Research Article

Forensic investigation of the Gouache landslide disaster, Western Region, Cameroon

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ABSTRACT

This study made use of a disaster forensic approach to investigate the root causes of the landslide disaster which occurred in Gouache, West Region, Cameroon on 29th of October, 2019 that registered 49 to 60 deaths. The aims of the study were to;1) identify the natural and man-made causes of the landslide; 2) determine household vulnerability factors; and 3) identify the administrative weaknesses that led to the disaster. To achieve this, geological data was collected from field observations; rainfall data for a period of 30 years (1988 to 2018) with additional monthly data (January to December) for 2019 was obtained from the National observatory on Climate change (ONACC), Yaounde; satellite imagery from Landsat ETM+ and 8 (2001 and 2020) and SRTM DEM were used to assess land use/ landcover changes and slope respectively; questionnaire administration, household and key informant interviews were used as primary data collection tools. Findings revealed that the root causes were: heavy rainfall that occurred prior to and during this event; the presence of weathered granitic rocks on steep slopes, and springs that increased landslide susceptibility. Susceptibility to landslides was fostered by human activities such as: significant reduction of the savannah vegetation and cutting of the slope for house construction. Household vulnerability factors were lack of awareness of landslide hazards and large household sizes (4-6 persons). Over 70 % of the landowners constructed without a building permit and had no land certificate. The administrative authorities acknowledged that Gouache was officially recognized as a landslide susceptible zone. The findings generated in this study would be useful for the government to strengthen or re-adjust existing policies or strategies of disaster risk reduction in the area.

Keywords: Landslide, Forensic investigation, Gouache, rainfall, disaster, vulnerability

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RÉSUMÉ

Cette étude a utilisé une enquête médico-légale sur les catastrophes pour étudier les causes profondes de la catastrophe du glissement de terrain survenu à Gouache, dans la région de l'Ouest au Cameroun, le 29 octobre 2019, qui a fait entre 49 et 60 morts. Il s'agissait : 1) d'identifier les causes naturelles et anthropiques du glissement de terrain ; 2) de déterminer les facteurs de vulnérabilité des ménages ; et 3) d'identifier les faiblesses administratives qui ont conduit à la catastrophe. Pour ce faire, des données géologiques ont été collectées à partir d'observations sur le terrain ; des données pluviométriques pour une période de 30 ans (1988 à 2018) avec des données mensuelles supplémentaires (janvier à décembre) pour 2019 ont été obtenues auprès de Observatoire National du Changement Climatique (ONACC), Yaoundé; des images satellite du Landsat ETM+ et 8 (2001 et 2020) et SRTM DEM ont été utilisées pour évaluer l'utilisation des terres / les changements de la couverture terrestre et la pente respectivement ; l'administration de questionnaires, les entretiens avec les ménages et les informateurs clés ont été utilisés comme outils de collecte de données primaires. Les résultats ont révélé que les causes profondes étaient : les fortes précipitations qui se sont produites avant et pendant cet événement ; la présence de roches granitiques altérées sur les pentes abruptes, et les sources qui augmentent la sensibilité aux glissements de terrain. La vulnérabilité aux glissements de terrain a été favorisée par des activités humaines telles que réduction significative de la végétation de la savane, et l'abattage des pentes pour la construction de maisons. Les facteurs de vulnérabilité des ménages sont le manque de sensibilisation aux risques de glissements de terrain et la taille importante des ménages (4 à 6 personnes). Plus de 70 % des propriétaires fonciers ont construit sans permis de construire et sans certificat foncier. Les autorités administratives ont reconnu que Gouache était officiellement reconnue comme une zone susceptible de subir des glissements de terrain. Les résultats générés par cette étude seraient utiles au gouvernement pour renforcer ou réajuster les politiques ou stratégies existantes de réduction des risques de catastrophe dans la région.

Mots-clés : Glissement de terrain, enquête médico-légale, Gouache, précipitations, catastrophe, vulnérabilité

1.0. Introduction

Landslides are among the most widespread geological hazards that threaten lives and property globally, most especially on the mountainous regions of the world (Huabin et al., 2005; Jamali and Abdolkhani, 2009). They form part of the processes that shape the surface of the Earth. However, when they threaten mankind, then they present a hazardous situation (Ramli et al., 2010). Recently, the occurrences of landslides have increased both in frequency and intensity as observed in a country like Brazil where landslides in 2022 resulted to approximately 231 deaths in February (Alcântara et al., 2023) and 503 deaths in July (Marengo et al., 2023) of the same year. These landslides are linked to a combination of attributes which include: climate, geological, morphometric, and anthropogenic factors that directly or indirectly cause slope instability (Singh, 2010). Even though the years 2020 and 2021 were dominated by the COVID-19 pandemic, in numerical terms, climate-related disasters such as floods and landslides remained the most frequent in both years (World Disaster Reports, 2022).

Landslides result in injuries and death; induce environmental, physical, and economic damages that impede the development of wealthy as well as poor nations and regions the world over (Jamali and Abdolkhani, 2009). According to the World Bank Report (Dilley et al., 2005), the profile of landslide exposure worldwide has the following dimensions: 3.7 million km^2 of land is exposed to landslides giving an estimation of 300 million exposed, which is equivalent to 5 % of the world's population. According to the World Disasters

Report (2022), heavy rains in Venezuela only generated floods and landslides that affected more than 150,000 people in multiple states resulting in severe damages on the local infrastructure, houses and crops in rural areas that led to the declaration of a state of emergency. Lacasse et al. (2010), however, observed that the increase in fatalities in the past 100 years is due to an increase in the exposed population and not an increase in the frequency or severity of natural hazards.

