

Types and Causes of Landslides and their Effect on Land Use Activities in Kittony Area of Elgeyo Marakwet County, Kenya

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ABSTRACT

The main objective of this study was to investigate the types and causes of landslides in Kittony area of Elgeyo Marakwet County, Kenya. The specific objectives were: To establish the types of landslides prevalent in Kittony area and identify the factors that cause landslides in Kittony area of Elgeyo Marakwet County. The study population comprised of 2000 residents of Kittony area in Elgeyo Marakwet County. Five members of the local administration and the County Geologist were included in the study. The sample size consisted of the following respondents: Two hundred and forty six residents of Kittony area which translated to 12.3 % of the total population was selected as study respondents through Simple Random Sampling. One local chief of Kittony area and a County Geologist was purposively selected and interviewed. This study adopted a descriptive survey research design and utilized a qualitative research methodology. The systems theory was used to underpin the study and a conceptual framework showing the interrelationship between the dependent and independent variables was used to guide and conceptualize the study. The findings of the study included: The types of landslides that exist in the area are mudslides, rock fall and earth flows. The heavy rains, poor soils and the rugged topography in the area as factors that triggered landslides. That the government despite assisting by providing humanitarian assistance and advising people to move to safer locations, more was needed in terms of relocating residents to safer areas and converting the affected areas into forest lands, building gabions to control soil erosion and controlling other human activities. This study can also be replicated in other areas having similar problems.

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Introduction

A landslide, also known as a landslip, is a geological phenomenon that includes a wide range of ground movements, such as rock falls, deep failure of slopes and shallow debris flows. Landslides can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific sub-surface conditions that make the area/slope prone to failure, whereas the actual landslide often requires a trigger before being released (Wikipedia free Encyclopedia).

Kenya has witnessed many rainfall triggered landslides (Karanja and Mutua, 2000). During the 1997-1998 El Nino events, most parts of the country received 2 to 12 times the monthly long-term mean rainfall amount that resulted in floods and landslides in various parts of the country (Ngecu and Mathu, 1999). Consequent impacts on water resources, agriculture, transport, health, and socioeconomic conditions were great. The estimated loss incurred by the agricultural sector alone was estimated to be about USD 236 million (Karanja and Mutua, 2000), one-tenth of the gross domestic Product. Landslides were triggered largely by long term human activities such as logging on slopes and vegetation gradation (Ngecu and Mathu 1999).

Landslides represented about 5% of all-natural disasters worldwide, between 1990 and 2005 (Kanungo et al., 2006). In Kenya, landslides frequently occur when the country

experiences heavy rainfall and often lead to loss of life and destruction of property (Standard media, 2010, 2011 and 2012; BBC news, 2010). Numerous factors contribute to slope failures in mountainous areas. However, intense rainfall according to Lakhan, (2009) is a trigger in both shallow and deep-seated landslides since rain water percolating the slopes increases the soil water content and reduces in situ matric suction, resulting in a decrease in the effective stress in the slope soils. This may induce slope failures when the critical pore water pressure threshold is exceeded (Corominas and Moya, 1999).

Earth flows are down slope, viscous flows of saturated, fine-grained materials, which move at any speed from slow to fast. Typically, they can move at speeds from 0.17 to 20 km/h (0.1 to 12.4 mph). Though these are a lot like mudflows, overall, they are slower moving and are covered with solid material carried along by flow from within. They are different from fluid flows because they are more rapid. Clay, fine sand and silt, and fine-grained, pyroclastic material are all susceptible to earth flows. The velocity of the earth flow is all dependent on how much water content is in the flow itself: if there is more water content in the flow, the higher the velocity will be. These flows usually begin when the pore pressures in a fine-grained mass increase until enough of the weight of the material is supported by pore water to significantly decrease the internal shearing strength of the material. This thereby creates a bulging lobe which advances with a slow, rolling motion. As these lobes spread out,

drainage of the mass increases and the margins dry out, thereby lowering the overall

This process causes the flow to thicken. The bulbous variety of earthflows is not that spectacular, but they are much more common than their rapid counterparts. They develop a sag at their heads and are usually derived from the slumping at the source (Environment Geology, 2008)

Earthflows occur much more during periods of high precipitation, which saturates the ground and adds water to the slope content. Fissures develop during the movement of clay-like material which creates the intrusion of water into the earthflows. Water then increases the pore-water pressure and reduces the shearing strength of the material (Easterbrook, 1999).

