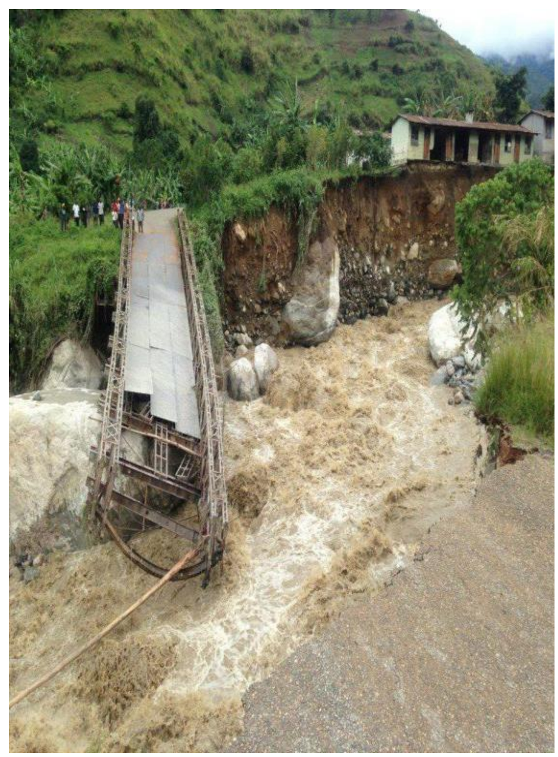
Crops have turned yellow due to too water logging.

These swamps are impassable during rainy season



Area overlooking Lake Bisina. The hut was damaged by floods.

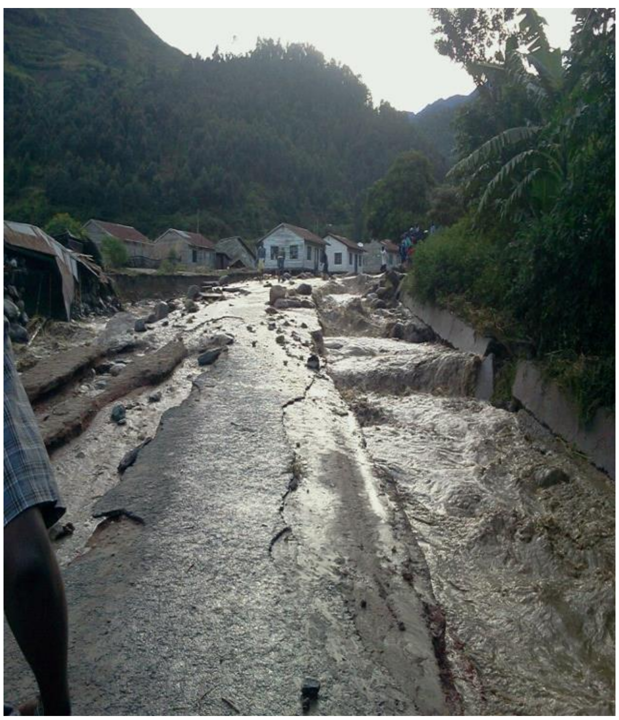
A broken bridge in Kilembe. Transport was greatly affected.



Houses hanging dangerously at the river bank in Kilembe after the floods.

Damaged electric poles in the Kilembe area. This affected power supply.

Roads damaged by flood waters in Kilembe.



Houses and roads damaged by flood waters.

A car that washed away by flood waters.

People watch floods at the Kilembe town

Electric wires lie in water channels.