In Cameroon, the growing concern and interest granted to landslides dates from 1950s. In the highlands, the expansion of cash crops has resulted in deforestation, reduction of land available for food crops, slope instability and bare soil (Tchindjang, 2012). As hilltops and mountains which were once denied access began to be cultivated and used by cattle grazers, land degradation set in resulting to large movements of landslides, which unfortunately most often were not recorded. Research carried out by Ayonghe et al. (2002), Lambi (2001), Tsou (2007) and Tchindjang et al. (2012), reported that more than 300 landslides have occurred (historical and oral memory), or recorded in Cameroon since 1954. These landslides have resulted to the death of over 122 people, causing severe damage to the physical environment.

Gouache is located in Bafoussam which is the Headquarters of the West Region of Cameroon (Figure 1). The area occupied by this Region is about 90.6 km^2 and the elevation is about 1,323 m above sea level. As of the 2005 survey carried out by the Mifi Department of Statistics, the population of Bafoussam was at 348,000 people. Landslides are common disasters in this Region and especially around the Bafoussam area. On July 20th, 2003, more than 120 landslides occurred within the Bamboutos caldera in the Region, killing 23 people, 700 livestock, and displacing more than 1000 people (Ayonghe and Ntasin, 2008). The Gouache landslide that occurred in Bamoungoum village in Bafoussam, on October 2019, completely destroyed 13 homes, killed a total of 43 people (CRTV, 2019), with many others injured and displaced.

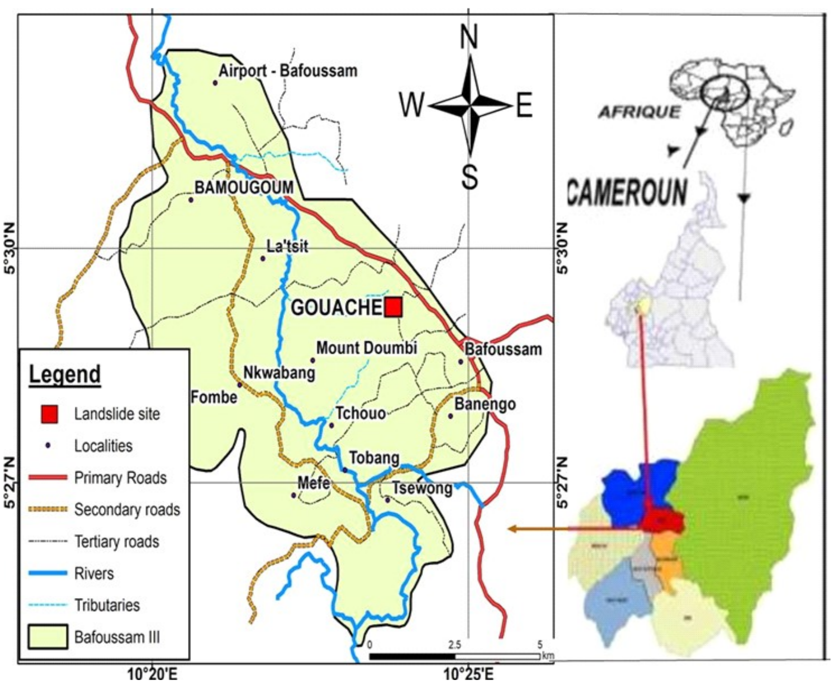

Figure 1. Map of Bafoussam III showing the landslide site within Gouache locality. Inset: Map of Western Region and its position within Cameroon Map.

This study therefore sought to identify the root causes, household vulnerability parameters and administrative weaknesses that led to the disaster through a disaster forensic approach. The term "forensic" in disaster study is used to indicate a search for root causes, in effect to identify those social features, physical forces, and associated institutional and social actors and factors that nourish and energize the risk drivers that are ultimately expressed in the patterns of vulnerability and exposure which enhance disaster outcomes in the event of natural or technological hazards (Oliver-Smith et al., 2016). The use of the disaster forensic investigation was established in 2010 as part of the Integrated Research on Disaster Risk (IRDR) (Burton, 2010). Despite its novelty, Wantim et al. (2018) used this approach to carry out further investigation of the 1999 Mount Cameroon eruption. The findings from this study revealed so many short and long-term socio-economic and health impacts of this eruption which would have gone unnoticed, thus the interest of using this technique for this study. It was therefore expected that the findings from this research would hopefully provide useful data and related information on the root causes of the Gouache landslide which could help the population in the Gouache community to be alert when inhabiting risky zones and provide information on their own mistakes that led to the landslide disaster.

2.0. Materials and Method

2.1 Study Design

This study made use of the descriptive cross-sectional survey research design and more specifically the concurrent triangulation approach in data gathering. The purpose is substantiated by the fact that generally, several methods are used to overcome a weakness in using one method with the strength of another as to clarify unexpected findings and/or potential contradictions; for instance, combining a survey questionnaire with observation (Creswell, 2003; Nana, 2018). In the context of this study, an interview guide, questionnaires, meteorological data for the last 30 years, field observation of the geology and satelite images were used to elucidate the land use changes. The study was a household-based survey as the researcher made sure that only one person, notably the one standing as a household head, was interviewed. More than 200 people were affected by the recent landslide out of a population of about 1000 inhabitants following reports from the Bafoussam III Council. Therefore, the target population were those affected by the landslide and the neighbouring inhabitants. All the target population was assumed accessible except those that had travelled during the study.

2.2. Sampling method and data collection

A purposive sampling was carried out, which allowed the researcher to select respondents that gave relevant information pertaining to the phenomenon under study. The study sample size constituted 200 inhabitants selected through a purposive sampling, specifically, those that were there in the night of the disaster. This study made use of a questionnaire, an interview guide, field observation and satellite imagery. The designing of these instruments and the types of data to be collected was based on the research objectives.

