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Title: The Challenges of Managing Increasing Landslides Vulnerability in Mount Elgon ecosystem, Uganda: A Case of Human Interactions with its Environment on the verge of collapsing.

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Abstract

Mount Elgon ecosystem has experienced a dramatic increase in landslides incidences in the last decade with often catastrophic consequences on settlers who dwell on its steep slopes. Many scientists argue that the problem has been brought by severe environmental degradation coupled with the changing rainfall pattern in the region. The problem has reached human-environmental crisis level with over 350 people buried alive in just one incident in March, 2010. The issue that affects over a million people is of big concern to Uganda government which is now planning to relocate thousands of people to safer places. The guiding question of the paper is to what extend has landslides affected the co- existence of the people and their environment on Mount Elgon. The overriding objective is to determine the possible causes, effects and measures put in place to deal with the problem. We analyze the environmental, socio-economic, livelihood and management indicators to determine the above mentioned variables. We take a snap-shot at enabling legislations being used to guide the process of managing the problem and also examine and compare similar situations happening elsewhere in the world with the view utilizing lessons learnt.

Key words: Landslide, Degradation, Environment, Causes and Management.

1.0 Introduction

The term ‘landslide’ includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another. Although the landslides are primarily associated with mountainous terrains, they can also occur in areas where activities such as surface excavations for highways, buildings and open pit mines take place.

Many factors contribute to landslides including geology, gravity, weather, groundwater, wave action, and human actions. In hilly and coastal areas of the world, landslides have been one of the major natural disasters that strike life and property almost perennially. It has brought untold misery to human settlements as well as serious damages to transportation and communication infrastructures. Major landslides catastrophes in the 20th Century include the following: in 1919, Indonesia, Kalut volcano erupted sending volcanic mudflows (lahars) over 185 km^2 destroying 104 villages and killing 5, 110 people; in 1920, China (Ningxia), earthquake caused 675 landslides that killed 100,000 people and created 40 lakes; in 1967, Brazil (Serra das Araras), heavy rains caused landslides killing 1,000 people; and in 1998 in Hunduras, Guatemala, Nicaragua and El Salvador, hurricane Mitch caused landslides, floods, debris-flows killing approximately 10,000 people (Martinez *et al*, 2001).

Although mass movements are a recognized and well-studied geomorphic hazard due to their major role in the development of hill slopes in mountainous areas and their considerable economic and social consequences (Sidle et al., 1985), information on landslides in the East African highlands is rather limited (Ngecu and Mathu, 1999). Nevertheless, mass movements have been reported in few notable literature examples: *Kenya* (Ngecu and Ichang’I, 1998; Ngecu and mathu, 1999; Inganga et al., 2001). *Uganda,* (Mwanga et al., 2001), *Rwanda* (moeyersons, 1988, 1989, 2003). *Tanzania* (Rapp et al., 1972; Christiansson and Westerberg, 1999) and *Ethiopia* (Ayalew, 1999; Temesgen et al., 2001; Nyessen et al., 2002). East African highlands are noted as a very heterogeneous region but have high vulnerability to slope instability in common. The high annual rainfall, steep slopes, high weathering rates and slope materials with a low shear resistance or high clay content are often considered the main preconditions for mass movements in East Africa, turning it in an inherently susceptible area. The main causal factors for slope failure in these highlands can be divided into preparatory and triggering causal factors (Glade and Crozier, 2004). Preparatory causal factor are those factors that make slopes susceptible to movement over time without actually initiating it, often reported for East African region include the increasing population pressure with slope disturbance and deforestation as a consequence and the reduction in material strength by weathering. While triggering causal factors are external stimuli responsible for the actual initiation of mass movements. Triggering causal factors in the region include earthquakes, excessive rainfall events and human disturbance such as slope excavation and terracing. The East African highlands regions lack the insight of clear local causes of mass movements. This in turn hampers the search for regional specific solutions.

