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# Landslides in active tectonics and varying precipitation regime, Satluj valley, Northwest Himalaya

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The Satluj river valley in the Northwest Himalaya cut across the Tethyan, Higher and Lesser Himalaya in the northeast to southwest direction. The major tectonic contacts in the region are South-Tibetan Detachment (STD) and Vaikrita Thrust (VT) which separate Tethyan from the Higher and Higher from the Lesser Himalaya respectively. This river valley experiences active tectonics and precipitation variability in space and time and hence result into landslides of different size, shape, failure frequency and type. In this study, a spatial landslide distribution pattern is achieved through dimensional mapping of 36 landslides in the Satluj river valley using Google Earth imagery and field observation. The pattern shows an inverse relation between landslide size and shape factor (length/width) in which size decreases from the Tethyan Himalaya towards Lesser Himalaya while shape factor increases. However, the Higher Himalaya region, especially it's upper and lower tectonic contact exhibits an anomaly in this size-shape pattern where size of the landslides increases abruptly. This anomalous behaviour at the upper and lower tectonic contact i.e. STD and VT respectively, was further related with stream power erosion law parameters. The weak/shattered phyllite, slate rockmass and lithological variation are observed to contribute to the anomaly at the STD. The disequilibrium condition in the erosion and uplift of the river channel as inferred by the change in the concavity index from 0.44 to 0.57 and rapid variation in the steepness index (ks=100-600) are considered to control the hillslope response at the VT region. Alongwith the steepness index (ks), the ratio of valley floor width to valley height (Vf) was also used to understand the active tectonics. Interestingly, the inverse relationship of the Vf and ks at the tectonic contacts signifies the interrelationship of valley morphology and channel gradient at these locations. The effect of this relationship is also observed on the hillslopes in the form of landslides as debris slides are associated with the high Vf (0.8-1.0) peaks while rockfalls are abundant in narrow gorges having very low Vf (0.2-0.3). The Tethyan and Lesser Himalaya regions are found to be relatively less tectonically active as observed by the pattern of steepness index (ks) and the Vf ratio. The spatial variability of rainfall was also taken into account using rainfall data of the last 14 years (2000-2013) from four rain-gauge stations. The rainfall data reveals a pattern in which average annual rainfall decreases from the Lesser Himalaya towards Tethyan Himalaya with sudden decrease in the Higher Himalaya region. This sudden decrease is considered to be subjected to the orographic control of the Higher Himalaya. Further analysis of the precipitation data shows the spatially varied influence of the Indian Summer Monsoon (ISM) and Western Disturbance (WD) on the hillslopes and hence on the landslide distribution. Thus, this study helps to understand the control of active tectonics and precipitation variability on the landslide distribution pattern of the Satluj valley.

Key words: Landslides; Tectonics; Precipitation; Northwest Himalaya