Supplementary data was gathered through topographic maps, and satellite images. Other cartographic information such as geographical coordinates required for the geo-referencing of features on the field and representing them on maps were captured with the use of a global positioning system (GPS). Satellite images acquired from the United States Geological Survey (USGS), were used to capture the land use changes of the disaster zone between 2001 and 2020. These images were processed using the remote sensing software ENVI 5.1 and maps were produced using the ArcGIS software. ENVI 5.1 was also used for pre-processing, change detection, visual interpretation and the production of land cover maps.

Rainfall data from the meteorological station of the airport located in Bafoussam III was obtained from the National Observatory on Climate Change (ONACC), Yaounde. These was analyzed according to Ayonghe and Ntasin (2008), with the aim of identifying quantity thresholds and durations which might have been responsible partially or directly in triggering the landslide.

2.3. Image acquisition and data analysis/ processing

The satellite images used in this study were limited to those from the optical multispectral sensor all obtained free of charge from the United States Geological Survey Website (USGS). Satellite data was acquired from the Landsat Enhanced Thematic Mapper (ETM+), Landsat 8 sensors and Radar sensor (acquisition of the 30 m Digital elevation model (DEM)). A total of two Landsat images were used: ETM+ 2001 and the 2020 Landsat 8 image. They were acquired already geo-referenced (WGS 84 projection and datum: UTM Zone 32N). The criteria used in the selection of the images depended on: seasonality (both images were collected in the dry season: February and March) required for a more accurate assessment; availability of images within the geographic coordinates defined as per cloud cover; image that covered the period before (2001) and after (2020) the landslide required to determined how settlement patterns changed over time in the area. All the images had a spatial resolution of 30 m which greatly enhanced the analyses. These images were then processed using the ENVI 5.1 software to determine the changes in settlement and other landcovers that took place in the past 19 years. The 30 m DEM was processed using ArcGIS 10.7 to derive the contour map (relief and topography) of the area.

Quantitative data processing included coding the questionnaire by assigning numbers to each item on the questionnaire using Statistical Package for Social Sciences (SPSS version 21) which was used to run the analysis. The results where then exported to MS Excel whereby descriptive statistics were carried out, and the ultimate data displayed on graphs and tables.

3.0 Results

3.1 Natural factors that caused the Gouache 2019 landslide

The main natural causative factor that caused the disaster as perceived by the respondents was heavy rainfall (82.4%; Figure 2). This could be perceived from statements made during interview sessions such as: "this was caused by rain. It really rained heavily. It rained continuously, and that led to this landslide". The least cited natural cause was vegetation type (2.0 %).

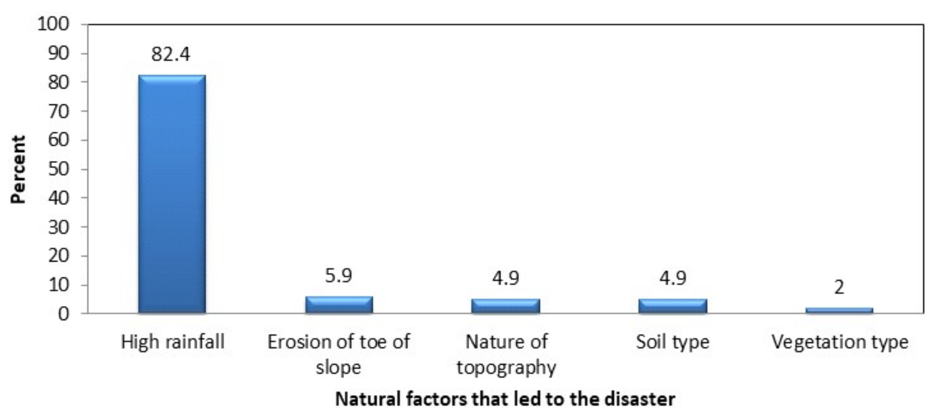

Figure 2. Respondents perception of natural factors that caused the Gouache landslide

The rainfall plot for the last 30 years 1988-2019 showed that the highest precipitation of 2044.4 mm was recorded in 1985 meanwhile the lowest rainfall of 1313.7 mm was recorded in 2013 (Figure 3a). It started rising from 1864.4 mm in 2014 to 2100.7 mm in 2019. The graph shows a significant rise in average rainfall in the year 2019 in the past 31 years (Figure 3a). A rise in rainfall was recorded from January to September in Gouache with peak values in September (592 mm) and October (544 mm) that corresponded to the month of the landslide (Figure 3b). The lowest rainfall was recorded in the month of December (0.5 mm). Further analysis of the rainfall data for the month of October when the disaster occurred revealed that the highest rainfall was recorded on the 25 of October 2019 (Figure 3c). This was followed by a drastic drop on the 26th and a significant increase on the 29th of October when the landslide occurred (Figure 3c).

