

Assessing the Socioeconomic Impacts of Landslides Disasters on Rural Communities: A Case Study: Kagogo Sector in Burera District

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Abstract: The study examined the socioeconomic impact of landslide disasters on rural communities in Kagogo Sector, Burera District, Rwanda—a high-risk zone frequently affected by landslides that destroy homes and threaten lives. The research aimed to identify the causes of landslides, analyze their socioeconomic effects, and assess the link between their occurrence and community welfare. Using a descriptive survey design, the study targeted 5,290 households, sampling 400 households and 5 local leaders through purposive, stratified, and simple random sampling. Data collection involved questionnaires, interviews, documentation, and field visits, with results presented using tables, figures, and charts. Analysis was conducted using descriptive and inferential statistics, including regression in SPSS. Findings revealed that landslides are mainly caused by heavy rainfall, soil composition, steep slopes, vegetation loss, and poor land use planning. Human activities such as deforestation, improper farming, mining, quarrying, and road construction exacerbate the problem. Landslides result in soil degradation, deaths, injuries, and homelessness, severely affecting socioeconomic conditions. Statistical analysis indicated that landslides negatively impact socioeconomic status by 91.39%, with strong agreement among respondents on the key issues. The study recommends that the government promote reforestation, strengthen Meteo Rwanda's disaster preparedness, and that communities avoid practices contributing to landslides.

Keywords: Socioeconomic impacts, landslides, disasters, Rural community, topography.

I. INTRODUCTION

In Asia and Europe, landslides have been documented for several millennia. In 1767 B.C., an earthquake in Honan Province, central China, caused landslides that blocked the Yi and Lo rivers, resulting in the oldest known landslides (Xue-Cai and An-ning 1986). The influence of disasters on economic development is significant. They are thought to cost the world over USD 250 billion annually due to disruptions to livelihoods, fatalities, and damage to properties and infrastructure (Okuyama and Sahin, 2009; UNISDR, 2015). This influence is anticipated to grow as marginal land is used more frequently and as climate change-related weather patterns shift (Mendelsohn and Saher, 2010). Although high-income nations have more total monetary damage from disasters, low- and middle-income countries experience higher total deaths and relative damage as a percentage of GDP (Kahn, 2005; Okuyama and Sahin, 2009; Toya and Skidmore, 2007; UNISDR, 2015).

The global trend of landslide activity is expected to continue in the 21st century due to the following factors: 1. increased urbanization and development in landslide-prone areas; 2. continued deforestation of landslide-prone areas; and 3. increased regional precipitation caused by changing climate patterns. Despite advancements in recognition, prediction, mitigation measures, and warning systems, landslides still cause significantly more socioeconomic losses than is generally acknowledged. This indicates the significance of landslides. In most of the world today, population pressures are growing, which has sped up urbanization and growth. For instance, over the 15 years between 1970 and 1985, the land areas of the 142 American cities with a population of 100,000 or more rose by 19%. According to Leggett's (1973) estimation, the 48 contiguous United States will have 360 000 km² of pavement or built upon by the year 2000. This region is roughly the

same size as the state of Montana. Large volumes of geologic materials have been disrupted by human activity as a result of these population pressures in the construction of industrial structures, housing developments, mines and quarries, dams and reservoirs, and communications networks. Due to the massive scale of these activities, they have been more and more extended into landslide-prone areas; thus, these developments have played a significant role in the recent rise in destructive slope failures.

The rate of devastation of forests is rising in many emerging nations across the globe. Eliminating forest cover raises the occurrence of landslides, erosion, and flooding. The best-documented example of this is Nepal. Deforestation is producing major landslide problems in many of these countries, and it is predicted to continue unchecked into the 21st century. The World Resources Institute (Facts on File Yearbook, 1990) estimates that every year, between 15 and 20 million hectares of tropical forest—an area the size of the state of Washington—are lost. El Niño produced regional weather changes in western North America that resulted in substantially greater than average precipitation in mountainous areas for around three years in the early 1980s. A significant rise in landslide activity was seen in California, Colorado, Nevada, Oregon, Utah, and Washington, among other states.

Landslide costs include both direct and indirect losses that affect public and private properties. Direct costs are the repair, replacement, or maintenance resulting from damage to property or installations within the boundaries of the responsible landslides or from landslide-caused flooding. All other landslide costs are indirect. Reduced real estate values in landslide-prone areas, lost productivity in the forestry, agriculture, and industrial sectors, and lost tourism revenue as a result of infrastructural damage or other occurrences are examples of indirect costs. reduction in output in humans or animals as a result of illness, death, or psychological stress; measures to prevent or lessen more harm from landslides; negative effects on irrigation systems and streams' water quality outside of the landslide. (ROBERT L. SCHUSTER)

Additionally, 11,694 persons lost their lives to the world's major natural catastrophes in 2019, according to the 2019 Global Natural Disaster Assessment Report. Tens of thousands of people were impacted by this, accounting for 17.29 (0.19%) of the population, and 0.20 billion USD (0.16%) were lost directly.

