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Hydrological connectivity as a concept for upscaling runoff and erosion in semi-arid areas

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Upscaling of runoff and erosion measurements from plot to catchment scale has often been addressed as an important issue. Extrapolation of plot measurements usually leads to a large overestimation of runoff and erosion at the catchment level, because infiltration and deposition in between are not sufficiently accounted for. We propose the concept of hydrological connectivity for upscaling runoff and erosion from plot to catchment level. Hydrological connectivity can be defined as the physical linkage of water and sediment through the fluvial system, which is a scale independent definition. In our study we examine hydrological connectivity at three scale levels, namely plot, hillslope and catchment level.

At plot scale vegetation is the main factor influencing the hydrological connectivity because of the occurrence of vegetation patterns with bare patches functioning as source areas and vegetation patches functioning as sink areas. With a balloon we made detailed aerial photographs of different vegetation types and calculated spatial metrics for the different vegetation patterns with the FRAGSTATS program. The spatial metrics that are important for hydrological connectivity, e.g. the landscape division and connectance index, were approximately linearly related to the percentage vegetation cover. This made it possible to correlate pattern metrics from plot scale to vegetation cover estimated from NDVI images at the catchment scale.

At the hillslope scale other factors, like slope, slope curvature and substrate affect the hydrological connectivity. In our study area one of the important thresholds at this scale is the occurrence of agricultural terraces. These terraces decrease the hydrological connectivity as long as they are maintained, however when these terraced fields are abandoned gullies start to form in the terrace walls and the hydrological connec-

tivity increases considerably. We analysed data from a field survey of 230 terraces to determine which factors increase the risk of terrace failure. With these factors we can predict which terraced fields in the catchment are more vulnerable to terrace failure, thus where the hydrological connectivity at the hillslope scale increases.

Finally, at the catchment scale thresholds like checkdams and geomorphological boundaries determine to what extent the catchment becomes connected. With a spatially distributed runoff and erosion model, e.g. WaTEM-SEDEM or LAPSUS, data from the plot and hillslope scale were added as extra layers and together with the thresholds at catchment scale the distribution of runoff and erosion was calculated. The model results can be verified by field observations of connectivity patterns after a rainfall event. Using the concept of hydrological connectivity makes it possible to identify sinks at the different scale levels, which prevents overestimation of runoff and erosion while upscaling plot data to catchment level.