In Uganda, landslides are common in the districts of Manafwa, Bududa, Mbale, Sironko, Bulambuli, Bukwo, kabale, Rukungiri, Mbarara, Kasese, Bushenyi, Bundibujo and Kanungu. However, no systematic scientific research has been conducted on landslides (Muwanga et al 2001). Mount Elgon volcano in Uganda is the most sensitive area for landslides in Uganda. Mass movements associated with intense rainstorms are reported to have occurred sporadically since the twentieth century but the increase in fatalities and destruction as a consequence of the enormous population growth draws attention of the phenomenon nowadays. By studying the causal factors for land slide on Mount Elgon, this paper tries to contribute to the restricted knowledge on landslides in Uganda, East Africa region.

2.0 **Methodology**

2.1 Study area

The study area comprises the parishes adjacent to Mount Elgon National Park, Uganda. The people in these parishes are the one who affects and are affected directly by the existence of the protected area, Mount Elgon National Park, a key watershed in the region. The park adjacent parishes experienced the highest incidents of landslides on Mount Elgon between 2000-2010 mainly because of deforestation and poor agricultural methods. Mount Elgon National Park (MENP), Uganda extends from $0^{0}5'$ – $1^{0}25'$N and $34^{0}14'$ – $34^{0}44'$N (figure 1). The mountain extends 80 km north-south and 50 km east-west with a 20 km-long Nkokonjeru Arm to the west. Forested protected areas covers the higher altitudes of Mount Elgon. Mount Elgon National Park (Uganda side) has a surface area of 1,145 $km^2$and is contiguous with the Mount Elgon Forest Reserve and Mount Elgon National Park on the Kenya side, which has together a surface area of about 900 km^2. It is therefore, an important trans-boundary ecosystem between Kenya and Uganda. Mount Elgon is the oldest of the East African extinct Pliocene shield volcanoes that last erupted 3 million years ago. Extensive erosion has created a landscape with gentle long slopes. From its highest peak, Wagagai (4321 m above sea level), located on one of the world larges caldera, the mountain descends to the plain in a series of precipitous cliffs which are separated by deeply sloping ‘shelves’ and deeply dissecting streams. The mountain is mainly made up of weathered granites of the Basement Complex with tuffs, rocks, ash and coarse agglomerates. Lava and mud flows are present in much lower quantities but resulted into creation of well-developed fenitized aureole in the granites surrounding the complex that are conspicuous for a few kilometers from the outer edge of the complex. The shattering and shearing of

rock might have led to increased sensitivity to slope instability (Davies, 1957; Reedman, 1973).
The soils of Mount Elgon are Acrisols, Ferralsols, Nitisols and Luvisols (Deckers et al., 1999). Those found in the forest belt are brown to red-brown clay-loams, up to a meter or so deeper. They originated from Elgon volcanic and Basement Complex. Above 3,000 meters, however, shallow black humus soils predominate. These soils are relatively young and fertile with high concentration of calcium, sodium, and potassium. Under natural conditions, the soils support a varied tropical forest. Cleared of forest cover, these same soils support a high productive agriculture and a high population density, although landslides are a hazard on steeper cleared slopes during rainy periods because of their loose characters (UWA, 2000).

The mean annual rainfall on Mount Elgon ranges from 1,500 mm on the eastern and northern slopes to 2,000mm in the south and west with a bimodal rainfall pattern. Major rains fall between April and October with a short dry spell often experienced around June. The driest months are December and January. Like other mountain ecosystems, Mount Elgon has moderate climate and resources that attract human exploitation. This therefore makes it a highly threatened ecosystem in East Africa. The ecosystem is important water shed, supplying fresh clean water all year round to Turkwell River, Lake Turkana, and the Lake Victoria basin, the Nile River basin via Lake Kyoga and thousands of local communities (Horward, 1991; Forest Department, 1992). It also supports a large human population, the Bagisu communities live right up to the edge of the park in the southern and western sides of the mountain, and similarly, the Sabiny communities are found to the northern edge of the park.

