EGU22-5566
https://doi.org/10.5194/egusphere-egu22-5566
EGU General Assembly 2022

Modelling the spatial variation in susceptibility to gully initiation and stabilization in the Southern Main Ethiopian Rift Valley

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Gullying is a common soil erosion process in Southern Ethiopia, damaging agricultural landscapes and contributing sediments to water bodies. River catchments extending across the rift escarpment within lakes Abaya and Chamo Basin in the Southern Main Ethiopian Rift are areas experiencing such problems. Impact of gullying depends on the state of activity of gullies, i.e. inactive gullies might have had a role in the landscape formation, but they can now be considered stable and not contributing to sediment delivery to the downstream, unlike the active gullies. In order to reduce the impact of active gullies, understanding the conditions under which gullies initiate, expand and stabilize is vital. In this paper, the location where new gullies initiate and where they stabilize is modelled spatially. To determine factors controlling for the initiation of new gullies, the potential gully initiation points were extracted along more than 4520 active gullies using slope and drainage area thresholds. The susceptibility of gully initiation is then modelled using logistic regression and frequency ratio methods, with a set of 14 predisposing factors. The conditions for gully stabilization are assessed by modeling the location of the head of more than 1080 inactive gullies. Highly susceptible areas for gully initiation are mainly modelled in rejuvenated landscapes downslope of knickpoints, where steep slopes have been recently formed by knickpoint propagation.most susceptible areas for gully initiation are observed in concave slopes with high topographic wetness index, whereas heads of inactive gully stabilized when slopes become convex with a lower topographic wetness index. The area under receiver characteristics curve (AUC) of the validation data ranges from 0.75 to 0.85 for all susceptibility models; prediction rate of gully initiation and stabilization vary from 70 to 93%. Our results indicate that the applied models are reliable and have very good prediction performance of gully initiation and stabilization and that such approach contrasting the gully initiation point and the gully head location enable to better understand the gullying process. The resulting susceptibility maps are a step towards contributing to the decision-making process on the optimized locations of soil and water conservation measures, and thus contributing to landscape sustainability.