Landslides in the highlands of East Africa degrade the soil extensively and result in the loss of property, infrastructure, and lives (Knapen et al., 2006, Mugagga et al., 2010, Ngecu et al., 2004). However, there is a significant underreporting of landslides in these locations due to the remoteness of the impacted areas and the tiny size of individual incidents. Because of this, the influence of landslides on human livelihoods and development is underestimated and receives little scientific attention (Msilimba, 2009, Jacobs et al., 2015).

The biggest socioeconomic impact of landslides in Kenya is death; for example, landslides in Gikondi village killed four people, Gacharage village killed eight, and Maringa village killed eleven. Landslide hazard assessment in Kenya 2011, 13 Landslides also cause property and agricultural land destruction; in Muranga District alone, landslides are estimated to have destroyed over \$100,000 worth of property, including homes, coffee and tea plantations, and domestic animals (Ngecu and Mathu, 1999).

In Rwanda, Landslides have been hazardous and overwhelming events impacting seriously all pillars of the Rwandan national strategy for transformation where the environment and socioeconomic aspects were affected. The relief of Rwanda is mountainous with an average altitude of 1700 meters (REMA, 2016). In Rwanda, landslides used to occur in hilly areas of the country including the western, northern, and part of southern territories (MIDIMAR, 2012). The study on the spatial distribution of landslide proneness and associated impacts on livelihoods of the community in Gakenke District showed that Sectors including Muyongwe, Kamubuga, Muzo, Kivuruga, and Janja are highly susceptible to landslides (Claude et al., 2020). The main objective of this study was to assess the socioeconomic impacts of landslides on rural communities in KAGOGO sector, Burera district.

II. CONCEPTUAL FRAMEWORK

The conceptual framework illustrates how landslides affect socioeconomics and the environment in rural communities. This is predicated on an analysis of the body of existing literature. On the other hand, there are effects on the environment and human health. The researcher takes into account both independent and dependent factors for this study, as shown in Figure 1. Landslides was the study's independent variable, while rural communities were its dependent variable. Furthermore, each variable has its associated variables and intervening variables was used in the figure.

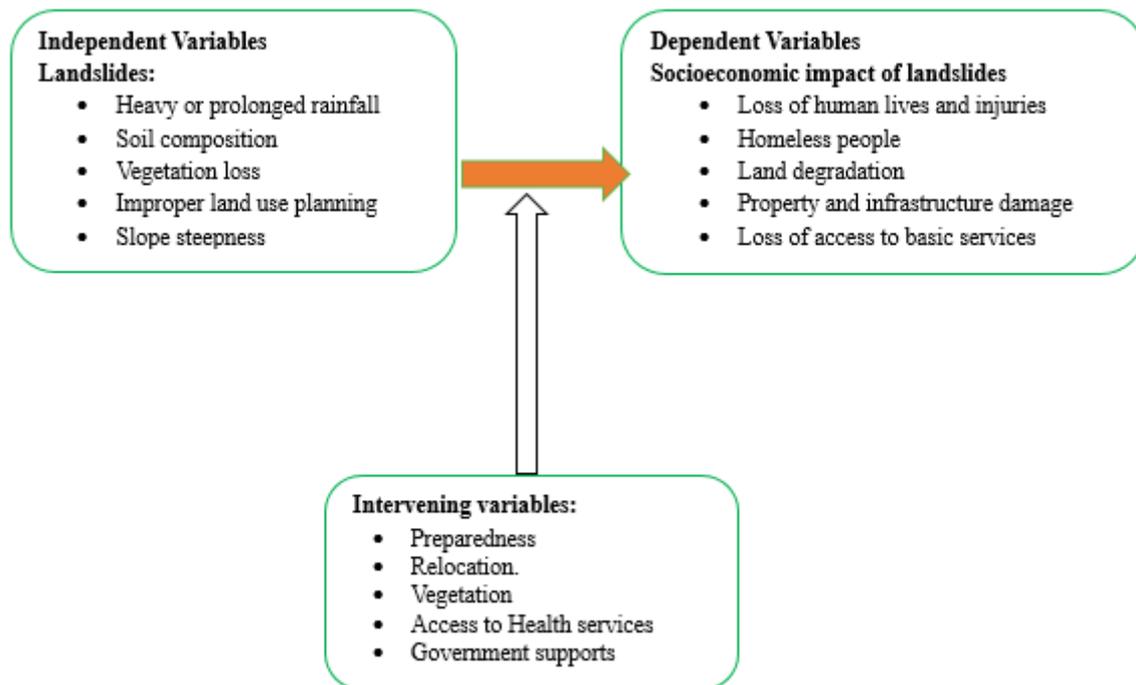


Figure 1: Conceptual framework

Source: Researcher, September 2024

By analyzing the figure above, one can say that this study analyzed the concepts of landslides as the independent variable and its components, considering that landslides are a causal agent of problems classified under socioeconomic impacts on rural communities. On the other hand, socioeconomic impacts are dependent variables because they are the consequences of the landslide outbreak. Finally, intervening variables come as solutions and supports, mitigation measures as well as preparedness for the threats of landslides.

