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Decadal gully development in Northern Ethiopia: Understanding networks, volumes and regional variability from remote sensing data

Amaury Frankl (1), Jean Poesen (2), Nelles Scholiers (1), Miro Jacob (1), Mitiku Haile (3), Jozef Deckers (2), and Jan Nyssen (1)

(1) Ghent University, Department of Geography, Gent, Belgium, (2) Department of Earth and Environmental Sciences, K.U. Leuven, Leuven, Belgium, (3) Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia

Understanding historical and present-day gully development is essential when addressing the causes and consequences of land degradation. For Northern Ethiopia, several reports exist on the severity of gully erosion, yet few studies quantified gully development. In this paper, gully network and volume development were quantified over the period 1963-2010 for an area of 123 km^2, representative for the regional variability in environmental characteristics. Gully networks were mapped from small-scale aerial photographs and high-resolution satellite images. As only gully length could be accurately defined from the aerial photographs and satellite images, quantifying gully volume development required to establish relations between gully network volume (V) and length (L) (or catchment area, A). Field observations indicated that the lithology and the presence/or absence of check dams or low-active channels were the most important controls of gully cross-sectional shape and size. From the network and volume development over the period 1963-2010, the occurrence of one cut-and-fill cycle is apparent. From a largely low-dynamic gully system in the 1960s, network expansion and increased erosion rates in the 1980s and 1990s caused the drainage density and volume to peak in 1994. The total gully density (Dtotal) was then 2.52 km km-2, coinciding with soil losses of 17.6 ton ha-1 y-1 over the period 1963/1965-1994. By 2010, improved land management and the region-wide implementation of soil and water conservation measures caused 25% the gully network to stabilize, resulting in a recent net infilling of the gully channels. The study validates previous findings that land degradation by gullying was severe in Northern Ethiopia in the second half of the 20th century, but also shows that when proper land management is applied, gullies can be transformed into a linear oasis, which increases the resistance of gullies to further erosion.