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Landslide Susceptibility Mapping in Lunar South Pole Region

Landslides represent one of the most hazardous geological phenomena affecting both the Earth and other celestial bodies in the solar system. These events, characterized by the rapid destructive movement of either rock or soil material along slopes, have always sparked the interest and study of scientists, as they can have shocking consequences on the environment and the utilisation of affected areas. However, while terrestrial landslides are well-documented and studied, their study on extraterrestrial planets and satellites poses a quite unique challenge. Understanding the mechanisms and causes of landslides at a planetary scale, not only provides us with valuable information about the history and evolution of those celestial bodies, but it can also help to assess risks and opportunities for future space exploration. During these initial months of PhD studies, the investigation of landslide phenomena has involved the Moon surface with a particular focus on the Southern Pole. The Lunar South Pole Region (LSPR) has garnered increasing attention due to its geological features, including permanently shadowed regions (PSRs) and volatile deposits such as water ice. The rugged terrain and the dynamic geological processes represent significant challenges for future missions aiming at exploring and utilising lunar resources. In this research work, a Landslide Susceptibility Map (LSM) was created starting from an inventory consisting of 47 gravitational events that were mapped through the photointerpretation of data from the Lunar Reconnaissance Orbiter (LRO) mission. Landslide locations were divided into 70% training and 30% validation datasets. Then, the Frequency Ratio (FR) model was applied to evaluate the landslide triggering factors and to generate the LSM. When creating the latter, it is crucial to consider both the contributing factors, which influence the predisposition of an area to geomorphological phenomena over long periods, and the triggering ones, which are short-term events that can originate landslides. Causative factors, represented by geological and morphological characteristics of an area, were derived from existing cartography and by the elaboration of Lunar Orbiter Laser Altimeter (LOLA) Digital Elevation Model (DEM – 118 m/pixel spatial resolution) within ESRI ArcGIS Pro software. Considering similar studies already carried out on the Earth, many authors have analysed the contribution of heavy rainfall (Gao et al., 2024) and earthquakes (Chen et al., 2022) as landslide triggering factors. Similarly, on the Moon, in the absence of rainfall, recent scientific papers (ex. Watters et al., 2024; Mishra & Kumar, 2022), assert that moonquakes, produced by lobate thrust fault scarps movement, have the greatest impact on regolith landslides that are triggered in the steep slopes of impact craters. In particular, to include the contribution of moonquakes into the FR model, it was decided to consider the variation of the Peak Ground Acceleration (PGA) as a function of epicentral distance, as suggested by Watters et al. (2024) and Mishra & Kumar (2022). Since PGA reaches not-significant level (~0.03 g) at farther distances, it was decided of sampling four different distances (i.e., 3, 12, 30, and 70 km) to locate shallow moonquakes of, respectively, 1, 2, 3, and 4 moment magnitude (Mw). Taking this into account, four buffer zones around the fault scarps, designated as seismic hazard zones, were defined within ESRITM ArcGIS Pro environment. Once the causative and triggering factors were implemented into the model and the LSM was produced, its accuracy was assessed by using the Area Under the Curve (AUC) method.

The study of landslide susceptibility allowed to identify the geological formations most susceptible to seismic-induced failures and it enabled to evaluate the safety conditions, not only for the sites chosen for the Artemis lunar mission landing, but also for future missions. Future developments of this work will involve: i) the integration of additional information, such as temperature variations in permanently shadowed areas; ii) the use of more accurate predictive models (ex. Weight of Evidence, Random Forest) to enhance the comprehensiveness of landslide susceptibility mapping; iii) a large-scale three-dimensional slope stability analysis in LSPR using engineering-geological data provided by past missions (ex. Luna 13, Apollo 11), iv) the application of this method to other celestial bodies (ex. Mars).

In conclusion, the methodology developed in this study provided a starting framework for evaluating landslide dynamic on celestial bodies, utilizing available data to deepen our understanding of geological hazards beyond Earth.

REFERENCE

Gao, B., He, Y., Chen, X., Chen, H., Yang, W., & Zhang, L. (2024). A deep neural network framework for landslide susceptibility mapping by considering time-series rainfall. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing;

Chen, S., Miao, Z., Wu, L., & He, Y. (2020). Application of an incomplete landslide inventory and one class classifier to earthquake-induced landslide susceptibility mapping. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13, 1649-1660;

Watters, T. R., Schmerr, N. C., Weber, R. C., Johnson, C. L., Speyerer, E. J., Robinson, M. S., & Banks, M. E. (2024). Tectonics and Seismicity of the Lunar South Polar Region. The Planetary Science Journal, 5(1), 22;

Mishra, A., & Senthil Kumar, P. (2022). Spatial and Temporal Distribution of Lobate Scarps in the Lunar South Polar Region: Evidence for Latitudinal Variation of Scarp Geometry, Kinematics and Formation Ages, Neo-Tectonic Activity and Sources of Potential Seismic Risks at the Artemis Candidate Landing Regions. Geophysical Research Letters, 49(18).

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