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Erosion mapping using LIDAR and RUSLE technique for landscape management in the island of Gozo, Malta.

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BACKGROUND

The Ramla valley was chosen on the basis of its unique geology, geomorphology, fertility, sandy beach and associated sand dunes, making it an important area for conservation and recreation. The site, located on the northeast of the island of Gozo is a dry, stream-cut valley formed by the recession of the edges of the Coralline plateaux by the undermining action of water, and by the weathering and erosion of Blue Clay slopes as a result of exfoliation and splash and running water. The valley has a catchment area of approximately 6 km^2, with a source at Ta' Bordin to the North of Għajnsielem at an elevation of about 90m. The valley is one of Gozo's major drainage systems, with a 3km-long axial watercourse complimented by no less than 6 tributaries.

MAIN OBJECTIVES

- To use, for the first time national (a) high resolution aerial orthophotography and (b) 1m LIDAR data to measure the degree of soil loss at the study site, and
- To use GIS and remote sensing data to synthesise input parameters into the RUSLE equation to measure soil erosion based on raster analysis instead of the traditional point analysis.

METHODOLOGY

The RUSLE equation consist of 5 components: R factor (the rainfall and runoff factor), the K factor (the soil erodibility factor), the LS factor (the slope length-gradient factor), the C factor (the crop/vegetation and management factor) and the P factor (the support practice factor).

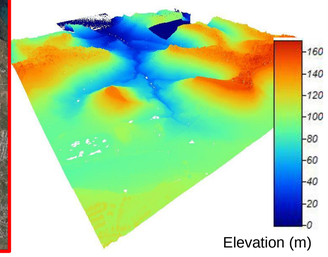
Using ArcGIS, information for the C and P factors were extracted by photo-interpreting and vectorising details from 11 orthophotos captured during 2011 covering the catchment area. The R factor was based on the rainfall data collected by a weather station located nearby. The LS factor was derived on the basis of the national 1m LIDAR data collected during 2011.

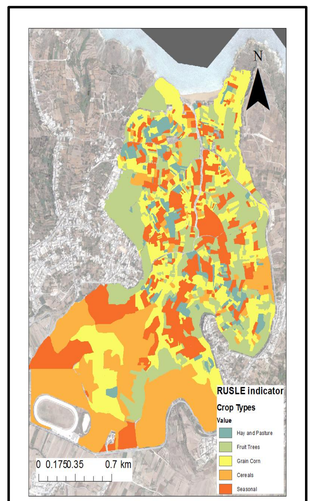
Information for the K factor were derived on the basis of geolocated *in situ* soil samples and laboratory characterisation of soil type. A GIS vector map covering the entire catchment area was derived based on the soil type identified and its distribution.

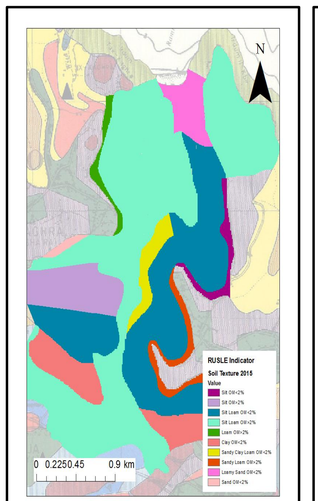
ArcGIS and SAGA GIS were used as tools to rasterize all the georeferenced vector layers to 1m pixel resolution, overlay the individual raster layers and calculate soil loss according to the RUSLE equation [A= R.K.L.S.C.P] using image algebra. A new raster layer was produced that represented the geographical distribution of the estimated rate of soil loss for the catchment area.

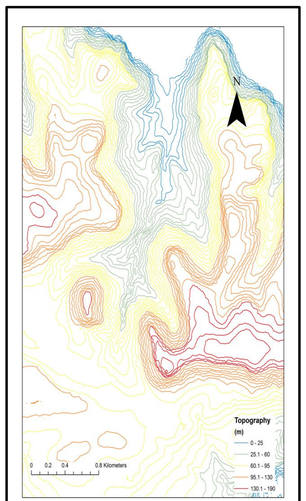
RESULTS

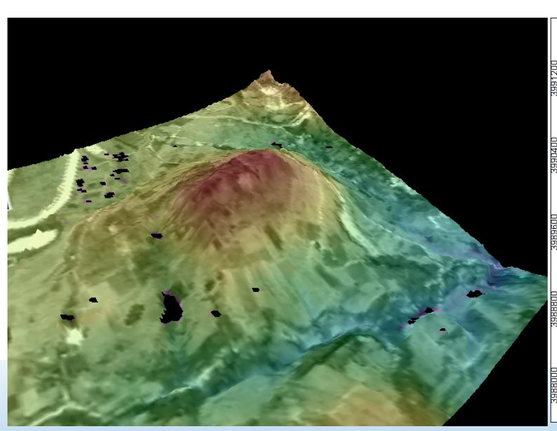
The soil erosion map produced for the Ramla catchment area shows locations that range from a low to high rate of around 110 tons/ha/year. The highest rate of soil loss were located at in-Nuffara hill, which has fallow field slopes that lack proper maintenance of rubble walls . The hill is also exposed to off-roading practice, which in combination with unsuitable soil conservation structures, are contributing to higher soil erosion. The soil loss at both Nadur and Xaghra headlands was also high, with a value of 83 tons/ha/year and 85 tons/ha/year respectively.

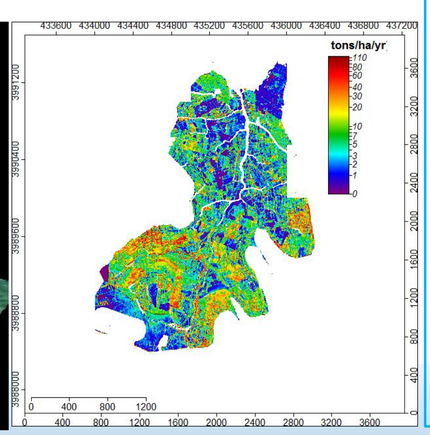












LIMITATIONS

These included (1) analysis of a restricted number of soil samples, which limited a higher definition of the soil type distribution in the study area, (3) applying standard RUSLE classification to local crop variety and soil tillage practices used to estimate C and P factors, and (3) collection of rainfall data from a single, nearby weather station.

MAIN FINDINGS

- Very few quantitative studies have been done on soil loss over the Maltese Islands. This study is the first investigation using the RUSLE technique and which was based on remote sensing and GIS analysis over a relatively large area.
- Soil loss within the Ramla catchment area takes place at a variety of rates with the highest rate of 110 tons/ha/year, based on 2011 data.
- Significant erosion takes place at in-Nuffara hill, which was estimated to be around 110 tons/ha/year. Factors such as motorcycle off-roading that is practised on its slopes, together with the presence of fallow fields around the hill make the soils more susceptible to erosion.
- Other problematic areas include the Nadur and Xagħra headlands, each with 85 and 83 tons/ha/year respectively. Their slopes are made up of blue clay and silty soils which make the soil more susceptible to erosion.

MAIN RECOMMENDATIONS

- The use of soil erosion models that could be more suitable for the Maltese landscape (such as Water Erosion Prediction Project) is advisable.
- Adaptive measures could include the maintenance of wall terraces, the routing of field runoff water, and awareness-raising activities on soil conservation practices.
- Initiation of a comprehensive project to monitor and measure *in situ* soil erosion at key sensitive points to verify the estimated soil loss produced by this study.
- It is important to maintain a crop-history database as a basis for a much needed assessment of agriculture practices at the area, aimed at monitoring and limiting further soil erosion, site management and conservation.

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