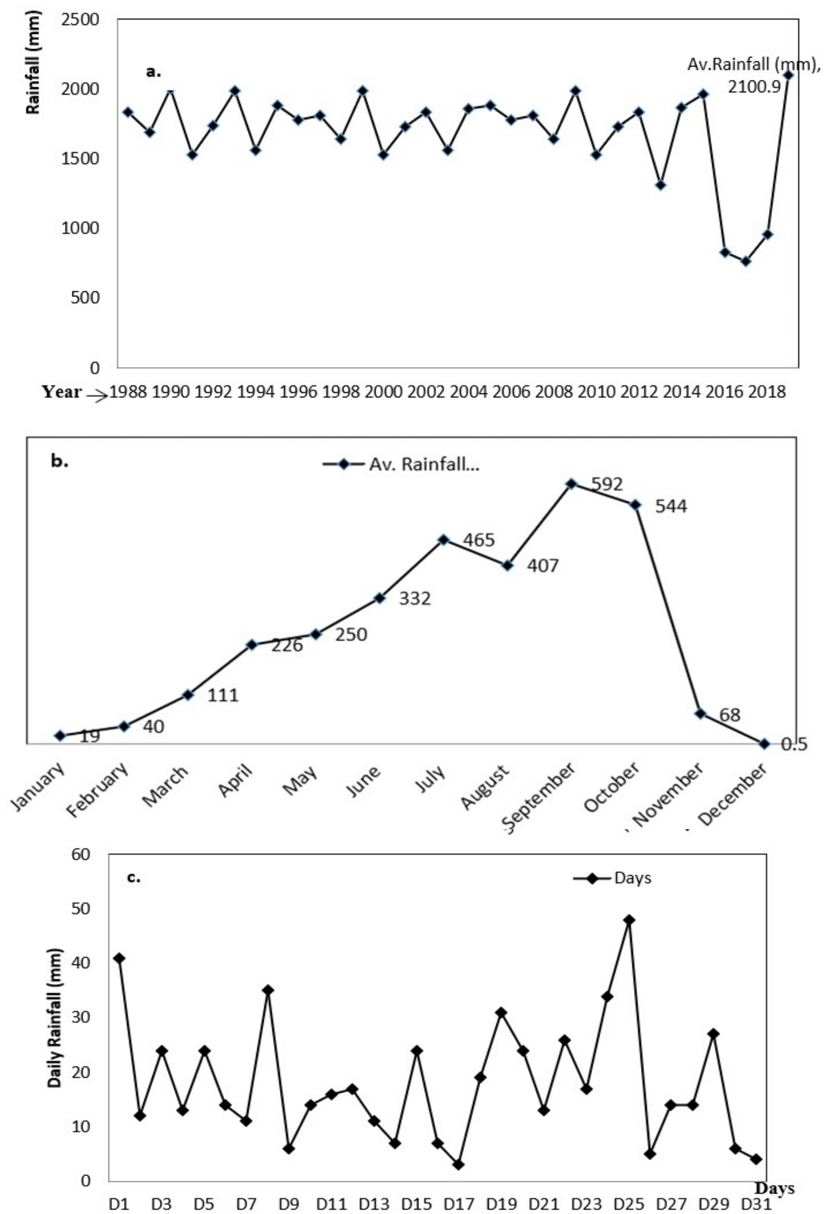

Figure 3. Rainfall plots showing **a.** yearly rainfall statistics for the last 30 years; **b.** monthly rainfall statistics in 2019 and **c.** daily rainfall statistics in the month of October when the landslide occurred

The nature of the geology of the area was also seen to be another natural contributory factor to the disaster. Geological data was obtained from field observations and investigations. The major rock types observed in the area were granitoids (Figure 4a) that had weathered to produce sandy and clayey soils (Figure 4b). Granitoids are light-coloured felsic rocks characterised by a coarse grain texture. The main minerals found in granites include plagioclase feldspars, quartz, and biotite. Feldspar (pink and white) decomposes chemically into clay minerals. Another important constituent of granite is quartz grain which is very resistant to chemical weathering and does not convert to any other mineral. It eventually goes into solutions but very slowly. Hence, disintegrated granite yields lots of quartz grains which are transported mostly by running water as sand grains. From these observations, it can be deduced that the original bedrock of the Bafoussam III Municipality is the granite feldspar which is an intrusive (or plutonic) igneous rock.

Granitoids are known to react with naturally formed acids to form clay, which is a weathering product of rock mass and contributes to landslide occurrence because of its chemical and physical properties. However, clay has a high potential to shrink or swell depending on the water content. This characteristic of clay makes it prone to sliding off a slope once it is saturated with water. It is believed that the intense rainfall which is experienced in Bafoussam not only contributes to the weathering of the rock mass found there, but also increases the water content in the clays that in turn leads to reduction in the stability of natural slopes. Also, building on slopes or cutting off the toe of the slopes further decreases their stability. As a result, the area becomes more susceptible to land sliding, which could explain why such an event had occurred.

Figure 4. Geology of Gouache at the landslide site showing: **a)** Fresh granitic rock, **b)** clayey soil with intercalations of weathered granites and **c)** landslide scar

The steep topography of the area was also a contributory factor to the landslide. The slope map produced from the 30 m SRTM DEM showed that most of the localities in Bafoussam III Municipality where Gouache is located are either found on gentle or moderate slopes (Figure 5). However, Gouaché and Fombé communities are located on drainage networks that are near moderate and steep slopes (Figure 5). In the case of Gouaché, the surrounding area denotes a yellow colour (Figure 5) which is steep slopes. In such an area, the amount of runoff due to precipitation will be high since the water has little time to soak into the soil. With a proper channel that allows this accumulated water to flow back into waterbodies, there is little risk of floods and landslides. However, the presence of communities around this channel distorts the proper flow of water and thus increases the risk of flooding or land sliding.

