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Spatial modelling of gully initiation in the Abaya-Chamo lakes catchments, southern Ethiopia

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Lake Abaya and Lake Chamo are located within the rift valley that cuts across eastern Ethiopia. Severe soil erosion, predominantly gully erosion in the midlands and highlands, and flash flooding along rivers in the lowlands resulted in sediment and nutrient accumulation in the rift lakes. In this study, conducted in four river catchments on the Western border of the Abaya-Chamo rift, an inventory of gully channels is made and factors controlling the location of gullies are analysed. The inventory, which was prepared using Google Earth imagery and field surveys, consists of 7336 gullies over a study area of 1050 km², resulting in a high average gully density (1.56 km.km^{-2}) with specifically high densities (3.74 km.km^{-2}) in the Northern Shafé river catchment. Of all mapped gullies, 56% show signs of active erosion (i.e. mostly bare gully walls and bed, and/or fresh sediments deposited in the lower parts of the gully). In order to reduce the effects of gully erosion, it is vital to understand the factors controlling gully initiation and locations most susceptible to develop new gullies. Instead of using gully head, which due to head cut retreat might not be representative of the characteristics of the gully initiation point, a slope-area threshold (SA) is used to identify the most probable gully initiation point along existing gullies. The spatial susceptibility of these sites to gully initiation is then modelled using the frequency ratio and logistic regression methods using a set of 15 geo-environmental variables related to topography, soil texture, geology, rivers, knickpoints and land cover, as potential controlling factors. Active and inactive gullies are modelled separately. Slope, type of lithology, location of knickpoint rejuvenating the landscape through channel incision, distance from roads and mean annual rainfall are identified as very important controlling factors of gully initiation sites. The most susceptible gully erosion areas are observed in the steep midland, where limited population is living, and bare land and rangeland is dominant. The results show that the models are reliable and have a good prediction performance of gully initiation when using an independent validation dataset. The produced gully susceptibility maps highlight locations where soil and water conservation or other sustainable planning actions are required. Such maps are also needed to estimate the long-term contribution of gullies to the sediments delivered to the Abaya-Chamo Lakes.