The park lies in six districts, namely: Manafwa, Bududa, Mbale, Sironko, Kapchorwa and Bukwo. All the districts extend from the low lands to the forest on the mountain and usually separated by streams. The districts are divided into administrative units of county, sub-county, parish and village, in descending order of size. There are 111 parishes directly adjacent to the park boundary, out of these, 35 parishes were selected for this study (figure 2). The protected area begins considerable distance up the mountain, and most of the boundary is adjacent to land that is almost completely under agricultural production, reflecting the high population densities of these area. The average density of the park-adjacent population of Bugisu area (Manafwa, Bududa, Mbale and Sironko districts) is 756 people per sq. km, while that of Sabiny area (Kapchorwa and Bukwo districts) is 327 people per sq. km, with Bugisu area among the highest rural population in the country[1]. The Uganda side of the Mount Elgon terrain is highly rugged and most of the park-adjacent parishes lie between 1800-2500 meters above sea level with mostly no access roads. One has to walk for up to two hours from where the road ends to reach them.

Box 1: Smaller administrative units within Uganda (Mount Elgon).

Village: smallest administrative unit consisting of around 50-180 households
Parish: second smallest administrative unit consisting of around 10-25 villages

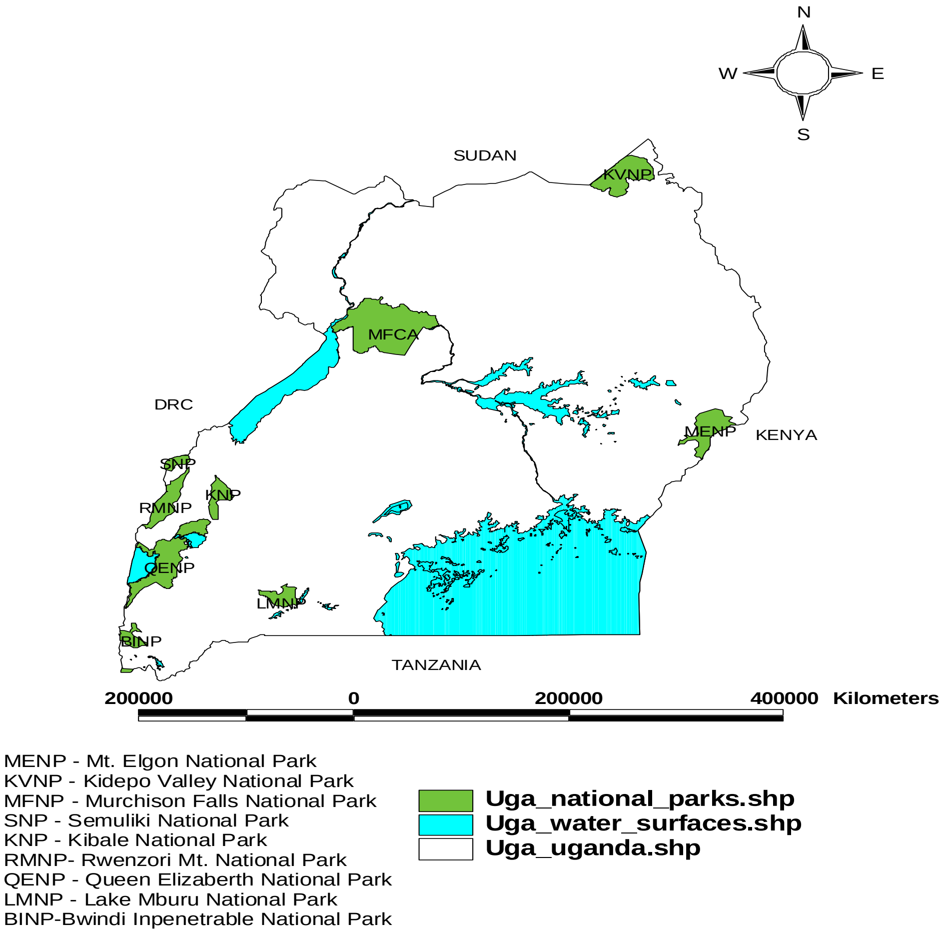

Figure 1. Map of Uganda showing location of national parks.

