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Impact of land-levelling measures on gully and soil erosion analysed by rainfall simulation and UAV remote sensing data in the Souss Basin, Morocco

Klaus Daniel Peter (1), Sebastian d'Oleire-Oltmanns (2), Johannes B. Ries (1), Irene Marzolff (2), and Ali Ait Hssaine (3)

(1) Physical Geography, Trier University, Trier, Germany (peterk@uni-trier.de), (2) Department of Physical Geography, Goethe University, Frankfurt am Main, Germany , (3) Department of Geography, University Ibn Zohr, Agadir, Morocco

Since the 16^{th} century with the rise and fall of sugar production, the Souss basin, situated between High and Anti-Atlas, is affected by gully erosion due to the deforestation of Argan trees. Nowadays, it is one of the most intensive agricultural regions of Morocco. On its sedimentary fans and alluvial terraces, a very dynamic land use change is going on since the early 1960s with transformations of traditional agriculture into agro-industrial plantations of citrus fruits, bananas and vegetables irrigated by deep aquifer groundwater. The implementation of land use change and further expansion of plantations into former agriculturally unsuitable marginal land is accomplished today by land-levelling measures with heavy machinery. The levelling of badland areas and the infilling of existing gully systems lead to changes and disconnections of the drainage system and watersheds on the sedimentary fans.

The aim of this study is the investigation of the influence of land-levelling measures and gully infilling on recent erosion rates and on both the re-activation of old and the initiation of new gully systems. An approach combining punctual process analysis through experimental rainfall simulation and gully mapping as well as volume quantification analysing on a local scale using unmanned aerial vehicle (UAV) remote sensing data was applied to relate runoff and sediment production in the gully catchment to current gully erosion rates. For conducting the rainfall simulations a small portable nozzle rainfall simulator with a rainfall intensity of 40 mm h^{-1} was used. We applied an autopiloted UAV for the monitoring of gullies with small-format aerial photography. Photogrammetric image processing enables the creation of Digital Terrain Models (DTMs) and ortho-image mosaics with very high (centimetre) resolution.

Results of the experimental geomorphological fieldwork show a significant increase of mean runoff coefficients and mean sediment loads (1.4 and 3.5 times higher respectively) on levelled study sites compared to undisturbed sites. Consequently, the most active gullies with the highest gully erosion rates are also found on levelled test sites. For one of the test sites it can be stated that gully erosion accounts for up to 95 % of the total soil loss of the catchment. The surface area serves only as runoff source. The infilling of old gully systems is mostly done by transferring large amounts of soil material from the hillslopes into the channels. This may lower the soil surface in a gully catchment by about 10 cm on average. Runoff water often follows the old pathways. Thus, infilled gully systems tend to be re-activated very fast. The freshly provided soil material can easily be eroded. Additionally, the bulldozer furrows lead to parallel drainage network patterns in the development of new side gullies.