



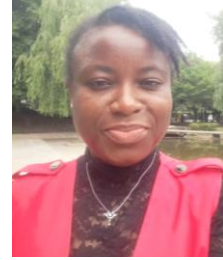
YEG-Article-16/2026

Improving Landslide Susceptibility Assessment in Mount Oku, Central Africa, Using Geo-environmental and Soil Geomechanical Data

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1. Introduction: context and rationale

This contribution builds on a keynote presentation delivered at the 4th African Regional IAEG Conference (6–7 September 2025, Windhoek, Namibia), which highlighted landslide susceptibility at Mount Oku as a representative case for data-scarce tropical regions in Africa. Landslides are a recurring threat across Africa, often overlooked internationally. In Cameroon, they endanger lives, infrastructure, and economic stability. Recent disasters on the Cameroon Volcanic Line (CVL) illustrate this increasing risk. On 5 November 2024, a double landslide in Dschang (West Region) killed more than 50 people (Fig. 1A–D). Similar fatal events were recorded in Gouache, Bafoussam (October 2023, 45 deaths), Mbankolo, Yaoundé (October 2023, 23 deaths), and Damas, Yaoundé (November 2022, >20 deaths), highlighting the urgent need for effective landslide risk assessment, monitoring, and early warning systems. This research derived from our previous investigations (Djukem et al., 2020; Djukem et al., 2024), focused on a 955 km² study area (Fig. 1D), located on the western flank of Mount Oku, a major stratovolcano on the CVL. This region is prone to landslides due to its humid tropical climate (long rainy season between April and November), steep topography, and high population density (162.3 people/km²), as highlighted by Djukem et al. (2020). Our goal is to contribute to the development of a proactive, multidisciplinary framework for landslide risk assessment in Africa's mountainous regions, starting with a scalable approach in Cameroon, specifically on Mount Oku's western flank. The study integrates two complementary streams: assessing geo-environmental and soil geomechanical influences on landslide susceptibility and evaluating potential seismic impacts on slope instability.