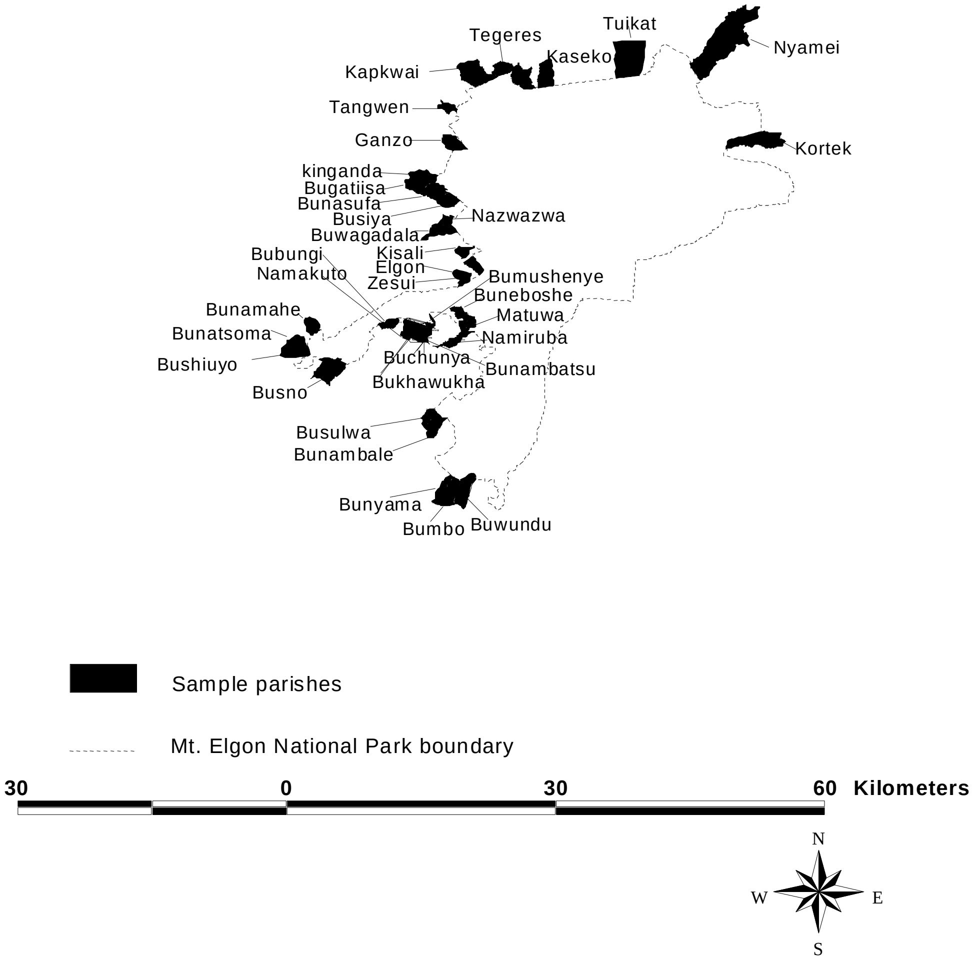

Figure 2. Map of Mt. Elgon National Park with adjecent sampled parishes.

2.2 Methods and materials

Using purposive sampling technique, all the 111 parishes adjacent to the park have been used as one cluster sampling unit. A total of 35 parishes representing 32% of the 111 parishes were chosen by simple random from each district to form another stage of cluster sampling unit as suggested by Lazerwitz (1968 pp284-285) that a minimum sample size of between 30% to 70% of the total population is a mean or proportion that can be considered to fall on a sufficiently normal distribution. The 35 sample parishes were selected from every district as shown below:

Table 1: Summary of administrative units sampled.

District	Total parish	Sampled parish	Sampled villages
Manafwa district	17	5	7
Bududa	28	9	12
Mbale	11	4	5
Sironko	29	10	18
Kapchorwa	18	6	7
Bukwo	8	1	2
Total	**111**	**35**	**52**

A total of 52 villages out of 124 (42%) from each of the selected 35 parishes were randomly sampled with 364 questionnaires, thus 7 questionnaires per village. A sample frame of 6952 households for the household survey was a list of households obtained from village leaders. This helped in determining the sample size at 95% level of confidence and 5% confidence intervals. The survey was conducted between March-August 2010 using pre-designed questionnaires. The study aim was to collect information on landslides especially its extent, frequency, perception of causes, effects and mitigation measures. Interviews were held in the homestead but in some cases, they were held at landside scene. Local language and units were used where necessary. All these preceded a series of PRA exercises including focus group interviews, sketch mapping and observation.