III. RESEARCH METHODOLOGY

Research Design

A research plan outlines the techniques and steps for gathering the required data. A research design, according to Grinnell (2010), is the procedure for the investigation, from formulating the problem to disseminating the results. This study examines how landslides disasters affect the socioeconomic of rural communities, specifically in relation to KAGOGO sector in BURERA district. The study employed Mixed Approach to mean quantitative and qualitative research approach to describe the data acquired from targeted respondents, who include some habitats of the region, and some sector leaders. After then, data interpretation was done using the descriptive analytical design.

Population and Sample Size of the Study

The entire population of the study who are supposed to provide information data related to the objectives of the study is based on 5290 households in KAGOGO sector (NISR,2022) and 5 sector leaders (1at sector level and 4 at cell level) and the leaders were used as key informants to collect qualitative data on socioeconomic impacts of landslides. Then the total population is 5290 households and 5 local leaders of Kagogo sector. Before identifying the respondents to this research, it is necessary to indicate how the sample size is determined. The sample size of the study is calculated using the following formula invented by YAMAN Taro in 1967; this formula is used in order to calculate the sample sizes and the population of this study are dispersed in households but all 5 leaders are retained as key informants.

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the marginal error of 5% through level of confidence of 95%. Thus, this formula is applied to the above sample.

$N= 11,192$, $e= 5\% = 0.05$. Then, $n= \frac{5290}{1+5290(0.05)^2} = \frac{5290}{13.225} = 400$ households' respondents. So, the sample size of this study is 400 households' respondents and 5 sector leaders of Kagogo taken as key informants.

Sample size for each stratum

To calculate the size, the rule of three formulae for stratified sampling is used (Cohen, 2003);

Proportionate Stratified Sampling Formula

$$n_i = \left(\frac{N_i}{N} \right) \times n$$

Where n_i = sample size for stratum i

N_i = population size of stratum i

N = Total population size

n = Total Sample size

stratum A (number of households heads of Kiringa cell) =1605

Stratum B (number of households heads of Kayenzi cell) = 1, 323

Stratum C (number of households heads of Nyamabuye cell) =1,505

Stratum D (number of households heads of Kabaya cell) =857

Source: NISR (2022)

The following table summarizes the target Population:

Table 1: Number of households for each cell in Kagogo Sector

Cells	Households	Calculations	sample size	%	Sampling method
1.Kiringa	1,605	$n_i = 400 \times \left(\frac{1,605}{5290} \right)$	121	31.25	Taken Randomly
2.Kayenzi	1,323	$n_i = 400 \times \left(\frac{1,323}{5290} \right)$	100	25	Taken Randomly
3.Nyamabuye	1,505	$n_i = 400 \times \left(\frac{1,505}{5290} \right)$	114	28.5	Taken Randomly
4.Kabaya	857	$n_i = 400 \times \left(\frac{857}{5290} \right)$	65	16.25	Taken Randomly
Total	5290	N= 400 households	100		

Source: Primary data, September 2024

The researcher used 121 households (31.25%) in Kiringa cell, 100 households (25%), Nyamabuye 114 households (28.5%), and Kabaya 65 households (16.25%), according to table 3.1. Additionally, the number of homes was chosen at random. All of those families were selected based on their location inside the Kagogo sector, the research region, their reachability and willingness to participate, and the fact that they were led by individuals of the right age.

Data Collection Techniques

This section is aiming to show the research collection techniques of the study including questionnaire; interview guide and documentation research techniques as follows:

Questionnaire Technique

As the primary method of contact between the researcher and respondents, the questionnaire will be helpful to the researcher. In order to gather textual and quantitative data (information), the researcher gave a questionnaire to different household's respondents that includes a series of questions about topics regarding which the respondents are expected to provide

information using Five points Likert Scale ranging from strongly agree to strongly disagree explained as follow: 1 stands for disagree, 2 stands for strongly disagree, 3 neutrals, 4 agree and 5 strongly agree. Furthermore, it was given to 400 households, households' heads in the Kagogo Sector based on their estimated numbers.

Interview technique

According to Krlinger (2017), an interview is a conversation during which the researchers try to get the participants to divulge information. Direct information gathering from respondents will be possible for the researchers if they craft qualitative questions that are pertinent to the objectives of the study. Thus, the researcher was able to collect data verbally from a selected key informants composed by 5 leaders from Kagogo sector and Burera district. Among the key informants there were those who oversee catastrophe management at sector level (1social affairs officer) and 4 executive secretaries of 4 cells in KAGOGO sector. This allowed me to collect data concerning the socioeconomic impacts of landslides disasters on rural communities in KAGOGO sector.

Data Analysis and Processing

Through field visits to the landslide-prone region and its surrounding areas, the researcher was able to assess both the site and the neighboring communities. Additionally, a photographic evaluation of the surrounding environment was conducted. This approach allowed the researcher to gather valuable information about the state of landslides in the Kagogo sector. Statistics analysis is a set of mathematical procedures that are formed from the collecting and analysis of real data. The statistical, analytical, descriptive, and synthetic research methodologies for data analysis enable the measurement and quantification of the study outcomes. The study results were therefore easier to number and quantify, and the data were easier to exhibit in tables and charts thanks to the research analysis. By contrasting the data with the study's conclusions, three research objectives were used to examine the data.

