Effects of land drainage and physical soil and water conservation on topographical thresholds for gully head development in North Ethiopia

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Abstract

The use of drainage ditches on sloping farmland has an impact on the farmland itself and on the downstream area, though its environmental impacts are not unequivocal. Researchers are still divided about the balance of the positive and negative effects which can be both on-site and off-site. A case study area was chosen around Wanzaye (North Ethiopia) where three different cropland-management practices were studied in 75 catchments: (i) the catchment-wide use of stone bunds on the contour, (ii) the use of slightly sloping drainage furrows (feses), and (iii) the combined use of stone bunds and feses. Three trends in cropland management around Wanzaye and the wider region are observed: (i) feses are exclusively made on rather steep slopes where small drainage areas lead to the rapid development of gully heads; (ii) stone bunds are constructed on both steeper and gentle sloping cropland; and (iii) larger and gently sloping catchments seem to be most suitable for the combined use of drainage ditches and stone bunds. A standardized procedure for topographical threshold analysis was applied to study the impact of different land management practices on gully head development in cropland. Topographical thresholds for gully head development reflect the vulnerability of lands to gullying, i.e. \( s > kA^b \), where \( s \) represents slope gradient of the soil surface and \( A \) the drainage area at the gully head, \( b \) an exponent, and \( k \) the resistance of the land to gully head development. The lowest \( k \)-values are found for feses catchments, which implies that catchments with the exclusive use of drainage ditches are the most vulnerable to gully head development compared to mixed catchments and stone bund catchments. Yet, on-site sheet and rill erosion are reduced by the use of feses as they reduce the runoff gradient.

Keywords: Sloping farmland; Topographical threshold; Soil erosion; Cropland management.