All data were coded and entered into SPSS and excel computer programs for analysis. Cross tabulation was used to identify different landslide characteristics between those who were practicing control measures and those who are not. Factor analysis was used to investigate factors influencing soil and forest conservation measures for landslide control.

3.0 Causes and effects of landslides on Mount Elgon

3.1 Causes

The study found out that the steep slopes of Mount Elgon on Uganda's side are prone to landslides. The landslides that usually occur in densely populated areas have been reported since the beginning of the twentieth century. The numerous fatalities and the damage done during the extreme rainfall events from 1997 to 2010 drew attention of this phenomenon. Statistical analysis shows that landslides dominate on steep concave slope segments that are oriented to the dominant rainfall direction (northeast). Besides steep slopes, other factors such as high rainfall, typical soil properties and stratification that often turn slopes into an inherently unstable area as well as human interface cannot be neglected. The study also revealed that deforestation has reduced the stability of the shallow soils and similarly, excavation of slopes, mainly for house building, is an important destabilizing factor. The growing population density not only increases the risk on damage, but hampers the search for solutions for the land slide problem as well. On Mount Elgon, landslide is common in Bududa, Sironko, Manafwa and a small part of Bukwo districts (figure 3).

Almost all types of landslides are common on Mount Elgon as described by Varnes, D.J., 1978. However, the predominant type is rotational landslide (Knapen et al., 2003), which occurs when the surface of rupture is curved concavely upward (spoon shaped), and the slide movement is more or less rotational. On Mount Elgon most landslides occur in debris, a mixture of rock fragments and fine earth. Such landslides are in the character of slumps like those of Ethiopian highlands (Ayalew, 1999; Nyssen et al., 2003) and the Aberdare Range in Kenya (Davies, 1996; Ngecu and Mathu, 1999) are typical examples of a small rotational landslide.

Analysis revealed that there are some natural factors that are also perceived to cause landslides on Mount Elgon. At least 80% of the people interviewed believed that geological factors are responsible for landslide on Mount Elgon. This can be explained with the phenomenon that many landslides occur in a geological setting that places permeable sand and gravel above impermeable layers of silt and clay, or bedrock. Water seeps downward through the upper materials and accumulates on the top of the underlining units, forming a zone of weakness. 63% of the people interviewed believed that on steeper slopes, gravity works more effectively in contributing to causing landslides. However, the gravity concept stops short of explaining why landslides are experienced at more gradual slopes in the study area. Landslides on Mount Elgon occur during intense heavy and prolong rainfall as everyone agreed with this natural phenomenon. This therefore means, water is the primary factor triggering landslides. It happens usually when storm water runoff saturates soils on steep slopes or when infiltration causes a rapid rise in groundwater levels. Groundwater may rise as a result of heavy rains or prolonged wet spell. As water table rise, some slopes become unstable. However, it has been difficult to assess from the communities a distinctive rainfall threshold for the initiation of landslides because of lack of such rainfall data for quantification. Only events of exceptionally high rainfall in certain years where associated to landslides. This type of global variation patterns of rainfall, some of which can be associated with the El Nino Southern Oscillation, falls under the general concept of climate change that is causing big concern today.

Anthropogenic or human actions factors that were found to be triggering landslide significantly included deforestation. The survey revealed that only 31% of the parishes (11) surveyed were not carrying out illegal agriculture in the national park. Of these 80% does not experience landslides. Mean while, 92% of the 24 parishes doing illegal agricultural encroachment in the national park experience landslides of various scales. Encroachment usually results into cutting trees which roots should hold the soil to leave way for growing crops. Agricultural encroachment on Mount Elgon small scale farmers start by clearing all vegetations to open land for cultivation before planting food crops such as banana, maize, yam, cassava and beans. Perennial crops such as coffee and some trees are not planted in the park due to lack of land tenure security and a way of avoiding eminent conflict with the park authority that may result to destruction of the crops.

Another factor contributing to landslide cause significantly is excavations. The survey found out that 82% of the households interviewed had excavated by digging away large areas of slope to create flat surfaces. On Mount Elgon, slopes are leveled for various reasons including house building, footpath construction as well as leveling of farm land. Excavation destabilizes slopes since it removes their lateral support, causes water stagnation and increases infiltration, leading to an increased pore water pressure and landslide risk. Southern to western sides of the mountain were observed to be at more risk than the northern part due to excavation. It is because the areas have more stepper slopes. Fortunately, the encroached area in MENP had little excavation of the farm lands because of limited human settlement.