Finally, this study analyzed the quantitative data, because they were presented using numbers like percentages. On the other hand, qualitative data were used and analyzed, considering that ideas / information were recorded and analyzed. Means and percentages were employed as descriptive statistics analysis techniques for the data processing and analysis. Additionally, the data was computed using Microsoft Excel and SPSS, this is the inferential statistics analysis, where standard deviation and correlation coefficients were computed to show the link between variables. Lastly, the data were presented for analysis using tables, figures, and charts.

IV. RESEARCH FINDINGS AND DISCUSSION

Demographic profile of Respondents

The sample of respondents for this study consisted of 400 households and 5 leaders of KAGOGO sector used as key informants, then the researcher asked them to comment on various aspects of how landslides affect rural communities in Rwanda, with a focus on the socioeconomic impacts of landslides in Kagogo sector, Burera District. The respondents included household's heads (mother or father) or another member who was able to answer correctly to the research questionnaire from locals who lived close to the landslide-affected areas as well as 18 leaders taken as key informants. The demographic profile of the respondents includes the following: age, gender, occupation, and educational attainment.

Table 2: Gender of Respondents from Households

	Frequency	percentage
Male	196	49
Female	204	51
Total	N=400 households	100

Source: Household survey in Kagogo sector, September 2024

The respondents are made up of 196 males household's members (49%) and 204 females household's members (51 %).

Identifying causes of landslides disasters affecting rural communities

In keeping with the first goal, which was to identify the causes of landslides, this part provided the study findings. The information gathered is consistent with the conceptual framework's indications of landslide causes.

Heavy or prolonged rainfall as a cause of landslides in Kagogo Sector

One of the factors contributing to landslides in landslide-prone areas, such as the Kagogo sector in the Burera district, is heavy and protracted rain. The heads of 400 homes verified the indicators of heavy and continuous rain in the region, which are shown in table 4.5. The data was shown using the mean and standard deviation derived from replies on a five-point Likert scale. Formulas in Microsoft Excel were used for the computations.

Table 3: Assessing the indicators of heavy and prolonged heavy rain

Indicators	Mean	St.dev.
1.The ground becomes fully soaked because of your saturated soil.	4.22	0.613
2.Small cracks appear on slopes during rain season.	4.13	0.615
3. New water sources appear in unusual places.	4.26	0.883
4. water flow is increased in your area during rain season.	3.69	0.593
Overall mean/ St.dev.	4.075	0.369

Source: Researcher, September, 2024

Interpretation: In research, a 5-point Likert scale with an average score of 1-2 indicates low agreement, 3 indicates neutral or moderate agreement, and 4-5 indicates high agreement. Anthony, M., et al., (2021). Since all of its indications have been verified, the analysis of table 4.5 shows that the overall mean is 4.075, indicating substantial agreement that heavy and continuous rain is the primary cause of landslides reported at KAGOGO area. However, standard deviation might be examined in the manner described below: The responders were much in agreement when the standard deviation was low. A significant SD indicates disagreement because of the broad range of responses.

Finally, Table 3 above illustrates how each response refutes the assertion that landslides are caused by heavy rain in Kagogo sector as the Overall standard deviation is low (0.369). According to Zhang et al. (2023), severe rainfall considerably raises the risk of landslides, particularly in steep and mountainous areas, by soaking soils, decreasing slope stability, and causing mass movements.

Soil composition as the cause of landslides occurrence

The kind of soil in a given location determines the soil composition that contributes to landslide occurrences. The indications of the soil composition that encourage the occurrence of landslides in the Kagogo Sector of the BURERA district were shown in table 4

Table 4: Soil composition as the cause of landslides in Kagogo

Indicators	Mean	St.dev.
1.Your soil is clay-rich soils and is the cause of landslides.	4.62	0.60
2. Your volcanic ash soils causes landslides vulnerability	4.68	0.81
3. Your soil is steep terrain with shallow soils and can cause landslides.	4.90	0.33
4.Your soil is weathered lateritic soils and is cause of landslides in your area.	2.63	0.88
Overall mean/ St.dev.	4.20	0.65

Source: Researcher, September, 2024

By analyzing the table 4, it was found that the soil composition is also the cause of landslides occurrences in Kagogo sector as all the indicators of vulnerable soil to landslides have been confirmed at the overall average of 4.20 and standard deviation of 0.65. It is clear that the soil composition contributes more in landslides occurrences and this, is supported by some authors. The composition of the soil has a significant impact on the frequency of landslides. Because clay particles are tiny and have a tendency to hold water, they make slopes unstable and reduce friction between soil particles, making high clay soils more vulnerable.

These soils can lose cohesiveness and flow more readily when they get wet, which can lead to landslides. Sand and silt are examples of loose, unconsolidated soils that raise the danger of landslides, particularly on steep slopes or during periods of intense precipitation. Furthermore, a weak structure that breaks under stress can be produced by the presence of weathered rock pieces mixed into the soil. By trapping water and causing higher pore pressure and slope collapse, soil layering where permeable layers like sand are positioned atop less permeable layers like clay can further enhance the danger of landslides. Therefore, determining landslide threats and putting appropriate mitigation measures in place need an understanding of soil composition. (Highland & Bobrowsky, 2008).

