Soil erosion and sediment yield in Africa: Processes and factors

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Abstract

Soil erosion and sediment yield are major environmental concerns across Africa, where diverse climatic, topographic, and land-cover conditions generate strong spatial variability in erosion processes and sediment transfer. Although previous continental-scale studies have documented patterns of sediment yield (SY), the relative contribution of different geomorphic processes to observed SY remains insufficiently understood. This study addresses that gap by integrating a newly verified database of measured sediment yield from 425 African river outlets with continental-scale model outputs for rill and sheet erosion (RSE), landslide mobilization rates (LMR), and gully head susceptibility (GHS). The objective was to better understand how these processes interact and how they shape sediment delivery at the catchment scale across the continent. Catchment boundaries were recalculated using SRTM-based watershed delineation to ensure consistency in variable extraction, and a wide range of explanatory factors related to climate, vegetation, soils, topography, and morphology were also considered.

The results show that the average observed sediment yield across the studied African catchments is 6.07 $t \cdot ha^{-1} \cdot yr^{-1}$, while modelled RSE averages 9.42 $t \cdot ha^{-1} \cdot yr^{-1}$ and LMR averages 1.51 $t \cdot ha^{-1} \cdot yr^{-1}$. GHS reached a mean value of 0.44, indicating substantial susceptibility to gully initiation in many parts of the continent. Spatially, the highest SY values were observed mainly in North Africa, particularly Morocco, Algeria, and Tunisia, as well as in parts of East Africa such as Ethiopia. Correlation analyses revealed that observed SY is more strongly related to GHS ($r = 0.57$) and LMR ($r = 0.47$) than to RSE ($r = 0.36$), highlighting the important role of gullies and landslides in sediment production and transfer. In addition, the strong relationship between GHS and LMR ($r = 0.77$) suggests that these two processes are often interconnected through shared environmental controls such as slope, soil properties, and hydrological dynamics.

The comparison between observed SY and RUSLE-based RSE revealed three major situations. In 59% of catchments, RSE strongly overestimated observed SY, suggesting major sediment storage and deposition effects. In 25% of cases, RSE and SY were relatively consistent, indicating that sheet and rill erosion may reasonably approximate sediment export in some medium-sized basins with limited gully or landslide activity. In the remaining 16% of catchments, RSE underestimated SY, implying strong additional sediment contributions from gullies, landslides, or channel erosion. Climate-zone analysis further showed that the Mediterranean zone had the highest average SY and LMR, whereas tropical regions displayed the highest average RSE. The desert and Mediterranean zones also showed the highest GHS values, emphasizing the importance of gully-related processes in these environments.

Overall, this study demonstrates that sediment yield in Africa cannot be reliably interpreted through rill and sheet erosion alone. Instead, SY reflects the combined influence of hillslope erosion, gully development, landsliding, sediment connectivity, and depositional processes. These findings call for integrated modelling frameworks that move beyond conventional RUSLE-type approaches and explicitly account for multiple erosion pathways. Such an approach is essential for improving sediment yield prediction, identifying erosion hotspots, and

supporting more effective land management and soil conservation strategies across Africa's diverse environments.