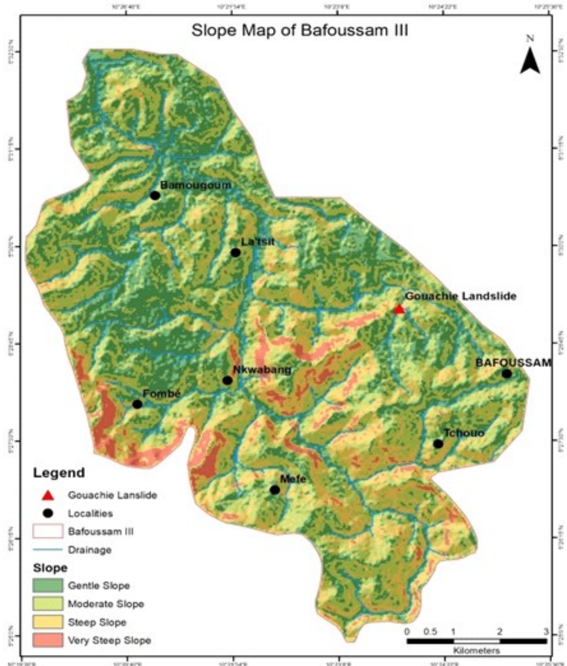

Figure 5. Slope and drainage map of Bafoussam III Municipality produced form the 30 m Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) showing the site of the Gouache landslide

3.2. Anthropogenic factors that led to the disaster

Participants perceived that the main anthropogenic factor that led to the landslide was the cutting of the slope for the construction of foundations of houses (85.3 %). This factor was followed by deforestation 5.9 %, congested settlements 4.9 % and excessive farming 3.9 % (Figure 6a). Other anthropogenic factors mentioned by key informants were: settlement on steep slopes; cutting of the toe of slopes for road construction and through erosion by a stream in a valley; the presence of cavities in the subsoil, and increased population in landslide risk zones.

Land use and land cover analyses using Landsat satellite imagery within a period of 19 years (2001 to 2020) in Gouache distinguished four major classes: vegetated area, bare soil, burnt area, and settlement (Figure 6b&c and Table 1). The statistics in Table 1 summarized in Figure 6b&c, show that between 2001 and 2020, there has been a significant decrease in vegetation from 32 to 21 % which shows an increase in human activities on the slope. Settlement increased from 18 to 29 %, the burnt area also increased from 23% to 26%, meanwhile, bare soil had a significant decrease from 27% to 24% (Figure 6b&c). All of this is as a result of a great increase in human activities on the slope which significantly contributed to the landslide

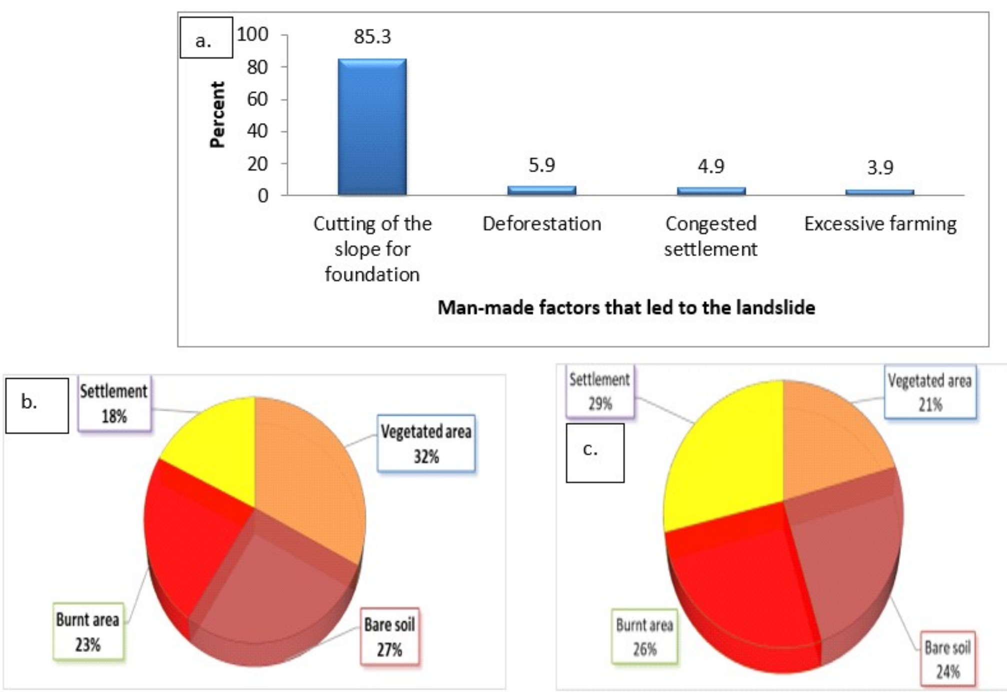

Figure 6: Anthropogenic factors that led to the landslide from: **a.** Respondents perception and **b&c.** landuse /land cover changes showing the total surface area (%) covered by different land covers in the Bafoussam III Municipality in: **b.** 2001 and **c.** 2020

Table 1: Statistics of land cover changes that have taken place in the Bafoussam III Municipality where the 2019 landslide occurred between 2001 and 2020

Land cover Classes	Years		Changes detected: 2001 to 2020	
	2001 Surface Area covered (km^2)	**2020** Surface Area covered (km^2)	Percentage Change (%)	Net change obtained (km^2)
Vegetated area	26.49	16.92	46.95	-9.56
Bare soil	21.93	20.02	54.79	-1.90
Burnt area	18.49	21.20	57.09	2.70
Settlement	14.66	23.45	18.92	8.80

NB: Positive values for net change indicate increase and negative values represent a reduction or decrease in that class between 2001 and 2020 Date when images were acquired: 5th Feb. 2001 and 5th March, 2020. Sensors: Landsat ETM+ for the 2001 image. Landsat 8 for 2020 image

3.3. Household vulnerability

3.3.1. Awareness and impact of the landslide

All the households (58) who participated in the study, were eye witnesses of the Gouache landslide disaster (Figure 7a). In terms of the effects of the landslide, 91.4 % of the households were directly affected meanwhile, 8.6% were indirectly affected (Figure 7a). The majority of the households (83 %) said they had no warning about the landslide since it occurred late at night while 17 % said there was a warning. According to the key informants interviewed, the landslide event was a natural phenomenon that had never happened in the community before and accordingly took the community by surprise.