A debris slide is a type of slide characterized by the chaotic movement of rocks soil and debris mixed with water or ice (or both). They are usually triggered by the saturation of thickly vegetated slopes which results in an incoherent mixture of broken timber, smaller vegetation and other debris (Easterbrook, 1999). Debris avalanches differ from debris slides because their movement is much more rapid. This is usually a result of lower cohesion or higher water content and commonly steeper slopes. Steep coastal cliffs can be caused by catastrophic debris avalanches. These have been common on the submerged flanks of ocean island volcanos such as the Hawaiian Islands and the Cape Verde Islands (Le Bass, 2007).

Statement of the problem

In Kenya, More than 50,000 people in three areas of Kittony, Embobut and Kakisoo in Elgeyo Marakwet County were warned to relocate from their homes to safer grounds due to possible landslides following heavy rains that pounded the area (Bii, 2014). In the year 2011, landslides hit Kittony area killing 15 people and injuring several others (Bii, 2014).

The government therefore needs to come up with a permanent solution by settling the families in safer areas since the current location has proved inhabitable due to landslides. A team of geologists who toured the place following the tragedy declared the area as unfit for human settlement. The area is prone to landslides due to the steep topography and loose soil making it inhabitable (Mulama, in Bii, 2014)

Despite many studies having been conducted in Europe on Landslide occurrence as a response to land use changes, limited studies have been conducted in Africa, and

specifically in Kenya. Many studies have also dwelt on how land use activities have led to landslide occurrences, this study therefore sort to investigate the types and causes of landslides.

Objectives

This study had the following two objectives: -

i)To establish the types of landslides prevalent in Kittony area of Elgeyo Marakwet County, Kenya

ii)To identify the factors that causes landslides in Kittony area of Elgeyo Marakwet County, Kenya

Research Questions

i)What types of landslides are common in Kittony area of Elgeyo Marakwet County?

ii)What geological and topographic factors cause landslides in Kittony Area of Elgeyo Marakwet County?

Conceptual Framework

Figure 1 shows the interaction between the independent variables which are the types of landslides, factors causing landslides, effects of landslides and solutions to the problem of landslides and how they affect the dependent variable which is land use activities. The intervening variables include things like rainfall availability and soil type.

Research design

This study adopted a descriptive survey research design. According to Joppe (2000), a descriptive survey study helps to gather data at a particular point in time with the intention of describing the nature of existing conditions, identifying standards against which existing conditions can be compared and determining the relations that exist between specific events. Mugenda (2010) recommends the design to collect data in order to answer questions concerning current status of the subject in the study. Surveys can be used for explaining or exploring the existing status of two or more variables at a given point in time. The design enables the researcher to have a wider coverage and comprehensive description of the observed characteristics and interrelationship in the target population (Creswell & Miller, 2005).

Descriptive survey design enables the researcher to collect original data for the purposes of describing and measuring the characteristics of a population, which is too large to be observed directly. The design was selected because it is very convenient in collecting substantial amount of views from respondents over a wide area using limited resources (Kombo and Tromp, 2006).

