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Application of a Geospatial Model to Map Gully Risks in the Region of São João del Rei, Brazil, Based on Geographical Information System and Logistic Regression

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Deforestation is one of the factors that have contributed to the increase in erosion and the intensification of geomorphological processes in several regions of Brazil. The region of São João del Rei, located in southeastern Brazil, is geographically characterized by the occurrence of several erosive processes. Recent surveys conducted in this region have mapped 391 gullies of different sizes. This paper presents a geospatial model for mapping the gully occurrence risk in São João del Rei constructed with the QGIS 2.18 software, topographic data, orbital image data and logistic regression. The risk model uses six spatial variables: vegetation index (VI), slope (SLO), distance to roads (ROD), distance to rivers (RID), altitude (ELV) and river density (RIDE). The maps of the SLO and ELV variables were constructed from ASTER GDEM2 images. For the construction of the distance surface maps (ROD and RID), we used vector data from digitized topographic maps. The vegetation index map was constructed from OLI-Landsat spectral data using the NDVI algorithm. First, the polygons of a sample containing 218 gullies were mapped using Google Earth™ images. Next, the centroids of these polygons were mapped, and a point map was created that referred to the location of each gully. Then, a map of 218 control points, which were randomly distributed in the study area and located in areas without gullies, was created. Five hundred-meter buffers were drawn around the points with gullies and the points without gullies. Within the buffers areas, medians were extracted from the values of the six model variables. These values were analysed by logistic regression, considering the occurrence of gullies to be a dependent and dichotomous variable (Y = 1 or Y = 0). The other spatial variables were considered independent. The logistic regression results showed that the variables RIDE ($p < 0.0001$, OR = 0.9998); ROD ($p = 0.0003$, OR = 0.9993); VI ($p = 0.0007$, OR = 0.0003); SLO ($p = 0.0055$, OR = 0.8663); RID ($p = 0.0265$, OR = 0.9960) and ELV ($p = 0.0241$, OR = 1.0059) contributed significantly to the prediction of gully occurrence. The risk model was based on the mapped probability (p) of a gully occurring in a pixel. For the construction of the risk map, probability (p) equation was introduced in the Raster Calculator module of QGIS. The map legend represented the gully occurrence probability values. The results show that this methodology can be used to map areas susceptible to erosive processes located in regions that do not have detailed soil maps.