The affected population were mostly children, women and elderly persons in the Gouache community (Figure 7b). In terms of the number of deaths recorded by households, 45 % of respondents were of the opinion that between 40 to 59 persons died; while 35 % attested to over 60 deaths (Figure 7c). These statistics were corroborated with key informant interviews that cited the fact that not all the bodies of victims were retrieved from the site.

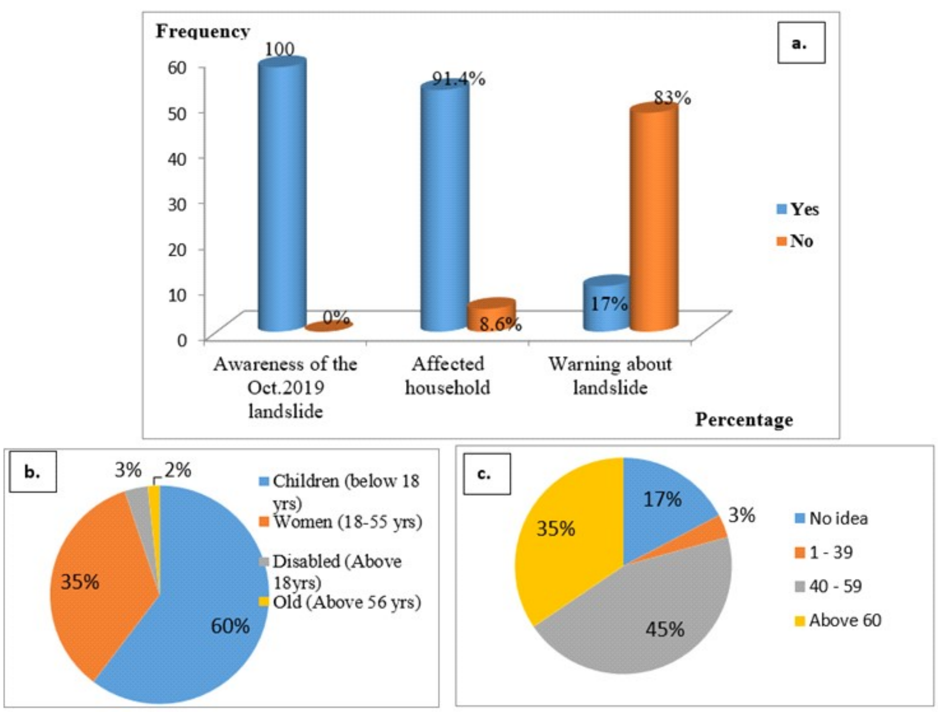

Figure 7: Charts presenting**: a.** awareness level and impact of the 29th October 2019 landslide on households**; b.** classes of affected household members and **c.** number of deaths recorded

In addition to the recorded deaths, there were also displaced victims as summarized in Table 2. A significant percentage (46.6 % and 32.8%) of the respondents indicated that between 200 and 299 persons; and 01 and 199 persons were displaced respectively.

Houses that were not affected by the landslide (Figure 8a) were all demolished by the council after the landslide event (Figure 8b), and hundreds of persons relocated to different areas where they were provided with a temporal residence.

3.2.2. Risk factors that contributed to the landslide vulnerability

The underlying risk factors of the landslide event revealed that 29.3 % of the respondents were not aware they were in a landslide prone area (Table 3). Others (13.8%) attributed the disaster to the fact that their homes were built on steep slopes. Another group (12.1%) attributed the risk to the number of persons who lived in the same household and 3.4 % said some household members were too weak to run away when the event occurred especially children.

Table 2: Number of displaced persons in the affected area Table 4: Number of displaced persons in the affected area

Displaced persons	Frequency	Percent (%)
No idea	7	12.1
01 -199	19	32.8
200 - 299	27	46.6
Above 300	5	8.6
Total	**58**	**100.0**

Figure 8: Landslide site at Gouache showing: **a)** the landslide scar in the centre and buildings that were unaffected at the side of the scar; and **b)** demolition of these buildings after the landslide event

Table 3: Risk factors of the landslide event

Risk Factors	Frequency	Percentage (%)
They were not aware	17	29.3
Location of their homes	8	13.8
Weak to run away	2	3.4
Event took place in the night	24	41.4
Many persons lived in the same house	7	12.1
Total	**58**	**100.0**

Further probing on the reason of settlements constructed in the affected areas revealed that the main contributing factor that led to the settlement on a hill slope was low income (71.6 %) due to the cheaper rate of rent in the area. The non-respect of building regulations was highlighted by 8.8 % of the participants. Social conflict was perceived by 7.8 %. The socio-political crisis, notably the Anglophone crisis brought in many displaced people from the Northwest and Southwest Regions into the area. Marginalization was perceived by 7.8 %, based on the fact that poor people are forced to settle in risky zones because of a lack of initiatives from the government like the provision of social housing for low-income earners. Other socioeconomic factors highlighted were: family ties/emotional attachment. This is a likeness to being around family or people of the same tribe or ethnic group.

3.4. Policy for disaster management

A dominant share of participants making 71.6 % disagreed that there are early warning systems to monitor landslides while 63.7% stated that there was no emergency plan for handling landslides. With respect to policy for disaster management, 80.4% perceived that population and urbanization are fast growing pushing people to risky zones, and 77.5% were of the opinion that government land tenure policy is unfair and marginalized the poor. Moreover, community members insisted that houses that were built in risky zones were only destroyed after the disaster outbreak though the authorities were aware of the risk and officially recognized Gouache as a risky zone. The statistics in Table 4 gave the level of participant's perception of disaster risk policies and their effective implementation in the Gouache community.

