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Object-based gully feature extraction using high spatial resolution imagery

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Sustainable land management fundamentally requires understanding of the landscape, its status and the effects of ongoing processes, for which an efficient way of understanding, surveying and monitoring is needed. Given that gullies are one of the main drivers for soil loss in the system, there is an imperative need for detailed monitoring and better prediction of the gully locations.

The gully features considered in the study are narrower and deeper (width less than 10 m, that are not often identified in low resolution imagery) when compared to the river bank gullies (alluvial gully) that are larger in area, i.e. 100 m2 to 1 km2, and with widths ranging from 20 m up to 140 m (Knight et al., 2007; Perroy et al., 2010). This constitutes a real challenge for the semi-automatic detection of gullies, not only because of the size, shape and occurrence of gullies, but also due to the presence of a variety of overlapping land cover and land use, shadow and illumination variation. This study attempts to address the following problems:
1. Mapping gullies/gully systems through field work and manual image digitization is difficult and time consuming.
2. There is a lack of a generic algorithm to identify gullies from images.

This paper investigates the use of object-oriented image analysis (OOA) to extract gully erosion features from satellite imagery, using a combination of topographic, spectral, shape (geometric) and contextual information obtained from IKONOS and GEOEYE-1 data. A rule-set was developed and tested for a semi-arid to sub-humid region in Morocco. Feature extraction was carried out in eCognition Developer 8 that uses an object-oriented approach for semi-automated image analysis. The use of OOA to map gullied areas was based on thresholds with a physical meaning (slope, specific catchment area, NDVI) and satellite image-derived information (in particular texture, contrast, and edge).

The total area affected by gullying was estimated at approximately 8% and 18% of the total area in training and validation site respectively. When assessing the accuracy of detected gullies/gully systems it must be remembered that even a relatively low erosion level, renders the land around the gullies useless for any other landuse activity, effectively turning them into badlands. While a visual assessment indicated good detection of gullies, analysis of feature extraction accuracy or measure of acceptability, and evaluation of error sources and uncertainties were essential. Hence, a comparison of the gully system area for two sub-watersheds with different gully systems, one of which is simple and continuous (sw11) and another of which is complex and discontinuous (sw12) was performed. The percentage of gully system area indicated a negligible over estimation (between reference area and OOA area) in two sub-watersheds - 0.03% (sw11) and 1.77% (sw12). We also observed that finer gully-related edges within the complex gully systems were better identified semi-automatically than was possible by manual digitization, suggesting higher detection accuracy. OOA-based gully mapping is quicker and more objective than traditional methods, and is thus better suited to provide essential information for land managers to aid in their decision making processes, and to the erosion research community.