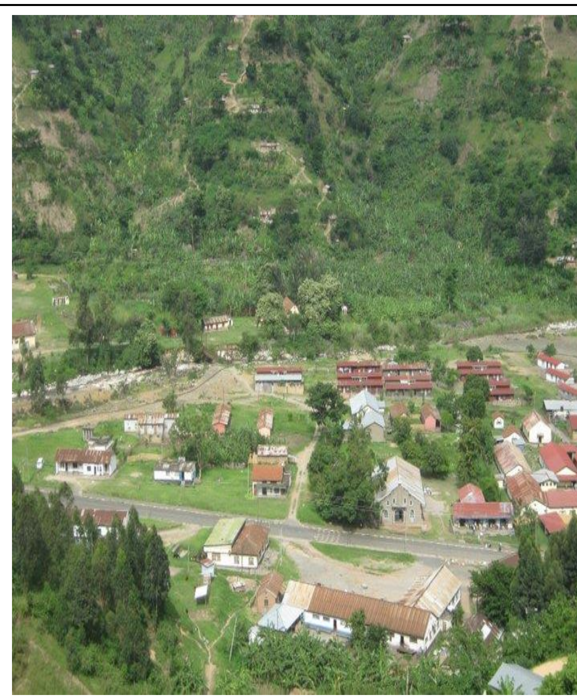
People being assisted to cross the flood in Kasese - town.

Kasese - Fort portal road cutoff by floods.

Houses damaged by floods. The houses now stand on pillars.

Huge potholes on roads created by floods.

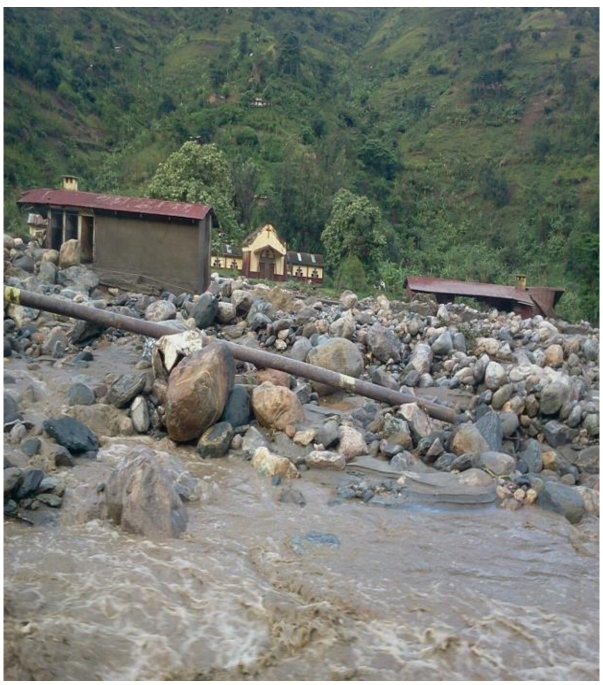
Broken bridge caused by too much water pressure and debris



Kilembe Mines Hospital before the floods. Photo credit: Kasese district

Silt and mud deposited by floods in the town.

Flood waters in Kasese town.



Broken pipes among debris brought by floods

Part of Kilembe Mines Hospital damaged by floods.

Lightning Pictures

One of the building in Runyaya school that was struck by lightning

Open windows in the class room at Runyanya P.S. This could have contributed to the pupils being struck.

A school roof at Runyaya P.S that was struck by lightning.

Lightning conductor on top of the roof at Runyanya P.S

School compound of Runyanya P.S.

Runyaya primary school borders Murchison Falls National Park

A tree which was struck by lightning killing three cows.