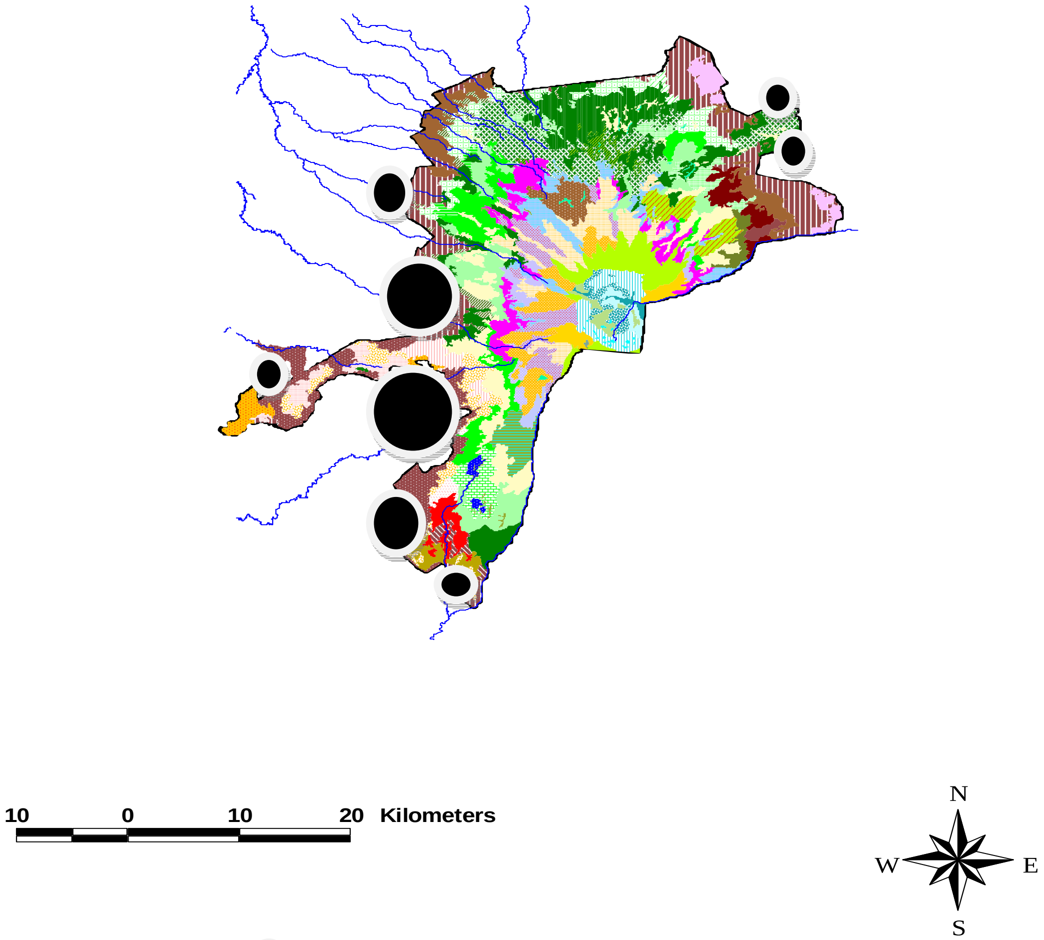

Figure [illegible]. Map of Mt. Elgon National Park showing vegetation and drainage

Figure 3: In the above figure, the dark circles depict the number of landslide occurrence and its extent around Mount Elgon National Park. The bigger circles the higher the number and extent per year. The areas affected by landsides in descending order as shown with the circles are: Bududa, Zesui, Bumasifwa, Tsekululu, Bumbo, Mutushet, Wanale, and Tulel.

