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Multi-scale risk assessment as a component to the national system for multi-hazard risk assessment in Cuba

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Landslides cause a considerable amount of damage in the mountainous regions of Cuba, which cover about 25% of the territory. Until now, only a limited amount of research has been carried out in the field of landslide risk assessment in the country. This research presents a methodology and its implementation for spatial landslide risk assessment in Cuba, using a multi-scale approach at national, provincial, municipal and local level. At the national level a landslide risk index was generated, using a semi-quantitative model with 10 indicator maps using spatial multi-criteria evaluation techniques in a GIS system. The indicators standardized were weighted and were combined to obtain the final landslide risk index map at 1:1,000,000 scale. The results were analysed per physiographic region and administrative units at provincial and municipal levels. The hazard assessment at the provincial scale was carried out by combining heuristic and statistical landslide susceptibility assessment, its conversion into hazard, and the combination with elements at risk data for vulnerability and risk assessment. The method was tested in Guantánamo province at 1:100,000 scale. For the susceptibility analysis 12 factors maps were considered. Five different landslide types were analyzed separately (small slides, debrisflows, rockfalls, large rockslides and topples). The susceptibility maps were converted into hazard maps, using the event probability, spatial probability and temporal probability. Semi-quantitative risk assessment was made by applying the risk equation in which the hazard probability is multiplied with the number of exposed elements at risk and their vulnerabilities. At the municipal scale a detailed geomorphological mapping formed the basis of the landslide susceptibility assessment. A heuristic model was applied to a municipality of San Antonio del Sur in Eastern Cuba. The study is based on a terrain mapping units (TMU) map, generated at 1:50,000 scale by interpretation of aerial photos and satellite images and field data. Information describing 603 terrain units was collected in a database. Landslide areas were mapped in greater detail to classify the different failure types and parts. The different landforms and the causative factors for landslides were analyzed and used to develop the heuristic model. The model is based on weights assigned by expert judgment and organized in a number of components. At the local level, digital photogrammetry and geophysical surveys were used to characterize the volume and failure mechanism of the Jagüeyes landslide at 1:10,000 scale. A runout model was calibrated based on the runout depth in order to obtain the original parameters of this landslide. With these results three scenarios with different initial volume were simulated in Caujerí scarp at the scale of 1:25,000 and the landslide risk for ninety houses was estimated considering their typology and condition. The methodology developed in this study can be applied in Cuba and integrated into the national multi-hazard risk assessment strategy. It can be also applied, with certain modifications, in other countries.