A home in Marera ,Bukedea district struck by lightning killing three people

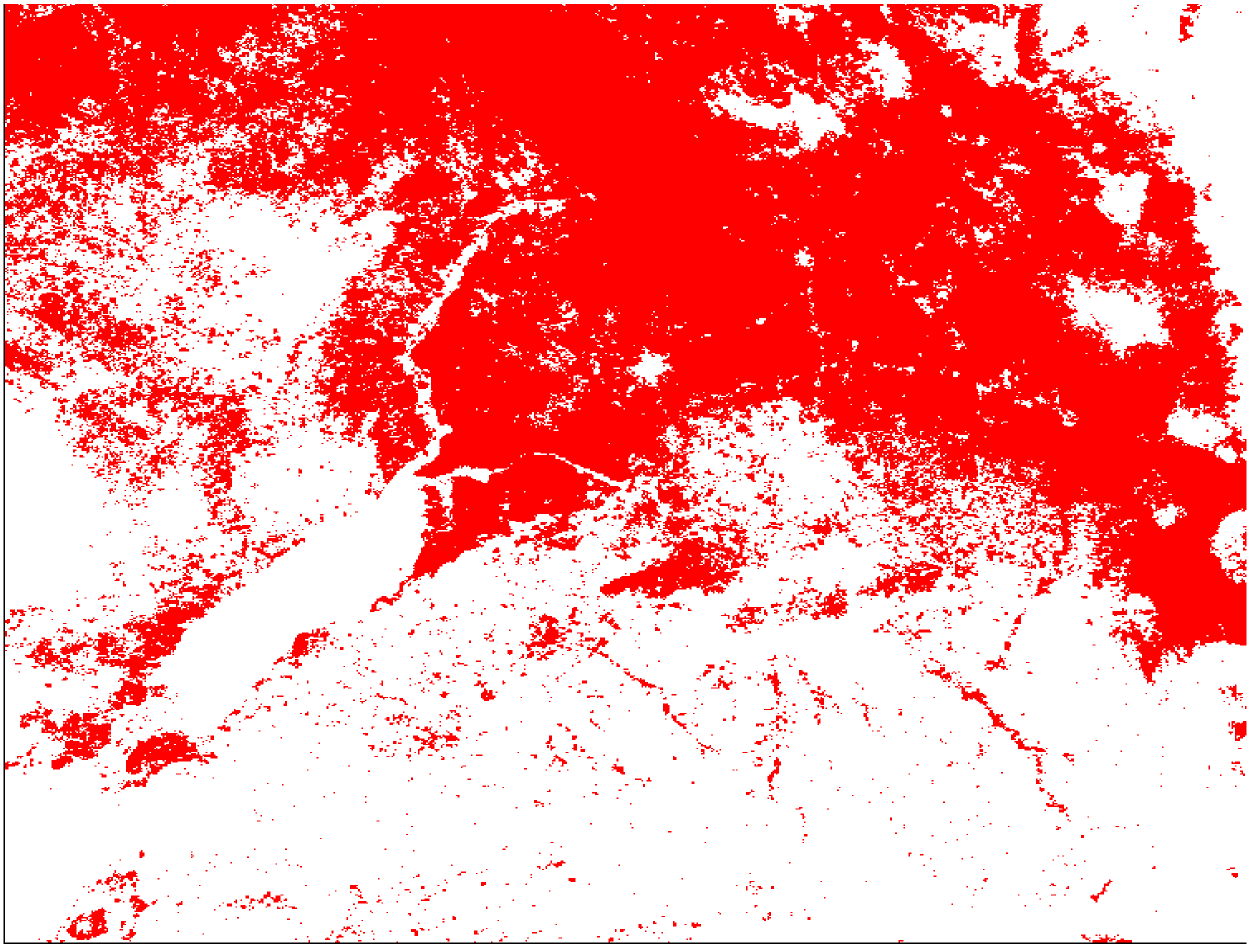
Compound of Runyaya primary school with open windows