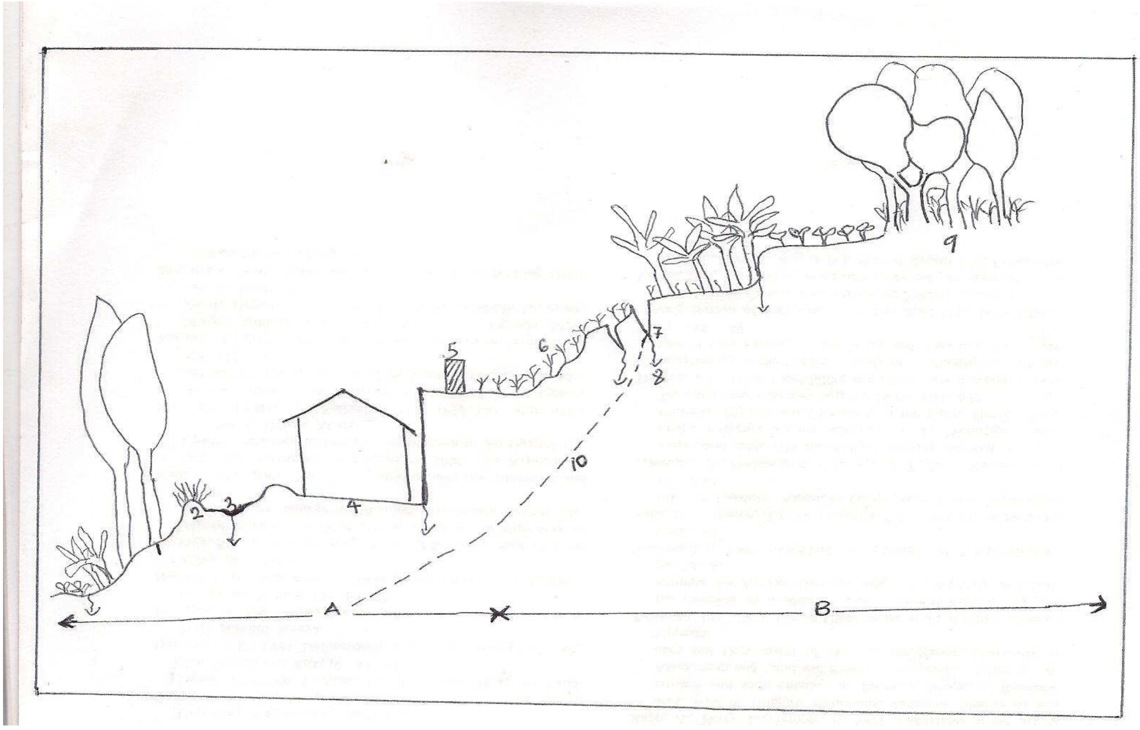

Figure 4: Geomorphological sketch of a typical park boundary village that had encroached on Mount Elgon National Park and prone to landslide.

A-Village portion outside the park

B-Encroachment area of the village sometimes up to 5kms inside the park

1-Few Eucalyptus trees for domestic use 2-contour with planted grass growth for animal feeding 3- excavated footpath with serious erosion infiltration effects 4-excavated slope to create flat area for house construction leading to increase infiltration and water pounding 5- Park boundary pillar in peoples field 6-usualy annual food crops planted in the park 7-hyrostatic pressure in water filled tension cracks enhances slope failures with increased infiltration 8-weak line of crack with high potential for land slide 9-unencroached forested park area.

Figure 5: Photograph of a typical MFNP boundary village with agricultural encroachment in the national park seen in the middle ground

Figure 6: Several agricultural encroachments on MENP resulted into landslides such as this one at Nametsi village in Bududa district that killed 350 people in March 2010.

One important thing to note is that seismicity as a triggering factor to landslides was ruled out during the interviews. The local communities assert that earthquakes in the Elgon region are rare even though situated in the East African Rift zone. This was also observed by Hollnack in 2001. More importantly, people do not associate the occurrence of earthquake with landslides. There was negative correlation of the two factors.

