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Giant landslide deposits and the modalities of their removal by fluvial sediment export in the central Himalayas

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Slope failures and deep seated landslides are usually considered as the most efficient processes for hillslope erosion in active orogens. Erosion in the Narayani basin in central Himalaya (Nepal) confirms such assertion, with in addition the probable predominance of the very large landslides in the erosive budget of the range. In the High Himalayan part of this basin, a number of pluri-kilometric giant landslides have been described and involve up to ten cubic kilometres mass wasting (e.g. Weidinger et al., 2002).
In this contribution, we discuss how the fluvial network do respond to such massive and sudden supply of debris, basing our analysis on several cases, documented by sedimentologic and geomorphologic observations, lithologic counting, geochemical tracing (down to the Ganga plain), and 14C or CRN dating. We first demonstrate that several massive fill terraces preserved along the Lesser Himalayan intramontane reaches are not climatically induced, but rather represent transient storage following giant landslide material export. Two types of deposits and therefore of sediment export modalities have been identified: either (1), as observed along a $\sim$100km long stretch of the Marsyandi river, through massive debris flow(s) runout following the break of a landslide-induced dam on main rivers, or (2) by the more gradual but efficient fluvial removal of the giant landslide deposits. In the second case, in particular when bedrock fracturing and crushing during landslide fall has strongly reduced the average debris size, because the steep Himalayan rivers are usually in strong over capacity or largely underloaded with fine to medium-size sediment, their can carry up to several cubic kilometres of sediments in one or two centuries. The coarsest part of the exported material is temporarily stored through aggradation in the massive Lesser Himalayan fill terraces because river gradient drops suddenly when river exits the High Himalaya, whereas the finest fraction is exported very rapidly further downstream, outside of the range. Once a large portion of the landslide debris has been eroded in the source deposit, river quickly returns to over-capacity conditions and to its long term or background conditions, and fill terraces are rapidly re-incised (re-erosion of the fill terrace occurs at rates incommensurate with long term bedrock downcutting rate).
The documented Himalayan examples illustrate that erosion of giant landslides deposits can overwhelm the sediment export of a river as large as the Narayani (A=30000km2; average sediment export=150Mt/yr) during several centuries, but that the landscape quickly (i.e. in a similar amount of time) recovers and returns to some long-term average state. The long term influence of these events on the morphology of the fluvial network remains therefore moderate, if we except the persistence of fill terraces remnants in the Lesser Himalaya for several tens of kyr.