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Process-oriented gully density modelling at the continental scale of Africa: first insights

Sofie De Geeter[1,2,3], Matthias Vanmaercke[2], Gert Verstraeten[1], and Jean Poesen[1]
[1]Division of Geography and Tourism, Department of Earth and Environmental Sciences, KU Leuven, Heverlee, Belgium
[2]Department of Geography, University of Liège, Liège, Belgium
[3]Research Foundation Flanders - FWO, Brussels, Belgium

Gully erosion is an important land degradation process, threatening soil and water resources worldwide. However, contrary to sheet and rill erosion, our ability to simulate and predict gully erosion remains limited, especially at the continental scale. Nevertheless, such models are essential for the development of suitable land management strategies, but also to better quantify the role of gully erosion in continental sediment budgets. We aim to bridge this gap by developing a first spatially explicit and process-oriented model that simulates average gully erosion rates at the continental scale of Africa.

We are currently developing a spatially explicit model that (i) allows to simulate the spatial patterns of gully density at high resolution (30-90 m); (ii) is based on the physical principles that control the gully erosion process; (iii) uses GIS and data sources that are available at the continental scale. Our model structure is based on the threshold-dependent character of the gully-initiation process where a proxy of flow shear stress is weighted against a proxy of local shear resistance at the pixel scale. To calibrate and validate this model, we make use of an extensive database of 44 000 gully heads mapped over 1680 sites that are randomly distributed across Africa. The exact location of all gully heads was manually mapped by trained experts, using high resolution optical imagery available in Google Earth. This allows to extract very detailed information at the level of the gully head, such as the local slope and the area draining to the gully head. Based on these variables, we simulate indices for peak runoff (based on the Curve Number method), the shear stress of the concentrated runoff and the critical shear stress of the soil. The combination of these indices reflects the process leading to gully initiation and therefore provides an accurate indication of the susceptibility of that location to gully initiation.

Preliminary results indicate that it is feasible to model gully head locations and densities using this process-oriented approach. However, important trade-offs exist between an accurate description of the (threshold-dependent) gully initiation process and the uncertainties on the GIS data used to describe this process. One important issue is the resolution of the digital elevation model (DEM) used to extract local slopes (S) and to delineate contributing areas (A). Comparing S- and A-values obtained from 30m SRTM-data with those obtained from higher resolution DEMs (5-12m) showed that SRTM data allows to obtain reasonable proxies of S and A but that uncertainties can be

significant and correction factors are needed to avoid biases.

Overall, our results indicate that modelling gully densities using a process-oriented and spatially explicit approach has (conceptual and pragmatic) advantages as compared to a purely empirical ‘black-box’ modelling approach and offers opportunities to better quantify this important land degradation process at the global scale.