Table 4: Participants' characterization of policy for disaster management

Items	Stretched					Collapsed	
	Agree	**Strongly agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Agree**	**Disagre**
There is an emergency plan for handling landslide*.	8.8% (9)	7.8% (88)	19.6% (20)	52.9% (54)	10.8% (11)	16.7% (17)	63.7% (65)
There are early warning systems to monitor landslides*.	3.9% (4)	5.9% (6)	18.6% (19)	53.9% (55)	17.6% (18)	9.8% (10)	71.6% (73)
There is a communication mechanism to notify the population on disaster threats.*	13.7% (14)	2.9% (3)	25.5% (26)	48.0% (49)	9.8% (10)	16.7% (17)	57.8% (59)
Government land tenure policy is unfair and marginalized the poor*.	35.3% (36)	42.2% (43)	15.7% (16)	5.9% (6)	1.0% (1)	77.5% (79)	6.9% (7)
Population and urbanization are fast growing pushing people to risky zones*.	30.4% (31)	50.0% (51)	12.7% (13)	6.9% (7)	0.0% (0)	80.4% (82)	6.9% (7)
MRS	5.5% (28)	5.9% (30)	18.4% (94)	49.4% (252)	20.8% (106)	11.4% (58)	70.2% (358)

N_{cases}=102; $N_{responses}$=510 *MRS: Reversed conceptual polarization.

Taking administrative procedures related to construction, majority of the respondents (80%) indicated that administrative procedures were not respected in the construction of houses. Over 70 % of the land owners at Gouache prior to the landslide, constructed without a building permit and had no land certificate. In terms of disaster communication, 57.8 % of the respondents cited that there were no communication channels to notify the population on imminent disaster threats.

4.0. Discussion

Heavy rainfall was cited by the respondents as the major natural factor that led to the Gouache landslide disaster (Figure 2). This information was corroborated with rainfall statistics plotted in Figure 3 which showed that the disaster occurred after peak periods of rainfall between September and October 2019. This information ties perfectly well with that of other studies that have examined the relationship between rainfall and landslide (Wiezorek, 1996; Gerrard and Gardner, 2000; Dai et al., 2002, Gabet et al., 2004; Alcântara et al., 2023; Marengo et al., 2023). Heavy rainfall leads to high water infiltration and increase in pore water pressures that reduces shear resistance on a slope and promote the downhill movement of material (Dynes, 1994). Average annual precipitation for Cameroon is approximately 1568 mm, while the mean number of wet days is around 138. This then shows that Gouache community has experienced a significant rise in rainfall over the past 30 years compared to rainfall recorded in 2019 (2100.7). In addition, the loss of vegetation in the past 19 years in the area as portrayed in Table 1, is believed to reduce the rate of evapotranspiration on slopes, leading to higher groundwater levels which reduces cohesion through the loss of root strength and increases overland flow, enhancing the rate of erosion (Crozier and Glade, 2005).

Looking at the geology, the rock types observed at the site of the landslide were weathered granitoids or granites that had broken down to form clayey to sandy soils (Figure 4) located along water channels (springs) found on moderate to steep slopes (Figure 5). Granitic soils are widely recognized to be very sensitive to weathering and vulnerable to landslides. The presence of springs/ streams at the foot of the slope where the landslide occurred, increased the susceptibility of the slope to sliding. Many landslide disasters have been recorded in Japan on granitic slopes following heavy rains (Chigira and Ito, 1999). Taha and Kabir (2005) further attested that in Malaysia, slope instability tends to occur more frequently in granite soil formation compared to metasediments.

The major anthropogenic factors that caused the landslide were linked to poor land use/ land cover practices that led to deforestation and cutting of the slope for foundation/construction purposes (Figure 6). Other factors included congested settlement and excessive farming. Kjekstad and Highland (2009) and Margottini et al. (2013) mentioned that, human activities such as construction of highways, clearing land for crops, mining and quarrying, and other activities that alter drainage patterns; causes change in the vegetation regimes; alter the grade of the slopes; and usually result to change in the morphology of the landscape and could cause landslides. Dorren (2004), however, indicated that human activities leading to decreased stability of hill slopes are still minor when compared to geological factors, but are of great importance locally, such as undercutting of slopes during quarrying or excavation for infrastructure. Studies carried out by African Wildlife (2006) and Huppert et al. (2006) attest that, the cumulative impact of human activities without regard for nature has turned recent landslides from a natural phenomenon into a man-made disaster of epic proportions. Thus, the major causes of increasing landslide catastrophes are directly related to human activities and settlements resulting from population growth and urbanization, environmental degradation, land use change caused by human activities which make communities much more vulnerable to natural hazards.

According to the key informants, the occurrence of the Gouache landslide event took the residents by surprise since it was a natural phenomenon and had never happened in the community before. All of the households (58) who participated in the study, were eye witnesses of the Gouache 2019 landslide. In terms of the effects of the landslide, 91.4% of the respondents were affected in terms of lives lost, property and infrastructure (Figure 7). Studies carried out by Chen et al. (2008); Kamp et al. (2008) and Moayedi et al. (2011) asserts that in recent years, landslide occurrence has become more frequent, characterized with more devastating impact such as lives lost, destroyed human settlements and infrastructure (such as settlements, roads, bridges and utilities). Statistics obtained from the field revealed that there were over 49 deaths (Figure 7c) as opposed to the total number of 43 previously mentioned by the media (CRTV, 2019) during the event. Field survey revealed that all the victims could not be recovered from the affected site. Majority of the households (83%) said there was no warning about the landslide since it took place at night. This shows that the impact of the landslide is attributed to the fact that no warning alerts were available, coupled with the fact that the event took place late at night when the rains were falling. The generated statistics from this study highlighted the most vulnerable population (66%) to be children, women and the elderly. (Figure 7). The household size also played a significant role in increasing the vulnerability of the affected population. Findings from this study showed that the majority of the households (75 %) in the study site had between 4 to 6 members. Wisner et al. (2004) established that the social characteristics of household members such as age, income, gender, health status, and disabilities are important factors that increase vulnerability to landslides hazards.