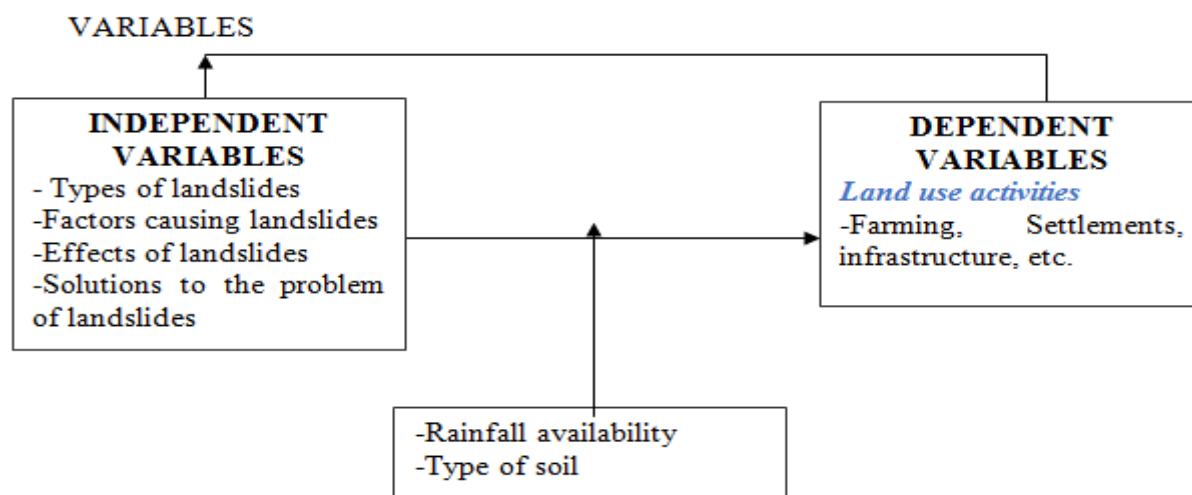


Figure 1. Relationship between dependent and independent variable.

Source: Researcher

Therefore, the variables that were studied were at their natural occurrence and not manipulated by the researcher. The survey method was appropriate because it is a self-report study, which required the collection of quantifiable information from the sample. This involved collection of both quantitative and qualitative data. This study was concerned with the investigation on the occurrence of landslides and their effect on land use activities in Kittony Area of Elgeyo Marakwet County.

Target population

Population refers to an entire group of individuals, events or objects having a common observable characteristic and a sample is a smaller group obtained from the accessible population ((Mugenda, 2008). The study population comprised of 2000 residents of Kittony Area in Elgeyo Marakwet County. Five members of the local administration and one County Geologist.

Sample size and sampling procedures

Orodho (2005) defines a sample as a set of respondents (people) selected from a large population for the purpose of a survey for a study. Sampling is the act, process or technique of selecting a suitable sample or a representative part of a population for the purpose of determining characteristics of the whole population (Kombo and Tromp, 2006). The sample size consisted of the following respondents: Two hundred and forty six residents of Kittony area which translates to 12.3 % of the total population was selected as study respondents through Simple Random Sampling. One local chief of Kittony area and a County Geologist were purposively selected and interviewed. The local chief and a County Geologist were purposively selected because being local administrators who are constantly in touch with the people and link them to the county government they are better placed to respond to the issues affecting the local residents and the efforts the county government is making to address their problems.

Types of landslides common in Kittony area

The county geologist was interviewed and asked what type of landslides are common in Kittony area. He explained that mainly they experienced Earth flows and Mud flows: Earth flows

Earth flows are down slope, viscous flows of saturated, fine-grained materials, which move at any speed from slow to fast. Typically, they can move at speeds from 0.17 to 20 km/h (0.1 to 12.4 mph). Though these are a lot like mudflows overall they are slower moving and are covered with solid material carried along by flow from within. They are different from fluid flows because they are more rapid. Clay, fine sand and silt, and fine-grained, pyroclastic material are all susceptible to earth flows. The velocity of the earth flow is all dependent on how much water content is in the flow itself: if there is more water content in the flow, the higher the velocity will be. These flows usually begin when the pore pressures in a fine-grained mass increase until enough of the weight of the material is supported by pore water to significantly decrease the internal shearing strength of the material. This thereby creates a bulging lobe which advances with a slow, rolling motion. As these lobes spread out, drainage of the mass increases and the margins dry out, thereby lowering the overall velocity of the flow. This process causes the flow to thicken. The bulbous variety of

earthflows is not that spectacular, but they are much more common than their rapid counterparts. They develop sag at their heads and are usually derived from the slumping at the source.