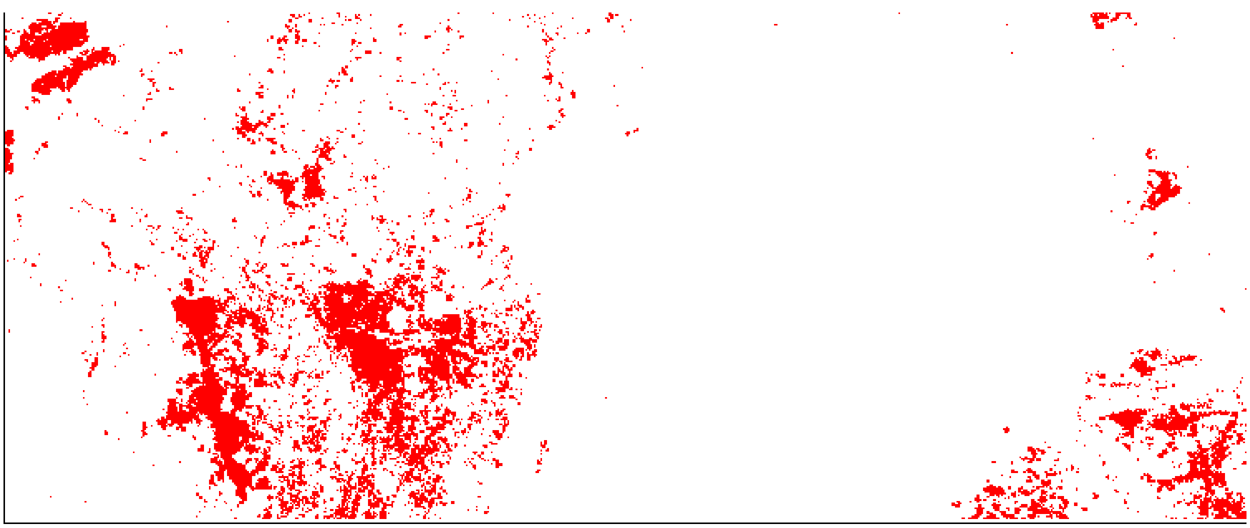
Trees near the school

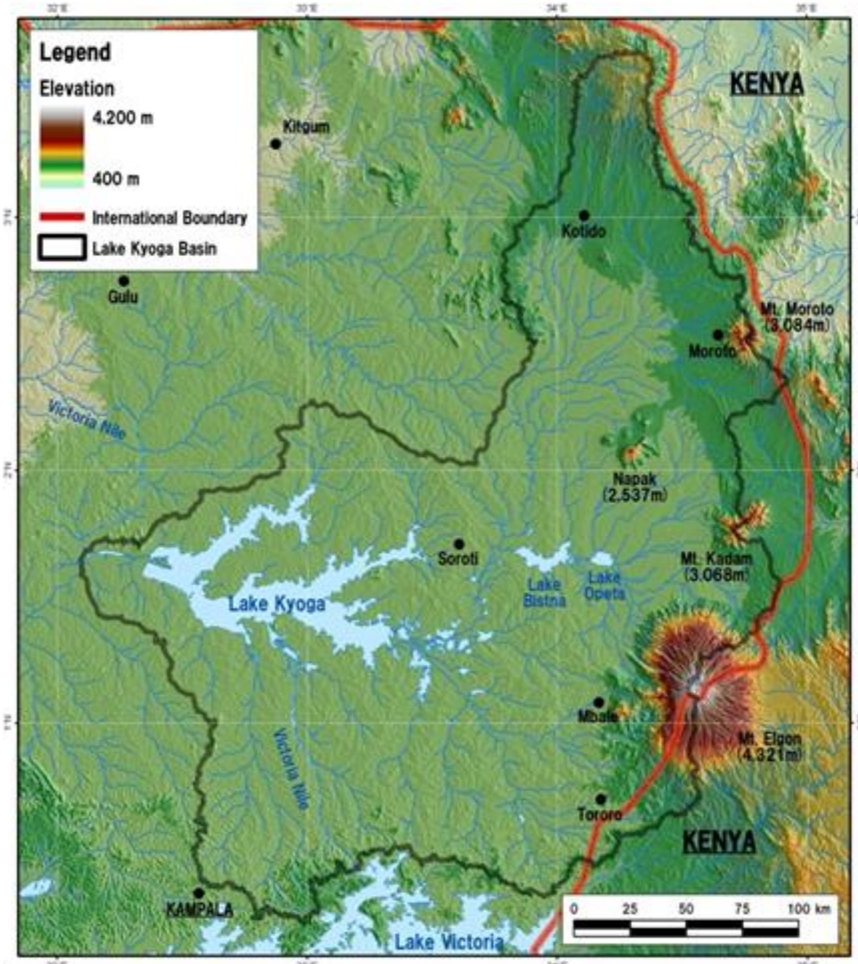
A homestead neighboring the school in Kumi was also struck by lightning killing a cow

This tree was struck by lightning in 2005 in Teso region.

Fire prone areas from MODIS satelite (1/4/2000 to 1/1/2013).







Location Map of Lake Kyoga Basin

Source: Ministry of Water and Environment, Uganda.