Vegetation loss and landslides

Vegetation loss is caused by deforestation which is anthropogenic activity and it contributes in landslides occurrences of an area. The table 5 presented what Kagogo inhabitants think about this issue in their region.

Table 5: Vegetation loss assessment in Kagogo sector

Indicators	Mean	St.dev.
1. In your area deforestation is observed.	4.07	0.82
2. Land-use changes are observed in your area.	4.73	0.61
3. Burn scars is observed in your local area.	4.90	0.33
4. Increased bare ground is available in your region.	3.74	0.56
Overall mean/ St.dev.	4.36	0.58

Source: Researcher, September, 2024

Through the interpretation of Table 5, the heads of the households of the respondents confirmed that landslides during rainy seasons are a result of the loss of vegetation in their area. This is seen by the 4.36 overall mean. In the five-point Likert scale this mean is known to signify the high agreement. However, Kagogo inhabitants did not disagree but rather gave a neutral or mild response, suggesting that they are not sure whether the growing amount of barren terrain is observed.

Increased bare ground is the term used to describe the growth of land areas where the soil surface is exposed due to the removal or death of vegetation. Activities like deforestation, overgrazing, drought, or wildfires frequently cause this state. Without vegetation, the soil loses stability and is more susceptible to erosion from wind and water, which can lead to desertification, land degradation, and a higher chance of natural disasters like landslides (Zhao et al., 2023).

Improper Land Use Planning

Human activities like improper land use planning are one of the causes which favor a region to be prone to landslides occurrences. The table 4.8 presented the data collected from Kagogo sector about the situation of improper land use planning.

Table 6: Survey on Improper Land Use Planning in Kagogo sector

Indicators	Mean	St.dev.
1. Construction on unstable slopes is done.	4.50	0.67
2. Vegetation removal without reforestation efforts is observed.	4.15	0.75
3. There are poor drainage systems in your sector.	4.06	0.74
4. Excessive excavation and slope undercutting.	4.98	0.14
Overall mean/ St.dev.	4.4	0.62

Source: Researcher, September, 2024

The interpretation of Table 6 indicated that Improper Land Use Planning in Kagogo Sector is observed considering that all the indicators have been confirmed at the mean ranging in 4, which shows a high agreement. On the side of excessive excavation and slope undercutting, its mean is 4.98 if rounded off it is 5 and this indicated that about all households' heads responded strongly agree.

Slope undercutting and excessive excavation are two main causes of landslides, especially when they result from poor land use planning. By eliminating the base's supporting material, excavation weakens the soil or rock's shear strength and destabilizes naturally occurring slopes. In a similar vein, the natural buttressing effect that stabilizes a slope can be eliminated by slope undercutting, which is frequently done to build roads, structures, or agricultural terraces. According to recent studies, there is a direct link between increased landslide incidents and slope alterations brought about by humans. The danger of landslides and slope instability is greatly increased by poorly designed excavation operations that lack appropriate geotechnical studies. The study highlights how a lack of integrated land use planning makes landscapes more susceptible to landslides, particularly in mountainous and quickly urbanizing areas. (Wang and others, 2023)

Slope Steepness

Landslides are caused by the steepness of the slope. This renders the area vulnerable to landslides, and the majority of Rwanda's northern regions have steep slopes, making them high-risk areas for landslides and other natural catastrophes. The data from the Kagogo area about the problem of slope steepness as a contributing factor to landslide occurrences was displayed in Table 7.

Table 7: Slope steepness assessment in Kagogo sector

Indicators	Mean	St.dev.
1.Slope steepness is high in your region.	3.74	0.56
2. Slope steepness is among the causes of landslides in your region.	3.72	0.54
3.In your region the slope is very long.	4.83	0.38
4.your region recognize land cracks.	4.73	0.57
Overall mean/ St.dev.	4.25	0.51

Source: Researcher, September, 2024

According to the averages and standard deviations presented in table 7, some respondents agreed that the steepness of the slope is the reason why landslides occur in their area, while others offered neutral or moderate answers. The aggregate mean of 4.25 indicates that the comments were in accord. According to research by Peng et al. (2022), one of the most important physical factors affecting the likelihood of landslides is slope steepness. According to their findings, slopes with angles more than 25 to 30 degrees were far more likely to have landslides, particularly when trigger events like intense rain or seismic activity occurred. Additionally, the study demonstrated that steeper slopes are less stable and more vulnerable to mass movements since they have thinner soil layers and less plant cover.

Socioeconomic impacts of landslides disaster in Kagogo sector

Analyzing the socioeconomic effects that landslide disasters have on rural communities is the study's second goal. A questionnaire and an interview were used to gather the qualitative data. The questionnaire's questions were connected to the socioeconomic effect indicators that were discussed in the conceptual framework section.

