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The impact of reforestation on discharge and sediment fluxes in drylands: long-term evidences from the Western Rift Valley Escarpment (Northern Ethiopia)

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Deforestation and land degradation have been common problems in the Northern Ethiopian highlands, including for the Western Rift Valley Escarpment. In particular, the rapid deforestation of the steep catchments (average slope gradient of 44% $\pm$ 10%) in the second half of 20th century, together with rainfall variability and over-cultivation, resulted in the development of dense gully and scar networks. Subsequently, huge amounts sediment were taken to the densely populated graben bottoms. In response, extensive reforestation interventions were carried out as of the 1980s, resulting in improvements of vegetation cover in many catchments. This study analyses the spatio-temporal changes in vegetation cover and rainfall variability and their impact on discharge and sediment transport in escarpment catchments. Degree of rehabilitation was examined in 20 adjacent catchments by correlating the density of scar networks incised down to the bed rock with Normalize Difference Vegetation Index (NDVI) and slope gradient. Based on these results, 11 contrasting catchments were selected for detailed investigation. To study the current spatio-temporal variability in rainfall and its relation with daily peak discharge, 7 rain gauges were installed at different locations and altitudes. Trendlines of decadal rainfall variability since 1996 will be established based on the analysis of NOAA's rainfall estimates, and long-term rainfall variability will be explored by correlating the field data to long-term rainfall measurements in nearby synoptic stations. The changes in land use and cover will be detected from aerial photos of the 1935, 1965 and 1986. Peak discharges were monitored using 11 crest stage gauges. Fixed boulders were painted in stream reaches to quantify the transport of bedload. This was done by photographing the stream reaches and by measuring the displacement of painted boulders after flood events. In a multiple regression analysis, scar density was negatively related with NDVI and positively with average gradient of very steep slopes ($r2 = 0.53$; $p<0.01$, $n= 20$). Data for the rainy season of 2012 showed no relationship between rainfall distribution and altitude. Average daily peak discharge in the 11 rivers was positively related with daily rainfall depth as well as with catchment size and negatively with NDVI ($r2 = 0.83$; $p<0.01$, $n=11$). Further analysis of the data will allow better understanding of past degradation phases and the impact of land use/cover changes and rainfall variability on the rehabilitation of mountain streams.

Keywords: peak discharge; crest stage gauge; boulders; bed load; reforestation.