3.2 Effects

Landslides impact causes disastrous impact on the livelihood of the inhabitants on the steep and unstable slopes of Mount Elgon. Through interviews of the local people, from 1933 to 2010, landslides have caused fatalities to more than 550 people with the worse recorded in 1933, 1964, 1970 and 2010. A very serious event was as the heavy rains of 1997-1999 that displaced a large amount of material down slope and destroyed crops worth millions of Uganda shillings as well as dwellings of more than 3000 people also disappeared. The Nametsi landslide of 2010, in Bududa district, displaced more than 2000 households and destroyed farmland and infrastructures such as dispensary, school roads and

shopping centers in the whole village. It is not surprising that in the 1930s was when serious deforestation started on Mount Elgon and continued till to date (scott, 1998).
It was also found that mass movements also reduce and alter arable land boundaries leading to land conflicts. This is compounded by the fact that land shortage and high population related problems are already acute in this area. The overall effect is food shortage and poverty that are exceptionally higher in the study area. During long rains and after landslides both water quality and quantity are affected by debris, rocks, soil that is swept along water sources sometimes blocking water channels. Communities often suffer from water related diseases.

4.0 Mitigation measures

Uganda has effective legislation as regards disaster preparedness under which land slide victims are supported. The legislation strategies seek to ensure that appropriate administrative, legislative and technical resources and mechanisms are in place to ensure timely and effective prevention, mitigation and response before, during and after the occurrence of disasters. This was after realizing that disasters are complex occurrences whose relationship with development cannot be ignored in pursuit of sustainable development (UNDP, 2007). However, Implementation has remained significantly inadequate. For instance, Government of Uganda, through the Prime Minister's Office ought to resettle inhabitants of landslide prone areas on Mount Elgon to safer areas elsewhere in the country systematically over the years as incidents intensified. But this was not the case, even when the Nametsi landslide occurred; only 500 households out of the 2000 were yet resettled in Kirandongo district, some 480 Kms away in north western Uganda and it occurred 6 months after the incident (UWA, 2010). Kirandongo resettement was the first government landslide-induced resettlement in Uganda over years. At Bulucheke camp, the Nametsi flood victims were mainly being supported by donations from well wishers (figure 7 below).

One of the resettlement challenges that came out during the survey was people's strong cultural attachment to their 'ancestral land' and therefore resisting being moved elsewhere. There was also fear of mixing with other ethnic groups, weather change and vulnerability to diseases in new areas that came up as hindering factors.

The survey revealed weak and uncoordinated environmental regulatory mechanisms on Mount Elgon and the country at large. Terracing which causes water stagnation, increased filtration, leading to increased pore water pressure and therefore a landslide risk, is still being encouraged by Uganda National Environment Regulations for Mountainous and Hilly Areas Management (Kajura, 2001). Unfortunately, in the encroachment areas terracing as a technique was rare. Other stricter regulations that inhibit cultivation of slopes steeper than 15% or close to rivers and streams are not known by the local population and certainly not being followed in any of the villages surveyed. Due to the high population pressure, they are simply not applicable on Mount Elgon. Funds to support landslide related mitigation measures are inadequate and many local leaders and technical people simply lack skills and capacity to manage such disaster.

Figure 7: The Uganda Red Cross Society distributing basic items to victims of Nametsi landslide at Bulucheke camp, Bududa in March 2010.

5.0 Conclusion

Although the forest of Mount Elgon National Park has played a significant role by contributing enormously to the improvement of peoples livelihoods through the provision of forest products and regulation of water flow, it encroachment by the neighboring communities has greatly increased the risk of landslide occurrence in the area. The situation is not any better with the increasing human population that is already highly dense. There is severe land shortage on Mount Elgon, not enough to feed the many mouths and forcing people to utilize even the most landslide-prone marginal land due to lack of alternatives. This means the risk of damaging slopes and other forms of land degradation that will increase slope failure is not ending in a near future. The landslide problem on Mount Elgon is therefore a true challenge of 21^{st} century whose permanent solution is hard to find.

Nevertheless, as a short term solution, instability can be partly reduced by enforcing regulations that encourage sustainable utilization of land and the environment by reducing on human impact. Things such as excavation, terracing of slopes and contracting structures that concentrate water to vulnerable zones should be avoided. Total reforestation of degraded areas of the park as well as deep-rooted tree planting by communities should also be encouraged. Evacuation and resettlement of people from this area elsewhere should be planned and done systematically by government besides encouraging people to use various human population control methods.

End note

1. Figures are from the 2002 Population Census and have been compounded at an annual increase rate of 3.2 per cent (national average at time of census) to give an estimated figure for 2010.

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