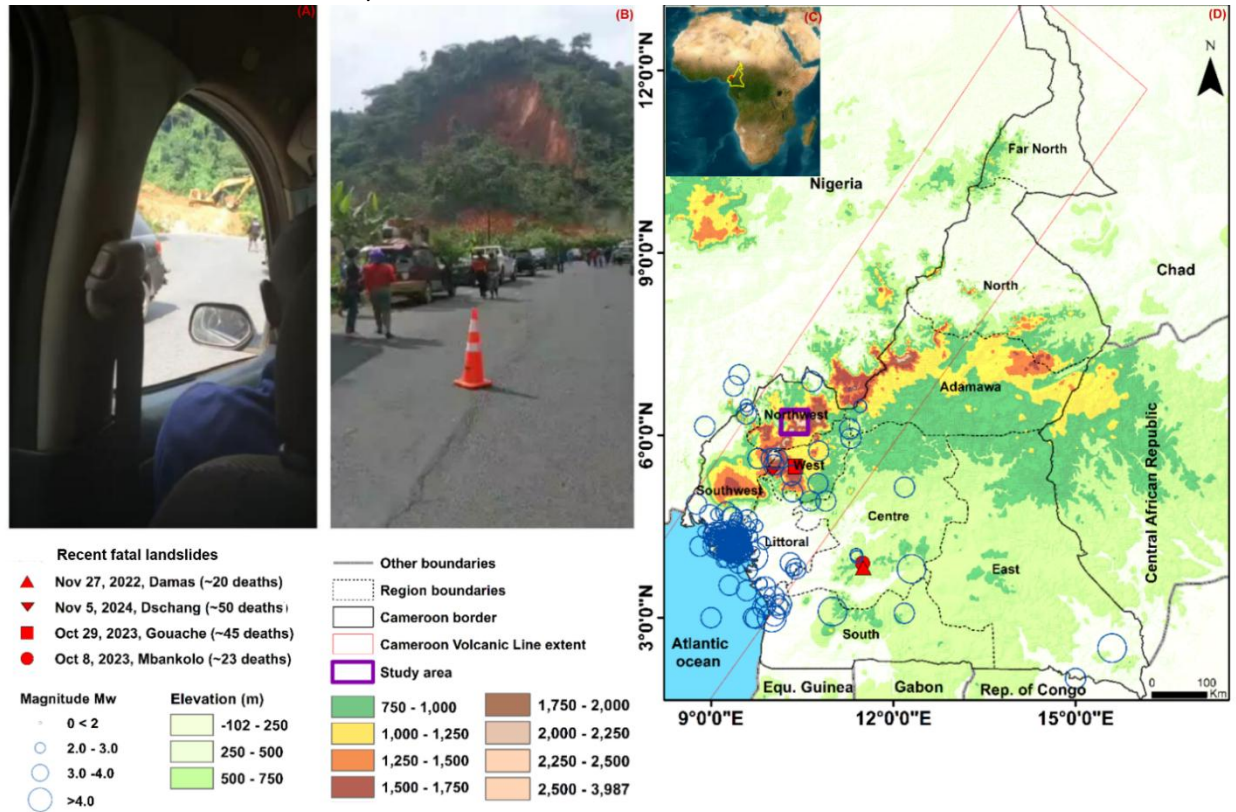


Fig. 1. Recent catastrophic landslides in Cameroon. (A) Passengers waiting for road clearance after the first landslide; (B) Panic among passengers following the second event in Dschang, West Region (November 5, 2024); (C) Regional location of Cameroon within Central Africa; (D) Map showing locations and death tolls from major recent landslides across Cameroon. Images in (A) and (B) were sourced from publicly shared social media footage, and (D) has been modified from Djukem et al. (2024).

2. Concise methods and results

2.1 Influence of soil and geo-environmental factors (2020 Study focus)

We compiled a landslide inventory by identifying and mapping 179 landslides (shallow to deep slides, debris flows, and complex slides) through field surveys with GPS and Google Earth multi-temporal imagery from 2009 to 2018. Eleven representative soil samples were collected from failure and non-failure sites at depths between 0.25 and 7.3 meters. The laboratory experiments conducted to determine the physical and mechanical behaviour of the soil included physical tests: particle and bulk density, moisture content, and grain size distribution, Atterberg limits and the Methylene Blue Value (MBV) to assess swelling potential. Mechanical tests included: Direct shear tests to calculate the intrinsic cohesion and internal friction angle. Geo-environmental parameters involved slope, elevation, land use, and



proximity to rivers and roads. Model performance was evaluated using ROC curves by comparing predicted landslide susceptibility values with observed landslide locations.

Results revealed that soils in the study area, developed mainly on weathered basalt and trachy-rhyolite, are dominated by highly plastic clays with high moisture content and strong swelling–shrinkage behaviour. Lithology is the dominant control on landslide occurrence, followed by slope angle and curvature (Fig. 9h, a, and g in Djukem et al., 2020). ROC validation shows that the geo-environmental model achieves 80% predictive accuracy, increasing to 93% when soil properties are included. Therefore, used alone, the soil model overclassified the area, mapping 99% as highly susceptible and failing to distinguish moderate or low susceptibility (See Figs. 10, 11 and 12 in Djukem et al., 2020). While inadequate on its own, soil data clearly increases predictive power, raising the accuracy from 80% (geo-environmental only) to 93% (combined model).

2.2 Seismic impact and combined triggers (2024 Study focus)

i. Methodology

In this study, the methodology was extended to distinguish between rainfall- and earthquake-triggered landslides using a combination of deterministic and statistical approaches. Climatic triggering was assessed with the Infinite Slope Model, which calculated the static factor of safety for six scenarios combining two sliding depths (3 m and 7.5 m) and three moisture conditions (dry, natural, and fully saturated). Seismic effects were evaluated using the Newmark displacement method, assuming a magnitude 5.2 earthquake at 10 km to estimate permanent slope displacements once critical acceleration was exceeded. Finally, K-means cluster analysis grouped observed landslides into three classes based on their proximity to ridges and rivers, helping to infer whether failures were more consistent with seismic (ridge-controlled) or rainfall-driven (river-controlled) triggering mechanisms.

