Adopting rainfall threshold analysis for landslides in Central Africa using satellite rainfall estimates

Monsieurs Elise1,2,3, Dewitte Olivier1, Kirschbaum Dalia4, Demoulin Alain2,3

**CONTEXT**

- Rainfall thresholds are the most used instrument in landslide hazard assessment and early warning tools.
- Improvements have been made towards more reproducible techniques for the identification of triggering conditions for landsliding, and standardized threshold calibrating techniques.
- The now well-established rainfall intensity or event – duration thresholds for landsliding suffer from several limitations.
- No threshold mapping involving landslide susceptibility as a proxy integrating the causative ground factors has been proposed to date beyond local-scale physically-based models.
- Rainfall threshold research is almost nonexistent in Africa, related to the dearth of data on timing and location of landslides.

**OBJECTIVES**

- Improve the frequentist method for rainfall threshold definition.
- Account for more than solely the aspect of rainfall characteristics in the threshold analysis.
- Make the approach applicable in regions with limited rainfall gauge data.
- Provide the first regional rainfall thresholds for landsliding in tropical Africa.

**LANDSLIDE CAUSE**

- Regional ground conditions affect the meteorological conditions required for landsliding.
- We adopt here the landslide susceptibility model proposed by Broeckx et al. (2018), produced through logistic regression (4:1 L:NL ratio) including topography, lithology, peak ground acceleration and precipitation.
- This avoids problems of data subsetting in regions with limited data when regionalizing the input data according to individual predisposing factors.

**ANTECEDENT RAINFALL THRESHOLDS**

- We identify the first rainfall thresholds for landsliding in the western branch of the East African Rift. The obtained AR thresholds are physically meaningful and range, without correction for satellite rainfall underestimation, from 9.5 mm to 23.1 mm for an exceedance probability of 5%.
- The applied method has the main advantage of directly mappable susceptibility-dependent rainfall thresholds.

**LANDSLIDE TRIGGER**

- Infiltration depth and, thus, residence time of the rain water in the soil increase with daily rainfall. We take this into account by introducing also daily satellite rainfall estimates (TUMPA 3B42 RT) in the filter function and expressing antecedent rainfall (AR) in the form of an exponential function of time t, over a period empirically fixed to the preceding n days:

\[ AR_t = \sum_{k=0}^{n} e^{-\alpha t} x \cdot F_k \]

- AR is calculated over a period of six weeks. A fairly long period is required because all landslide types are included in the data set, including large-scale and deep rotational slope failures.

**FUTURE WORK**

- Regionally-focused susceptibility maps
- Higher resolution Satellite Rainfall data (IMERG)
- Larger landslide database, allowing for:
  - Threshold validation;
  - Distinction of landslide types and hence;
  - Calculation of adapted thresholds

**REFERENCES**

- Monsieurs Elise, Dewitte Olivier, Kirschbaum Dalia, Demoulin Alain

**CONTACT**

elise.monsieurs@africamuseum.be

---

**MAP**

- Landslides in the western branch of the East African Rift (WEAR)
- Antecedent rainfall thresholds
- Landslide trigger framework
- Modified frequentist approach for threshold calibration
- Cause-Trigger framework

---

**ANALYSIS**

- Rainfall thresholds are the most used instrument in landslide hazard assessment and early warning tools.
- Improvements have been made towards more reproducible techniques for the identification of triggering conditions for landsliding, and standardized threshold calibrating techniques.
- The now well-established rainfall intensity or event – duration thresholds for landsliding suffer from several limitations.
- No threshold mapping involving landslide susceptibility as a proxy integrating the causative ground factors has been proposed to date beyond local-scale physically-based models.
- Rainfall threshold research is almost nonexistent in Africa, related to the dearth of data on timing and location of landslides.

**RESULTS**

- Regional ground conditions affect the meteorological conditions required for landsliding.
- We adopt here the landslide susceptibility model proposed by Broeckx et al. (2018), produced through logistic regression (4:1 L:NL ratio) including topography, lithology, peak ground acceleration and precipitation.
- This avoids problems of data subsetting in regions with limited data when regionalizing the input data according to individual predisposing factors.

**Conclusions**

- The applied method has the main advantage of directly mappable susceptibility-dependent rainfall thresholds.
- The first rainfall thresholds for landsliding in the western branch of the East African Rift have been established, representing a significant step forward in understanding the triggering mechanisms of landslides in this region.

---

**Acknowledgments**

- Support from the Flemish government (FWO) and the Belgian Science Policy Office (Belspo) is greatly acknowledged.
- The authors would like to thank all the researchers and practitioners who contributed to the data collection and analysis.

---

**Supporting Information**

- Monsieurs Elise, Dewitte Olivier, Kirschbaum Dalia, Demoulin Alain
- Contact: elise.monsieurs@africamuseum.be