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UAV-based erosion mapping and modelling for the preservation of terraced cultural landscapes in northern Italy

Anton Pijl (1), Edoardo Quarella (1), Lara Reuter (2), Teun Vogel (2), and Paolo Tarolli (1)

(1) Department of Land, Environment, Agriculture and Forestry, University of Padova, Italy (anton.pijl@phd.unipd.it), (2) Soil Physics and Land Management Group, Wageningen University, The Netherlands

The rise of affordable high-accuracy remote sensing techniques such as the Unmanned Aerial Vehicle (UAV) facilitates erosion mapping in agriculture and detailed identification of land degradation patterns. UAV-based topographic data can serve as direct input for spatial erosion models, and auxiliary spatial information (e.g. land cover) can also be determined in such surveys. In this study, several terraced vineyards were analysed in northern Italy, representing a valuable but threatened Mediterranean cultural landscape type. Soil loss rates and spatial erosion patterns were simulated in a GIS environment by applying the Revised Universal Soil Loss Equation (RUSLE) and SIMulated Water Erosion (SIMWE) model. Surveys were carried out using a DJI Mavic Pro® micro-drone resulting in high-resolution Digital Elevation Models with centimetric accuracy through Structure-from-Motion (SfM) photogrammetry. Additional model input data were based on existing local datasets (e.g. rainfall, soil properties) of which some were downscaled using field observations.
Model simulations revealed interesting spatial erosion patterns caused by land management approaches (e.g. wheel tracks, soil cover, conservation structures) and different terrace designs. Dry-stone wall terraces (orthogonal) showed limited runoff and sediment fluxes, but are known to being inherently unstable when overly saturated. Earth bank terraces (inclined) showed progressive surface fluxes downstream, leading to flow concentration and rill and gully patterns, validated by field observations. Cultivation along the slope direction (no terraces) showed soil loss distributed across the hillslope, but with critical concentration patterns wherever vine rows converge, matching field-observed rills and gullies. Soil and water conservation structures (sediment traps and channels) were shown to partially mitigate the latter effect. The results show how high-resolution topography data and spatial erosion modelling can provide diverse insights in the degradation problems related to different agricultural strategies. RUSLE is generally more adoptable in terms of requirements of input data and computational capacity, due to its empirical nature. The physically based SIMWE, on the other hand, provides temporal simulations and has stricter requirements, yet produces erosion patterns closer to field observations (i.e. ponding and downhill propagation of fluxes). Preservation plans for cultural landscapes can be supported by such a quantified impact assessment of agricultural practices on land degradation.