General analysis of socioeconomic impacts of landslides

Table 8: Agreement findings about socioeconomic impacts of landslides

Indicators	Mean	St.dev.
1. Landslides caused cultivable soil degradation.	4.42	0.49
2.Landslides caused high Fatalities, injuries rates.	4.67	0.47
3.Landslides made people be homeless.	4.33	0.82
4. Landslides caused property and infrastructure damage.	4.12	0.80
5. Loss of access to basic services (healthcare, education, public transportation).	4.31	0.72
Overall mean / St.dev.	4.37	0.66

Source: Researcher, September, 2024

I found that, if I round off, all of those claims regarding the socioeconomic consequences have been agreed upon at the mean of 4.37 by looking at table 8. This study illustrates the negative impacts that landslides have on the local community, since the Kagogo sector in Burera is recognized as a high-risk area for landslides than others in this sector.

Results regarding socioeconomic impacts of landslides from the Burera archives

According to the report of disasters that happened in the BURERA district on the date of May 2024, because of heavy rain which hit the northern and western parts of Rwanda, it caused floods and triggering landslides and led to casualties and damages. According to the government of Rwanda, at least 127 people died across the affected provinces (8 people in Burera/ Kagogo), media reported several injured people. In addition, some houses were collapsed and main roads were impassable due to floods and landslides. (Echo, 2023).

After the severe floods and landslides that affected northern, western and southern Provinces of Rwanda on 2-3 May 2023, the death toll has increased and further damage has been reported. Media reports, as of 16 May, up to 131 fatalities, and more than 5,800 displaced families across the affected Provinces. Key assets and infrastructure were also damaged including 6,391 houses, 2 health centres, 29 bridges, many national and district roads, numerous voltage lines as well as 5 power stations. 58 schools were affected. With the same report, more than 100 people died and 18,000 have been displaced. Homes, roads, as well as crops and livestock have been severely impacted. (UNDCG, 9 Jun 2023).

Table 9: Level of negative effects of landslides in KAGOGO/ BURERA

Sector	Deaths	injuries	Destroyed houses	Damaged houses	Total affected houses
1. Bungwe	0	3	13	0	13
2. Butaro	0	0	0	0	0
3. Cyanika	0	0	0	1	1
4. Cyeru	0	0	3	4	7
5. Gahunga	0	0	0	0	0
6. Gatebe	0	0	0	2	2
7. Gitovu	0	0	1	11	12
8. Kagogo	8	2	69	38	107
9. Kinoni	0	0	6	11	17
10. Kinyababa	0	0	13	37	50
11. Kivuye	0	0	1	10	11
12. Nemba	0	0	2	2	4
13. Rugarama	0	0	0	0	0
14. Rugengabari	0	0	0	14	14
15. Ruhunde	0	0	1	1	2
16. Rusarabuye	0	2	21	2	23
17. Rwerere	8	0	4	10	14
TOTAL	16	7	134	143	277

Source: Adapted from Burera Report on Disasters, May 2024

In May 2024, 134 buildings were destroyed by landslides, 143 houses were damaged, 16 people were killed, 7 were injured, and 277 households were impacted overall, according to the table. Eight people were killed, two injured, 69 buildings were demolished, 38 houses were damaged, and 107 dwellings were affected overall, according to an analysis of the detrimental

effects of landslides in Kagogo. Additionally, 76 homes were evacuated from the location, and 4.2 hectares of crops were destroyed, according to the report. All of this data demonstrates how landslides in KAGOGO have a detrimental effect on local populations.

Results from an Interview Guide for Leaders

Using an interview guide, eighteen leaders at the sector level were called in person. Among these leaders are the following: One social affairs officer at sector level and four executive secretaries at cell level from each cell of Kagogo sector. The objective of the interview was to search for confirmation information about the contribution of anthropogenic activities to landslides in Kagogo sector, Burera district. The data is summarized in the figure 2

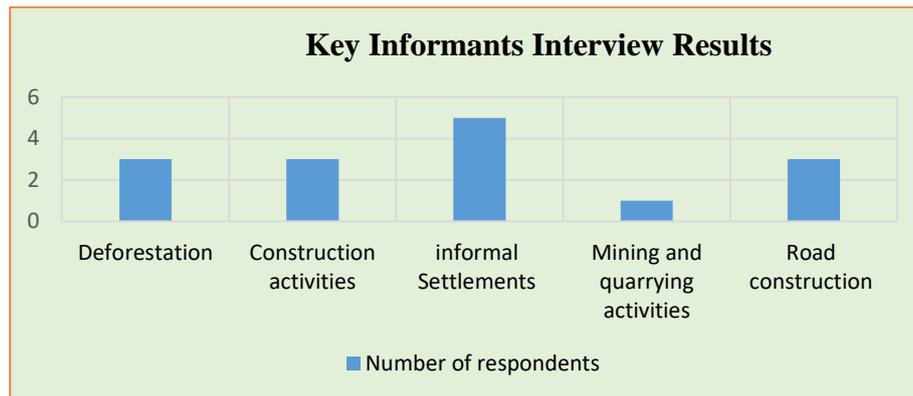


Figure 2: Contribution of human activities to landslides occurrence in KAGOGO Sector

Source: Primary data, September 2024

By analyzing Figure 2, it was found that 3 out of 5 leaders identified deforestation as a human activity contributing to landslide occurrences in Kagogo. Three out of 5 leaders mentioned construction activities, while all 5 out of 5 leaders highlighted informal settlement patterns, mining, and quarrying activities was 1. They further noted that all of these anthropogenic activities are observed in Kagogo Sector, Burera District, which contributes to landslide occurrences. Finally, they indicated that due to the geological structure of Kagogo, which is similar to that of the entire district, improper agricultural practices and building on slopes also contribute to landslides. As a response, measures such as evacuating residents from high-risk zones are routinely implemented whenever landslides occur.