Lightning statistical table

Date	District	No. of people killed	No. of people affected	Other property damaged	Location/activity	Part of the day
17/9/2007	Hoima	7	14	none	classroom	afternoon
16/2/2008	Bushenyi	3	0	none	classroom	afternoon
12/9/2009	Masindi	2	0	none	grazing cattle	evening
30/3/2010	Bushenyi	1	4	none	Kitchen	not known
8/1/2010	Kabale	1	7	none	taking shelter in a hut	evening
31/8/2010	Hoima	1	3	none	inside house	afternoon
25/9/2010	Masindi	1	3	none	outside	afternoon
14/10/2010	Rukungiri	1	18	none	classroom	evening
26/10/2010	Kisoro	1	4	none	house	afternoon
11/11/2010	Hoima	3	8	none	house	afternoon
31/12/2010	Hoima	2	20	none	outside in a tent	evening
14/6/2011	Ibanda	1	1	none	outside at a funeral	not known
28/6/2011	Mbarara	2	0	none	under a tree	afternoon
28/6/2011	Kamwenge	1	0	none	not known	not known
28/6/2011	Kiryandongo	19	70	none	classroom	afternoon
4/7/2011	Kibale	3	0	none	under a tree	not known
4/7/2011	Mbarara	3	0	none	in butchery	afternoon
4/7/2011	Rwenge	3	8	none	not known	afternoon
5/7/2011	Hoima	1	14	none	in dining hall	evening
5/7/2011	Kyankwanzi	1	0	none	not known	not known
3/7/2011	Hoima	0	1	none	not known	not known
8/8/2011	Hoima	1	0	none	inside tobacco hut	evening
4/7/2011	Rubirizi	1	0	none	on veranda	evening
18/9/2008	isingiro	0	27	none	at school	afternoon
25/11/2011	Kibaale	0	40	none	outdoors	midday
28/2/2012	Kibaale	1	4	none	Kitchen	evening
13/8/2012	Kanungu	2	0	none	not known	not known
28/9/2012	Kisoro	3	0	none	under a tree	not known
28/8/2012	Kisoro	2	0	none	in house	not known
3/9/2012	Kiryandongo	1	4	none	on way to school	not known
7/9/2012	Kasese	1	0	none	not known	not known
12/9/2012	Kabale	2	0	none	grazing cattle	evening
15/9/2012	Kisoro	3	0	none	not known	evening
5/11/2012	Kasese	1	2	none	under a tree	evening
5/11/2012	Kabarole	2	2	none	in the garden	evening
5/11/2012	Kabarole	1	2	none	playing	evening
12/8/2007	Kamuli	1	5	none	at school	not known

14/8/2008	Bugiri	2	0	none	inside house	not known
19/4/2010	Mayuge	0	9	none	inside classrooms	not known
31/5/2011	Jinja	3	8	none	inside classrooms	afternoon
26/6/2011	Tororo	0	1	none	outside lining for supper	not known
22/6/2011	Kaliro	0	11	none	outside in the school	evening
26/6/2011	Tororo	1	1	none	under a tree	afternoon
28/6/2011	Mayuge	0	4	none	outside in the compound	not known
28/6/2011	Kotido	1	1	none	not known	not known
1/7/2011	Iganga	1	3	none	outside the house	afternoon
3/7/2011	Iganga	1	1	none	not known	afternoon
4/7/2011	Sironko	1	1	none	inside house	afternoon
4/7/2011	Busia	0	9	none	in bedroom	afternoon
4/7/2011	Kotido	1	1	none	not known	afternoon
Jan-12	Budaka	1	1	none	not known	afternoon
Jun-12	Amuria	3	0	none	not known	not known
7/8/2012	Mayuge	4	5	none	not known	evening
27/8/2012	Bugiri	1	9	none	not known	not known
27/8/2012	Buyende	0	0	6 cows killed	not known	not known
14/9/2008	Kampala	1	2	none	inside house	afternoon
8/8/2008	Kalangala	3	0	none	on the veranda	morning
28/8/2011	Wakiso	0	9	none	inside classroom	morning
31/8/2011	Jinja	3	8	none	inside a room	afternoon
1/8/2011	Buikwe	3	0	none	inside classroom	afternoon
1/7/2008	Iganga	1	0	none	not known	afternoon
21/7/2011	Jinja	3	8	none	outside the house	afternoon
23/7/2011	Buikwe	3	7	none	under a tree	afternoon
28/7/2011	Lyantonde	0	1	none	not known	not known
2/6/2009	Luwero	0	1	none	outside the house	afternoon
29/6/2011	Wakiso	0	3	none	not known	morning
1/6/2011	Buikwe	2	9	none	inside classroom	afternoon
16/6/2011	Buvuma	5	0	none	not known	afternoon
17/6/2011	Kalangala	1	0	none	inside the house	afternoon
11/6/2011	Kalangala	1	0	none	not known	not known
18/5/2011	Kalangala	3	0	none	on veranda	not known
22/10/2011	Mukono	1	3	none	Kitchen	afternoon
4/11/2011	Masaka	1	1	none	under a tree	afternoon
16/8/2011	Buvuma	5	0	none	inside grass thatched house	morning
27/11/2011	Rakai	2	8	none	school compound	morning
6/4/2012	Mpigi	2	0	none	in mosque	afternoon
1/5/2012	Masaka	2	3	none	in a boat fishing	morning
25/6/2012	Mpigi	4	0	none	not known	afternoon

