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Machine learning applied to soil erosion analysis in sub-watersheds with burned areas

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Soil erosion increases after forest fires contributing to the mobilization, transport, and deposition of sediments and nutrients in watersheds. This scenario interferes with water quality. Faced with a climate change scenario, forest fires in the Mediterranean region tend to increase, consequently, soil erosion must increase together, aggravating water availability. Measures to minimize the effects of soil erosion in watersheds must be used to guarantee the water security of the population and protected areas play an important role in this context. This study analyzed 761 sub-watersheds in northern Portugal, to evaluate machine learning models in watersheds with recurrent fires. The analyzed area has a high recurrence of forest fires and where important districts of the country such as Porto and Braga with high population density are located, in addition to protected areas where springs of watercourses that integrate important watersheds such as Douro, Cávado, Ave, and Mondego. The parameters analyzed were: total burned area of the sub-watershed in the period 1975-2020 (variable target), soil erosion by water in Europe - Revised Universal Soil Loss Equation (RUSLE2015), Topographic Wetness Index (TWI), and the morphometric parameters: Area (A), Perimeter (P), Length (L), Width (W), Orientation (O), Elongation ratio (Re), Circularity ratio (Rc), Compactness coefficient (Cc), Form factor (Ff), Shape factor (Sf), Altitude, Slope, Curvature. These data was analyzed with the machine learning Generalized Linear Models (GLM), Support Vector Machine Linear (SVMLinear), Support Vector Machine Polynomial (SVMPoly) and Random Forest (RF). The analysis was developed in R language using the classification and regression training caret package. The average R^2 for each model was RF (0.97), SVMpoly (0.96), SVMLinear (0.78) and GLM (0.78). In an analysis of boxplot plots of R^2, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) the RF and SVMpoly models recorded lower dispersion of R^2 and lower values of MAE and RMSE. While the GLM and SVMlinear models showed greater data dispersion in the three accuracy measures of the models. Regarding the analyzed parameters, those that registered the greatest importance were A, Cc, P, Rc, W, RUSLE2015, and TWI, indicating that an analysis that considers morphometric parameters, together with soil erosion data by water and soil moisture is an

important indicator in the analysis of soil erosion in watersheds. The study was developed within the scope of the CLICTOUR project (Project NORTE-01-0145-FEDER-000079), supporting fund European Regional Development Fund.

Keywords: Soil erosion, sub-watersheds, machine learning, burned areas, water security.