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Morphological dynamics of a gully system in the humid Ethiopian Highlands: the Debre Mawi Watershed

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Gully expansion in the Ethiopian highlands dissects vital agricultural lands with the eroded materials adversely impacting downstream resources, for example as they accumulate in reservoirs. While gully expansion and rehabilitation have been more extensively researched in the semi-arid region, few studies have been conducted in the (sub) humid region. For that reason, we assessed the severity of gully erosion and identified gully-forming processes in the sub-humid Debre Mawi watershed, 30 km south of Lake Tana, by monitoring 13 gullies. In addition, the rate of expansion of the entire drainage network in the watershed was measured using a 50 cm resolution aerial imagery flown in 2005 and 2013. More than 0.65 million tons (or 100 t ha-1 yr-1) of soil was lost during this period due to actively expanding gullies. The net gully area in the entire watershed increased from 4.5 ha in 2005 to 20.4 ha in 2013, which is more than 3% of the watershed area, and indicates the growing severity of gully erosion in the catchment.

Soil losses were caused by upslope migrating gully heads through a combination of gully head collapse and removal of the failed material by runoff. Collapse of gully banks and retreat of headcuts was most severe in locations with elevated groundwater table, saturating gully head and bank soils, destabilizing the soils by decreasing the shear strength. This was found to be the most important mechanism controlling gully expansion. Additional factors causing bank collapse are the gully head slope and drainage area. Soil physical properties (e.g., texture and bulk density) only had a minor effect.

Conservation practices that address the most important controlling factors are principally the most effective ways of protecting gully development and expansion. These consists of lowering water table elevation through subsurface drainage, and regarding the gully head and sidewall which reduce the occurrence of gravity-induced mass failures. Planting suitable species on the gully face and around the boundary will also decrease the risk of bank failure by reducing pore-water pressures and reinforcing the soil. Best management practices affecting the runoff contributing catchment may decrease the runoff-induced gully head erosion.

Keywords: Gully erosion, headcut retreat, land degradation, controlling factors, Debre Mawi