Field survey (Table 2) revealed that the Gouache landslide displaced between 200 and 299 persons. This large displacement was attributed to the fact that government authorities designated the area as a high-risk area after the incidence and initiated evacuation of the unaffected population. The results are in line with the findings of Lindell and Prater (2003) who found out that a significant structural impact of landslides to affected community is the destruction of household dwellings, which causes many more persons to be displaced, coupled to high social vulnerability perspective.

The main contributing risk factor that led to the settlement on the hill slope was low income. The responses from the respondents showed that they were mostly involved in low income generating activities (e.g. petty trading, subsistence farming) which stood clearly as an indicator of vulnerability. A study conducted by Khandlhela and May (2006) on poverty, vulnerability and the impact of landslide in the Limpopo province in South Africa revealed that, while disasters may affect everyone and play an important role in increasing vulnerability, poor people are more vulnerable from a web of circumstances that make them prone to the effects of disasters. In addition, most of the respondents had settled at Gouache over the past 10 years (74.5%) with some escaping from the civil unrest in the Southern part of Cameroon. Studies carried out by Steedman (1995) explains that growth of cities have created areas of highly concentrated vulnerability to slope failure, especially in less economically developed countries, where population growth and rural-urban migration can lead to the growth of urban slums on increasingly marginal land at the periphery of urban centres (Alexander et al., 2005). Population growth is therefore considered to influence the impact of landslides by exposing more individuals to risk and by driving the development to more marginal, often less stable terrain (Petley et al*.,* 2007).

An assessment of the administrative bureaucracy that influenced the landslide revealed that a dominant proportion of the respondents attested that there were no early warning systems in the area to monitor landslides and also no emergency plan for handling landslides. With respect to policy for disaster management, most people perceived that population and urbanization are fast growing, pushing people to risky zones, and they were of the opinion that government land tenure policy is unfair and marginalized the poor. Moreover, community members insisted that houses that were built on risky zones were only destroyed after the disaster outbreak, although the authorities were aware and officially recognized Gouache as a risky zone. Authorities of the Bafoussam III Council also mentioned that there was no disaster management /emergency plan. This put forward the inadequate coordination of activities among the various branches of administration, which could be very detrimental to disaster prevention and response. The sensitization and non-deliverance of building permits were seriously jeopardized by administrative tolerance as acknowledged by the authorities. This administrative tolerance was materialized on the field by people having built without building permits on the landslide prone areas. The lack of building permit was attributed to lack of money since it is too costly for the affected communities. Although the authorities were convinced, based on technical reports, that Gouache was a disaster prone area highly exposed to landslides, besides the inadequate prevention measures, they did not really prepare for the disaster outbreak. Oliver-Smith et al. (2016) stated that appropriate legislation, insurance against loss or liability, multi-sectorial and multi-stakeholder involvement, degree of participation in policy and decision making, integration of disaster risk management into other relevant policy areas such as urban and land-use planning, environmental management, insurance are important in disaster risk management, which were precautions that could have been taken in the case of the authorities concerned at Gouache prior to the disaster. As explained by Sinclair and Pegram (2003), landslides cannot be prevented but their devastating effects can be minimized if advance warning of the event is available. With large increase in population and increasing urbanization, there are more people living in informal settlements, which are often on landslides prone areas as this is the only underdeveloped land available near cities. This therefore implies that the government has to pay more attention on the improvement and effective implementation of disaster risk management policies.

5.0. Conclusions

The natural factors that caused the Gouache landslide were; heavy rainfall in the months prior to the slide and on the day of the disaster; the geology of the area made up principally of weathered granitic rocks that had produced clayey and to a lesser extent, sandy soil; the topography of the area being made up of moderate to steep slopes, and the presence of intermittent springs and streams on the slope. The susceptibility of the slope was enhanced by the following anthropogenic factors: poor land use and landcover practices in the last 19 years which had resulted to a significant reduction of the savannah vegetation; house constructions, cutting of the slope for foundation, increased population growth triggered by the socio-political crisis in the Anglophone regions that has led to the influx of internally displaced persons (IDPs) into the area due to the cheap rents, poverty, and administrative laxity which lured the economically deficient and socially weakened to move and seek refuge in these risky areas.

The study established that landslides in Gouache caused loss of lives and injuries to the people, between 49 to 60 deaths and over 200 displaced persons. This was the highest death toll ever experienced in the community and the first time the community ever experienced such a devastating landslide event. Household vulnerability to landslides in Gouache resulted from the lack of awareness, large household sizes, cheap land acquisition, low levels of income with no steady monthly income for households and reliance on informal forms of employment that increased their vulnerability to slope failures.

In terms of administrative preparedness for this disaster, findings revealed that there were no early warning systems installed to monitor landslides occurrence; no emergency plan for handling landslide; government land tenure policy was neither respected by the population, nor the stakeholders in charge of the follow up; the population did not follow administrative procedures in the construction of houses; land owners at Gouache prior to the landslide, constructed without a building permit and had no land titles; and lastly, there were no disaster communication channels to notify the population on imminent disaster threats.

After the occurrence of the October 2019 landslides, the government immediately ordered relocation of all the population living in the landslide prone areas thus there is a need to assess the effectiveness of the landslide adaptation strategies and policy measures put in place by the government to manage landslide risk in the area post-disaster. The findings generated in this study would be useful for governments (or other stakeholders) to strengthen or to adjust policies or strategies of disaster preparedness, prevention, mitigation and response relevant to attain the priorities of the Sendai Framework for disaster risk reduction (DRR) agenda 2030.

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