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Assessment of dry-stone terrace wall degradation with a 3D approach

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In the Mediterranean basin, terracing is a common element of agricultural lands. Terraces retained by dry-stone walls are used to conserve arable soil, delay erosion processes and retain rainfall runoff. Currently, agricultural land abandonment is widespread in the Mediterranean region leading to terrace wall failure due to lack of maintenance and consequently an increase in soil erosion. The objective of this study is to test the applicability of digital 3D documentation on mountainous agricultural areas for assessing changes in terrace wall geometry, including terrace wall failures and associated soil erosion. The study area is located at 800-1100 m above sea level, in the Ophiolite complex of the Troodos Mountains in Cyprus. Average annual precipitation is 750 mm. Two sites with dry-stone terraces were selected for this study. The first site had a sequence of three terrace walls that were surveyed. The uppermost terrace wall was collapsed at several locations; the middle at few locations; and the lowest was still intact. Three fieldwork campaigns were conducted at this site: during the dry season (initial conditions), the middle and end of the wet season. The second site had one terrace wall that was almost completely collapsed. This terrace was restored during a communal terrace rehabilitation event. Two fieldwork campaigns were conducted for this terrace: before and after the terrace wall restoration. Terrace walls were documented with a set of digital images, and transformed into a 3D point cloud (using web-based services and commercial software – Autodesk 123D catch and Menci Software uMap, respectively). A set of points, registered with the total station and geo-referenced with a GPS, enabled the scaling of the 3D model and aligning the terrace walls within the same reference system. The density (distance between each point) of the reconstructed point clouds is 0.005 m by Umap and 0.025 m by 123D Catch. On the first site, the model analysis identified wall displacements between 3 and 8 cm on 1% of the middle terrace wall. High displacement values (> 8-10 cm) were associated with presence or removal of vegetation and/or data gaps. On the second site, the 3D models indicated that the collapsed terrace had lost a volume of 1.9 m3, which was restored during the communal terrace building event. This digital 3D documentation approach is more economical than laser scanning and it is a promising method for assessment of terrace wall displacement and changes after terrace wall restoration.