Earth flows occur much more during periods of high precipitation, which saturates the ground and adds water to the slope content. Fissures develop during the movement of clay-like material which creates the intrusion of water into the earth flows. Water then increases the pore-water pressure and reduces the shearing strength of the material.

A mudflow is an earth flow consisting of material that is wet enough to flow rapidly and that contains at least 50 percent sand, silt, and clay sized particles (Linuzela 2006). This occurred in Kerio Valley, Kittony village where the mud killed 11 people and covered thousands of animals and structures on March 2011.



Figure 2. Earth Flow in Kittony Area.



Figure 3. Mudflow in Kittony Area.

Geological and topographic factors that cause landslides

The second objective of this study was to identify the Geological and topographical factors that caused landslides in Kittony area. To achieve this objective, the respondents were asked to respond to several items that the researcher felt in definition as consisting to this objective. These included; whether landslides occurred during rainy season, whether the soil type triggered landslides, whether the topography of the area contributed to landslides occurrence and also sought the opinion of the people on what caused landslides in the area. The results are summarized in the table 1.

Table 1. Causes of landslides.

Item	Agreed		No opinion		Disagree		TOTAL	
	F	%	F	%	F	%	F	%
Landslides Occur during Rainy season	241	98.0	5	2.0	0	0	246	100
Soil type triggers landslides	208	84.6	36	14.6	2	0.8	246	100
Topography of the area triggers landslides	232	94.3	14	5.7	0	0	246	100

Table 1 shows the results of the causes of landslides in Kittony area. When residents were asked whether landslides occurred during the rainy season, Majority 241(98%) agreed that it is during the rainy season that they experience these landslides, none disagreed while only 5 (2.0%) were undecided on the issue. This confirms the argument by (Ngechu and Mathu, 1999; Caine 1980; Glade et al, 2000; Wieczorek et al, 2000, Mikos, Cetina & Brilly 2004; Shakoor & Smithmyer 2005) that landslides in the area are triggered by heavy rains and its only during the rainy season that they experience landslides.

Asked whether the soil type also triggered the occurrence of landslides. A majority 208(84.6%) of the residents concurred with the statement, a few 2 (0.8%) disagreed, while 36 (14.6%) were undecided on the issue. A majority of the residents who agreed that indeed the soil type triggered the landslides are in agreement with the views of, Sidle *et. al.*, (1985) and Ingaga, et. al, (2001) who argues that the loose volcanic soils in the area when wet loosens up and flows down slope during the rainy season.

The residents of the area were further asked if the topography of the area was what triggered the land slides. Majority 232 (94.3%) agreed that the topography of the area contributed to the occurrence of landslides in the area. None disagreed, while 14(5.7%) were undecided on the issue. The majority who were of the opinion that the topography of the area indeed triggered land slide occurrence perfectly agrees with the views of (Biot 1960, O Loughlin 1981, Rosenqvist et al 1990, Finlayson and Stathem 1980, Crozier 1986 and Msilimba, G. 2002) who argues that the soil becomes loose and soft in the area during the rainy season hence the water logged soils easily move down slopes causing landslides.

The residents were further asked to give their honest opinion on what caused landslides in the area and the findings are summarized in Table 2

Table 2. Opinions of Residents on what Causes landslides.