Figure 3: Road construction causes landslides

Source: Researcher on field visit, February 2025

The assessment of the relationship between landslides and its socioeconomic impacts on rural communities in Kagogo sector

Assessing the connection between landslides and their socioeconomic effects on rural communities was the third goal. The data for this section, have been collected and analyzed using correlation coefficients calculated using multiple regression analysis with the help of SPSS in inferential statistics.

Regression Analysis to determine the relationship between variables**Table 10: Model Summary**

Model	R	R Square	Adjusted R Square	std. error of the estimate
1	0.985 ^a	0.9139	0.770	650.22180

a. Predictors: (Constant), mining practices

Source: SPSS / April, 2025

Important metrics pertaining to the overall fit of the regression model are shown in the Model Summary table. The socioeconomic impacts of landslides occurrences are strongly correlated, as indicated by the R-value of 0.985. This indicates that landslides frequency has a significant impact on the community's socioeconomic status. The R Square value of 0.9139 suggests that 91.39 % of the variance in socioeconomic impacts can be explained by the frequency of landslides in an area. This is a relatively high percentage, indicating that landslides play a dominant role in shaping socioeconomic conditions in the area. The Adjusted R Square value of 0.770 is also high and accounts for the number of variables included in the model, reinforcing the strong relationship between the variables.

The Standard Error of the Estimate (650.22) reflects the average distance that data points fall from the regression line, giving a measure of the model's prediction accuracy. While this statistic is useful, its interpretation is more meaningful in context with other information from the model, such as the p-values and F-statistics. The statistical technique of regression is used to estimate the relationship or associations between a dependent variable (y, or outcome variable) and one or more independent variables (x, or predicting variables). To help comprehend the variance in a dependent variable, regression analysis specifically analyzes the variation in independent variables with other confounding variables controlled. Where regression analysis meets machine learning is in the estimation and forecasting of the dependent variable's conditional expectation given the independent variables. Qinghua, Y. (2017). Furthermore, the researcher was able to quantitatively illustrate the relationship between landslides and their socioeconomic impacts in Kagogo Sector, Burera district.

Table 11: Analysis of Variance (ANOVA^a)

Model		Sum of Squares	df	Mean square	F	sig.
1	Regression	4565332.222	1	4565332.222	10.798	0.046 ^b
	Residual	1268364.978	3	422788.326		
Total		5833697.200	4			

a. Dependent Variable: socioeconomic impacts
b. Predictors: (Constant), Landslides occurrences

Source: SPSS / April, 2025

The ANOVA (Analysis of Variance) table assesses the overall significance of the regression model. The F-value of 10.798 tests whether the model is significantly better than using no predictors (i.e., a constant model). With a p-value of 0.046 (which is less than the significance level of 0.05), the result indicates that the regression model is statistically significant. This means landslides have a meaningful impact on socioeconomic status. The Sum of Squares values show the variance in socioeconomic development explained by the model (regression sum of squares = 4,565,332.222) and the unexplained variance (residual sum of squares = 1,268,364.978). The Total Sum of Squares (5,833,697.200) represents the total variance in the dependent variable, and the proportion explained by the model (R Square) is 91.39 %.

Will K. (2024) stated that A statistical test called analysis of variance (ANOVA) is used to evaluate how the means of more than two groups differ from one another. Fundamentally, ANOVA enables you to compare arithmetic means across groups at the same time. You can determine whether the differences observed are due to random chance or if they reflect genuine, meaningful differences. In this study, mean responses concerning landslides and socioeconomic impacts have been evaluated the way they differ among them.

Table 12: Dependent variable coefficients

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	298.420	401.803		0.743	0.512
	Landslides	0.9139	0.229	0.885	3.286	0.046
a. Dependent Variable: socioeconomic development						

More specific details on the connection between landslides occurrences and socioeconomic problems may be found in the Coefficients table then, p-value of 0.512, which is higher than 0.05, indicates that this result is not statistically significant. This implies that the constant is not a major component of the model. 0.9139 is the essential coefficient for landslides occurrences. This indicates that socioeconomic development should reduce by 91.39% units for every unit increase in landslides frequency. Generally speaking, a t-value larger than 2 indicates that the predictor is significantly influencing the dependent variable. Important metrics pertaining to the overall fit of the regression model are shown in the Model Summary table by changes in landslides occurrences.