12/6/2007	Kitgum	2	1	none	taking shelter in a hut	evening
12/3/2008	Gulu	2	29	none	sports field	evening
23/9/2008	Lira	1	4	none	church	morning
27/10/2008	Lira	2	0	none	inside the house	night
30/6/2009	Abim	3	0	none	sleeping in a hut	night
7/8/2009	Pader	1	1	none	sleeping in a hut	night
8/9/2009	Lira	1	2	none	lying in the bed	night
14/3/2010	Gulu	1	0	none	inside a hut	night
12/3/2010	Gulu	2	33	none	not known	not known
27/8/2010	Gulu	3	0	none	outside in compound	evening
Sep-2010	Apach	6	0	none	not known	not known
13/6/2011	Arua	0	10	none	outside the class	midday
Jun-2011	Amuru	2	13	none	not known	not known
27/6/2011	Alebtong	3	15	none	under a tree	afternoon
27/6/2011	Kitgum	1	1	none	inside the hut	afternoon
27/6/2011	Kitgum	0	50	none	inside classroom	afternoon
21/6/2011	Gulu	3	0	none	not known	not known
28/6/2011	Amuru	1	2	none	inside the hut	not known
18/7/2011	Kotido	0	5	none	not known	not known
3/7/2011	Pader	1	0	none	outside grass thatched hut	evening
1/7/2011	Amuru	0	10	none	sleeping in a hut	night
28/6/2011	Zombo	0	33	none	inside classroom	afternoon
Jul-11	Yumbe	0	6	none	not known	not known
Aug-11	Adjumani	2	5	none	not known	not known
26/8/2011	Arua	1	0	none	not known	not known
26/9/2011	Lira	0	53	none	in a classroom	not known
1/10/2011	Apac	1	0	none	on the way from the well	afternoon
7/10/2011	Otuke	2	43	none	inside a classroom	evening
12/10/2011	Adjumani	2	14	none	not known	not known
Apr-12	Arua	0	1	none	in the compound	afternoon
5/6/2012	Adjumani	1	3	none	Kitchen	not known
12/7/2012	Nebbi	2	6	none	church	evening
Aug-2012	Pader	0	0	Radio equipment destroyed	radio station	not known
Sep-2012	Nebbi	0	0	15 Cows	not known	not known
Sep-2012	Lamwo	0	0	32 cows	not known	evening
Apr-2011	Bukwo	1	2	0	house burnt	not known
June-5-2012	Kween	0	0	0	Sub-county headquarters shattered	
2011	Bukedea	3		8 cows	Trading centre, School and home	afternoon
2013	Kumi		2	2 cows	field, house	
2005	Kumi			1 cow	tree	

2004	Butaleja	3			at a bridge	evening
2012	Butaleja	1			house	evening
2013	Butaleja		2		way from school	evening