ii. Influence of water saturation (climatic trigger)

The combined modeling and statistical analysis highlighted both climatic and seismic influences on landslides at Mount Oku. Water saturation strongly affects slope stability, particularly for deeper landslides. For deep-seated failures (7.5 m), sites stable under dry conditions largely became unstable when fully saturated, with the proportion of observed landslides in the unstable domain rising from 86% to 97%, indicating rainfall-induced groundwater rise is sufficient to trigger these failures. Shallow landslides (3 m) also showed increased instability under saturation, with instability rising from 50% to 65%, though many remained marginally stable or stable, implying that additional triggers are needed for failure (See Figs. 10 d, e, and f).

**iii. Evidence of seismic influence**

Newmark displacement analysis showed that a hypothetical M5.2 earthquake could trigger landslides, particularly on slopes already marginally stable. For shallow (3 m) landslides, some sites that remain marginally stable under saturated conditions exhibit high displacement values (>10 cm), indicating seismic acceleration could push them to failure (see Fig. 9. a and b in Djukem et al., 2024). Sankey diagram analysis further revealed that while saturation alone destabilizes some slopes, others with medium to high ND values remain marginally stable, suggesting a combined triggering effect where earthquakes act on slopes already weakened by rainfall (see Fig. 11 in Djukem et al., 2024).

iv. Landslide clustering and topographic patterns

K-means analysis grouped the 179 landslides into three clusters (see Figs. 12 and 13 in Djukem et al., 2024), revealing spatial patterns linked to different triggers:

- Cluster 1 (57%, 100 landslides): Close to both rivers and ridges; mixed or indeterminate trigger.
- Cluster 2 (12%, 21 landslides): Far from ridges but near rivers; likely rainfall-induced, reflecting failures from toe erosion and increased pore water pressure.
- Cluster 3 (31%, 54 landslides): Near ridges and far from rivers; likely seismic, consistent with earthquake-induced failures near crests and supported by medium to high Newmark displacements.

This clustering provides strong spatial evidence that both climatic and seismic factors contribute to landslide occurrence, with specific topographic settings favoring different triggers.

3. Conclusion

This work shows that landslide susceptibility at Mount Oku cannot be reliably assessed using geo-environmental factors alone. Adding soil geomechanical data clearly improves predictions and helps explain why some slopes fail while others remain stable. Lithology, slope angle, curvature, and soil cohesion and water content emerge as the strongest controls on slope failure. The combined FoS–Newmark and clustering analyses further reveal that landslides in the region are driven by interacting triggers: prolonged rainfall primarily controls deep-seated failures through soil saturation, while earthquakes can initiate or reactivate shallow landslides on slopes that are already marginally stable.

Beyond the Mount Oku case study, these results highlight the broader value of harmonized, multidisciplinary approaches to landslide assessment in Africa. Aligned with the objectives of the 4th African Regional IAEG Conference, “*Creating a Safer Future*,” this work illustrates how site-specific studies in Cameroon can fit into a continental vision that promotes shared methodologies, regional databases, and practical guidelines. Such collaboration is essential for shifting landslide management in



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Africa from reactive disaster response toward proactive risk reduction, improved land-use planning, and the development of effective early warning systems.

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Acknowledgments

Special thanks to the IAEG Young Engineering Geologists (YEG) Travel Grant and the IAEG Women in Engineering Geology (WEG) Scholarship for supporting my participation in the 4th IAEG African Regional Conference, held in Windhoek, Namibia (6–13 September 2025). I also gratefully acknowledge the Berlin Center for Global Engagement (BCGE) for funding my visiting research stay at Technische Universität Berlin (TU Berlin), Germany (14 September – 4 October 2025).

This work was carried out with the support of **Prof. Fan Xuanmei** (SKLGP, Chengdu University of Technology, China), **Dr. Anika Braun** (Engineering Geology, Technische Universität Berlin, Germany), **Dr. Armand Sylvain Ludovic Wouatong** (Department of Earth Sciences, University of Dschang, Cameroon), and **Prof. Hans-Balder Havenith** (Georisk & Environment Group, University of Liège, Belgium).

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