According to the R Square value of 0.9139, the landslides occur in Kagogo sector account for 91.39 % of the variation in socioeconomic development. This is a rather high percentage, suggesting that landslides significantly influence the socioeconomic circumstances in the region. The significant correlation between the variables is further supported by the high Adjusted R Square value of 0.770, which takes into consideration the number of variables in the model. A measure of the model's prediction accuracy is provided by the Standard Error of the Estimate (650.22), which is the average distance that data points fall from the regression line. Although this statistic is helpful, it is best interpreted in conjunction with other model data, such as the p-values and F-statistics.

The Standard Error of the Estimate (650.22), or the average distance of data points from the regression line, provides a measure of the model's prediction accuracy. Despite its usefulness, this statistic is best read in combination with other model data, including the F-statistics and p-values:

- correlation < 0.2 as very weak
- correlations between 0.2-0.39 as weak
- correlations 0.40-0.59 moderate
- correlations 0.60-0.79 as strong
- correlations > 0.80 as very strong

Explanation And Interpretation of Results

The study aimed to examine the socioeconomic impact of landslides on rural communities in the Kagogo area of the Burera district, finding that prepared households perceive landslides as detrimental when considering socioeconomic factors. The study presented the causes of landslides such as heavy or prolonged rainfall, soil composition, vegetation loss, improper land use planning as well as slope steepness and all of them are the causes of landslides in Kagogo sector. Landslides have significant socioeconomic impacts, including soil degradation, human-social losses, property and infrastructure damage, loss of access to basic services among others. They can lead to fatalities, injuries, income loss, employment, homelessness, and business interruptions. Indirect losses include disease, disability, psychological effects, social cohesion, community destruction, and less investment. These were supported by the means in Five-points Likert scale ranged in 4 which is some high agreement responses.

However, it was shown that certain human activities were more responsible for the occurrence of landslides in Kagogo and other parts of Rwanda. Deforestation, inappropriate farming methods (such as overgrazing and steep slope agriculture), mining and quarrying, constructing on a slope, water leaks, and road development are a few of these. Leaders' key informants provided this information, which they verified via the use of interview guides. (see figure 4.1.) To analyze and interpret the results, the researcher compared them to other prior researches with the similar topics as they are explained in the paragraphs below:

The first study to compare with the present research was "Analysis of the Impact of Landslides on Rural Community Livelihoods in Rwanda: Case of Ngororero District" by Ihorikiza Marie Claudine and Pancras Ndokoye (2023). The results of this study demonstrate that landslides in Ngororero District significantly impacted the livelihoods of the local population, leading to housing destruction, food insecurity, income reduction, and fatalities and injuries among community members.

The study recommends that the government take control of the situation and ensure that both the government and the population use appropriate, durable materials when constructing homes and infrastructure (e.g., roads, schools, and medical facilities) to prevent potential damage from future landslides. (Ndokoye, P. & Ihorikiza, M., 2023). This study is related to present study, considering that it aimed at analyzing the impacts of landslides on rural communities of Ngororero district and the impacts were the ones of socioeconomic status as the ones of the presents studies. In addition, the results found concerning socioeconomic impacts of landslides are housing destruction, food insecurity issues, income decrease, and community member fatalities and injuries and those are not different from the findings of the present study; the only differences are related to case study and the research designs, where the research designs used includes correlational design where different statistics formulae have been used to identify the relationship between variables. The second study to be compared to the present study is entitled Local perception and adaptation strategies to landslide occurrence in the Kivu catchment of Rwanda by Ma-Lyse Nema, Prof. Bachir Saley Mahaman, Dr. Arona Diedhiou, Assiel Mugabe, in 2023

The results demonstrated that the most common landslide types in the research region include spreads, slides, falls, and flows. Road development, improper agricultural practices, deforestation, earthquakes, mining, heavy rain, and a 15-slope were discovered to create landslides that result in property losses, injuries, infrastructure damage, and human fatalities. Agroforestry, terracing, rainwater drainage systems, and moving people out of high-risk regions are some of the strategies used to reduce the danger of landslides. The way their community properly manages landslides is well-liked by the locals. Non-governmental organizations do not seem to be active participants in intervention efforts for landslide control in the research region, according to the findings, which also showed gaps in collaboration between the parties. (Ma-Lyse N., et al, 2023)

The types of landslides and the variables that influence them, mostly anthropogenic activities, were also described in this study. All of this material has been included in the current study. However, in contrast to the current study, which mainly examined the socioeconomic impacts of landslides on rural areas, this study looked at local perceptions and adaption tactics to landslide occurrences. Additionally, in terms of research design, this comparison study employed inferential statistics like ANOVA and beta coefficients, as they have been used in the present study.

V. CONCLUSION

In summary, The researches showed that the current situation of preparedness for landslides still presents challenges due to factors like limited monitoring technology, inadequate infrastructure in vulnerable regions, and the need for further community awareness and capacity building to effectively respond to landslide threats; For this reason, landslides preparedness should be taken into consideration in order to reduce the negative impacts of landslides on Rwandan communities is it impacts negatively on socioeconomic status of rural communities.

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