

Rainfall thresholds for precipitation-triggered landslides in Georgia considering climatic zoning

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Georgia is characterized by highly dissected topography and pronounced climatic diversity; consequently, hillslope processes—including landslides—constitute one of the country's primary natural hazards. The objective of this study is to estimate empirical threshold values of landslide-triggering antecedent cumulative rainfall for multiple temporal windows (R1–R30), using a landslide catalogue and daily precipitation records from meteorological stations. Rainfall thresholds are widely applied in landslide hazard assessment and early warning systems; however, their reliability depends on the correct delineation of rainfall events, the spatial configuration between landslides and meteorological stations, and the overall quality of the underlying datasets.

Landslide information was compiled from bulletins of the National Environmental Agency; only date-specific and independently verified cases were retained for analysis. The final working catalogue comprises $N = 519$ dated landslides. Each event was paired with the nearest hydrometeorological station, and antecedent cumulative precipitation was computed for the R1–R30 intervals. Statistical evaluation was performed for the $\text{Dist} \leq 15$ km subset ($n = 373$). Based on the Köppen–Geiger climate classification, each event was assigned a corresponding climate class extracted from a categorical raster. Climate classes were subsequently aggregated into three operational groups (Group1–Group3); Group4 was excluded due to insufficient sample size.

Thresholds were derived using **empirical percentiles (P05, P10, P25, P50)** for each temporal interval and group. Results indicate that for short accumulation windows (R1–R5), lower percentiles frequently yield 0 mm, whereas more stable indicators emerge for longer windows, particularly R20 and R30. For example, within the $\text{Dist} \leq 15$ km subset, Group2 yields **R20: P10 = 29.48 mm; P25 = 50.30 mm; P50 = 80.95 mm and R30: P10 = 46.60 mm; P25 = 78.85 mm; P50 = 117.30 mm. For Group3, R20: P10 = 16.02 mm; P25 = 32.18 mm; P50 = 61.35 mm and R30: P10 = 32.68 mm; P25 = 50.23 mm; P50 = 93.70 mm.** The derived percentiles were validated via coverage control (e.g., an expected exceedance of approximately 0.90 for P10), confirming the internal consistency of the computed ranges and procedures.

This study establishes rainfall-duration (R–D) thresholds for Georgia stratified by climatic zones, and may serve as an initial quantitative basis for a multi-level landslide early warning system. However, robust evaluation of real-world predictive skill requires inclusion of non-event (no-event) cases—i.e., rainfall episodes that did not trigger landslides.

References

Caine, 1980; Guzzetti et al., 2007; Segoni et al., 2018; Peel et al., 2007; Beck et al., 2018; Keggenhoff et al., 2014; Varazanashvili et al., 2012; Amiranashvili et al., 2020.