NATURAL HAZARDS

A more dynamic understanding of landslide risk

Changing social and biophysical dynamics, as well as data limitations, in the Kivu Rift in Eastern Africa make it difficult to plan for landslide risk. A study of historical remote sensing data identifies in detail the factors impacting the evolution of this risk.

Anthony Vodacek

In May 2021, the eruption of Nyiragongo Volcano near the Kivu Rift, between Rwanda, Burundi and the Democratic Republic of Congo (DRC), captured headlines due to the notorious hazard to the population in the region[1]. The geological rifting responsible for this and neighbouring volcanoes also created the highlands bordering the valley — a rugged terrain naturally susceptible to landslides, which are another ongoing, but less reported, hazard. To assess landslide risk, two research considerations are gaining importance: that land cover change and human settlements are dynamic; and that landslide susceptibility is an evolving phenomenon[2–4]. Writing in *Nature Sustainability*, Depicker and colleagues analyse the evolution of landslide risk since 1958 in the Kivu Rift, using archived aerial photographs and recent satellite data[5]. Their multi-component model advances landslide risk modelling by explicitly capturing the spatial and temporal dynamics over 58 years of population expansion and migration in this cross-border region. Their insights can be used to strengthen policies regarding regional environmental protection and sustainable development.

Deforestation is a key driver of landslides in developing regions, especially in the first 15 years after removing the tree cover[6,7]. Once deforested, heavy rain is usually directly responsible for initiating landslides. The main driver of deforestation in the Kivu Rift is agricultural expansion. Regional armed conflict, mining and population growth have also pushed people to clear hillside forests for subsistence farming[8]. The three countries in the Kivu Rift differ in their historical trajectories, so the region is particularly suitable to understand how social dynamics affect spatio-temporal landslide evolution.

Depicker and colleagues focus on the mortality risk of landslides. For example, in recent years approximately 50 deaths from landslides have been reported annually on the Rwandan side. While an underestimation, assuming this number has remained stable since the 1970s, the cumulative number of fatalities in Rwanda alone would be larger than the more dramatic loss of life reported from the Nyiragongo eruptions in 1977, 2002 and 2021[9]. Adding in Burundi and especially the DRC, where most regional deforestation is now occurring, it is reasonable to presume the number of annual deaths due to landslides in the Kivu Rift is in the hundreds.

Credit: Anthony Vodacek

Landslide risk is a product of population density and hazard. To estimate risk, Depicker and colleagues follow a multi-step modelling process[5]. Using historical aerial and satellite remote sensing data, they develop a new model of deforestation and afforestation that they incorporate in an existing landslide susceptibility model[4]. The historical aerial photographs from 1958 have approximately 1 m ground resolution. This unique aerial photography dataset enables a much longer and more accurate record of forest cover change and of associated landslide response to calibrate the forest cover model. They then use an inventory of landslides derived from fine-resolution remote sensing data from 2001 to 2016 along with forest cover change over the same interval to calibrate the landslide susceptibility model[7]. Next, they compute hazard as the probability of landslide occurrence within a certain time frame and area, again using their inventory of landslide observations for calibration. Finally, they calculate risk as the product of hazard and exposure, with the latter based on population density[10].

The risk estimates Depicker and colleagues report depend on the timing and patterns of observed deforestation and afforestation in each country for the period of the study[5]. The DRC carries most of the current risk, in part because more of the population live on very steep terrain. The lower risk in Rwanda and Burundi is a result of fewer people living on the steepest terrain and most deforestation having occurred before the time period of the study.

The work opens a few questions. The full time range in the model is calibrated with data from certain time intervals, therefore the model assumes that other periods throughout the decades show a similar response to that of the observations used for calibration. Testing the calibration method across time intervals at other sites would increase confidence in the method. Further, vulnerability in terms of mortality is assumed to be linearly related to exposure to a landslide, based on presumed poor-quality housing, and lack of early warning systems and of mobility. A study of vulnerability for the population in this region could clarify whether other factors mitigate this relationship.

Making the high-quality aerial photographic dataset used in this study open access in March 2022 will be a welcome addition to the remote sensing data of this region, and will enable further study of regional landslide risk as well as new studies in other fields such as conservation and social dynamics.

The work of Depicker and colleagues advances our understanding of landslide susceptibility and risk in an understudied yet dynamic region with significant risk to the population[5]. Their methodology comprehensively integrates forest dynamics and societal dimensions, two factors that impact risk; their risk modelling approach can inform further assessments elsewhere. Their results transform scientific knowledge into accessible information to support decision-making and communication to the broader public. This work provides insights to help set development policies that can improve sustainability while saving lives. ❐

Anthony Vodacek ✉
Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY, USA.
✉*e-mail: axvpci@rit.edu*

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References

1. Mount Nyiragongo: DR Congo residents flee as volcano erupts. *BBC News* (23 May 2021); https://www.bbc.com/news/world-africa-57215690
2. Mugagga, F., Kakembo, V. & Buyinza, M. *Catena* **90**, 39–46 (2012).
3. Ray, R. L., Jacobs, J. M. & Ballestero, T. P. *Nat. Hazards* **59**, 1317–1337 (2011).
4. Broeckx, J. et al. *Landslides* **16**, 571–584 (2019).
5. Depicker, A. et al. *Nat. Sustain.* https://doi.org/10.1038/s41893-021-00757-9 (2021).
6. Lehmann, P., Von Ruette, J. & Or, D. *Water Resour. Res.* **55**, 9962–9976 (2019).
7. Depicker, A. et al. *Earth Surf. Dyn.* **9**, 445–462 (2021).
8. Butsic, V., Baumann, M., Shortland, A., Walker, S. & Kuemmerle, T. *Biol. Conserv.* **191**, 266–273 (2015).
9. Pouclet, A. & Bram, K. *Bull. Volcanol.* **83**, 1–35 (2021).
10. *GHS Population Grid, Derived from GPW4, Multitemporal (1975, 1990, 2000, 2015)* (JRC & CIESIN, accessed 23 July 2021); https://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs_pop_gpw4_globe_r2015a

Competing interests

The author declares no competing interests.