What causes landslides In the area?	F	%	Cumulative %
Heavy rains and poor soil	233	94.7	94.7
Earthquake and Movement of People/Goods	9	3.7	98.4
Other	4	1.6	100.0
Total	246	100	

When Kittony residents were asked to give their honest opinion on what caused landslides in the area, a majority 233(94.7%) indicated that it was the heavy rains and poor soils in the area, 9(3.7%) indicated that it was the earthquakes and movements of trains, while only 4(1.6%) were either undecided or mentioned other causes. These further agrees with the views of (Ngechu and Mathu, 1999; Caine 1980; Glade et al, 2000; Wieczorek et al, 2000; Mikos, Cetina & Brilly 2004; Shakoor & Smithmyer 2005; Biot 1960; O Loughlin 1981; Rosenqvist et al 1990; Finlayson and Stathem 1980; Crozier 1986 and Msilimba, G. 2002) that during the rainy season, the loose volcanic soils sucks a lot of water and triggers' the soil down slope due to the topography of the area.

Summary of Finding on the Factors that cause Landslides

A majority of the residents accepted that landslides occur during the rainy season. This seems to agree with the argument of (Ngechu and Mathu, 1999; Caine 1980; Glade et al, 2000; Wieczorek et al, 2000, Mikos, Cetina & Brilly 2004 and Shakoor & Smithmyer 2005) that landslides in the area are triggered by heavy rains and it is only during the rainy season that they experience the landslides. A majority of the

respondents also agreed that the soil type also triggered the occurrence of landslides. This is in perfect agreement with the views of Sidle *et. al.*, (1985) and Ingaga, et. al, (2001) who argue that the loose volcanic soil in the area when wet loosens up and flows down slope during the rainy season.

A majority of the respondents also agreed that the topography of the area too contributed to the occurrence of landslides in the area. This agrees with the views of (Biot 1960, O Loughlin 1981, Rosenqvist et al 1990, Finlayson and Stathem 1980), Crozier (1986) and Msilimba, G. 2002) who argues that the rugged topography of the area which is hilly and sloppy has triggered the occurrence of landslides in the area because during the rainy season water logged soils easily move down slope causing landslides.

When the residents were asked their opinion on what indeed caused landslides in the area, a majority indicated that it was the heavy rains and poor soils in the area, followed by those who indicated that it was earthquakes and movements of trains. These further agrees with the views of (Ngechu and Mathu, 1999; Caine 1980; Glade et al, 2000; Wieczorek et al, 2000; Mikos, Cetina & Brilly 2004; Shakoor & Smithmyer 2005; Biot 1960; O Loughlin 1981; Rosenqvist et al 1990; Finlayson and Stathem 1980; Crozier 1986 and Msilimba, G. 2002) that during the rainy season, the loose volcanic soil sucks water and triggers the movement of soil down slope by the topography of the area.

Conclusions

1. The types of landslides that exist in the area are earth flows, mud slides, down slope, viscous flows of saturated, fine-grained material.
2. The heavy rains, poor loose volcanic soils and the rugged topography in the area were the geological and topographical factors that caused and triggered landslides in the area

Recommendations

1. Deforestation, settlement, infrastructure development, rapid population growth and urbanization are some of the human activities contributing to increased incidence of landslides.
2. County governments in landslide prone counties should put in place programmes and action plans with requisite budgets and institutions to the lowest level of administration.
3. It also calls for permanent personnel who are able to respond quickly. They should stock emergency disaster relief supplies, tools and equipment that can be rapidly deployed to save lives when this disaster strikes as suddenly as it does.
4. Policy recommendations on landslides for adoption by government should reflect worldwide best practices. Japan, New Zealand and Australia have implemented some of the most effective and stringent landslide policies and a lot can be learned from these countries.
5. The Kenya government should seek collaborative research partnership with these countries by seeking technical assistance to undertake landslide risk mapping and developing safe best practice environmental planning measures to adopt towards minimizing losses to life and property arising from landslides.
6. The researcher recommends that policies should be developed in landslides prone areas in the protection of lives and livelihoods in Kenya.
7. Government should continue providing humanitarian assistance to the people in the area and continue advising them to move to safer locations during landslides.
8. Drainage in the area should be improved, gabions built to control soil erosion and other human activities such as quarrying should be discontinued.

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