Reconstructing extreme monsoon floods in Indian Himalayan headwater streams (Kullu district, Himachal Pradesh)

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INTRODUCTION

In the Indian Himalayan region, hydro-climatic hazards are a major threat to the population and are commonly triggered by intense downpours during the monsoon season, cloudbursts or glacier lake outburst floods. Evidence exists for an increase in extreme flood-related disaster as a result of climatic changes and the current socio-economic development in this region. This tendency represents an important scientific and technical challenge, especially when it comes to the development of suitable adaptation strategies in the region aiming at minimizing negative consequences of floods. Moreover, strong evidence exists for the transformation of natural processes into man-made disasters. The lack of long and reliable records in this mountain region, however, has prevented the drawing of strong conclusions about climate-flood linkages in the longer term, and consequently its hazard and risk assessment. This is specifically the case of Kullu district (Himachal Pradesh, India) where the existing dataset of flood flows is restricted to a few flow gauge stations of very limited length. Here we present the first findings from flood reconstructions in two poorly gauged mountain catchments located in the Kullu region, one in the upper section of the Beas River and another one in the headwaters of the Sainj River catchment.

METHODS

We applied paleohydrological techniques and post-event field recognition to reconstruct the occurrence and magnitude of past flood events, which have been successfully tested in other ungauged catchment worldwide. This procedure consisted in the analysis of growth-ring responses of trees affected by past floods (e.g. scars on the stem surface caused by the impact of transported sediments). Defining events were based on the number of growth disturbance (GD) and their intensity, evaluated by mean of the weighted index(Wit). Scar heights were then used as paleo-stage indicators of the minimum water level reached during the flood event, which was then converted into peak discharge by means of the resolution of hydraulic equations.

RESULTS

The lack of long-term undertanding of flood frequency in the study valley hamper the proper flood disaster managments. In this context, the recosntructed flood events allow a better spatio-temporal varaibility of this process, which is imporant for local to regional scale. In the first case, the role of man-made flood disasters was assessed in a reach of the Beas River next to Palchan village where a primary school, bridge and hydropower plant were completely or partially destroyed during a recent flood. The second case yielded a multi-decadal flash-flood reconstruction in an ungauged catchment section of the Sainj River where hydropower dams have been recently constructed.

A total of 110 samples were analysed from 65 affected trees. Our paleoflood reconstruction and field observations in the Beas River suggest that the Beas River flood of 2012 has been amplified considerable in a short reach river due to human activity. By tracking field evidence and damage in trees, our analysis suggests that the flow interacted with a bridge pillar under construction, producing a shift in the flow direction which in turn triggered scour erosion and landslides at the opposite river bank. This phenomenon produced important geomorphic changes in the riverbed causing channel avulsion and damage to the infrastructure located downstream, namely a primary school building, hydropower station and bridges. In Sainj valley, we dated

10 unknown floods between 1937 and 2014. The peak discharge reconstruction suggests that bank-full discharge has been reached several times over the last decades. These findings imply high hydro-dynamic activity of the river with large transport capacity which could indeed have affect the capacity of hydropower dams located downstream.

CONCLUSIONS

The findings of this study will contribute to a better understanding of flood frequency in this poorly gauged area and clearly show the role of human development with respect to disaster severity. The dated events are extended back to 1930's and constitutes a baseline data for peak discharge reconstruction.

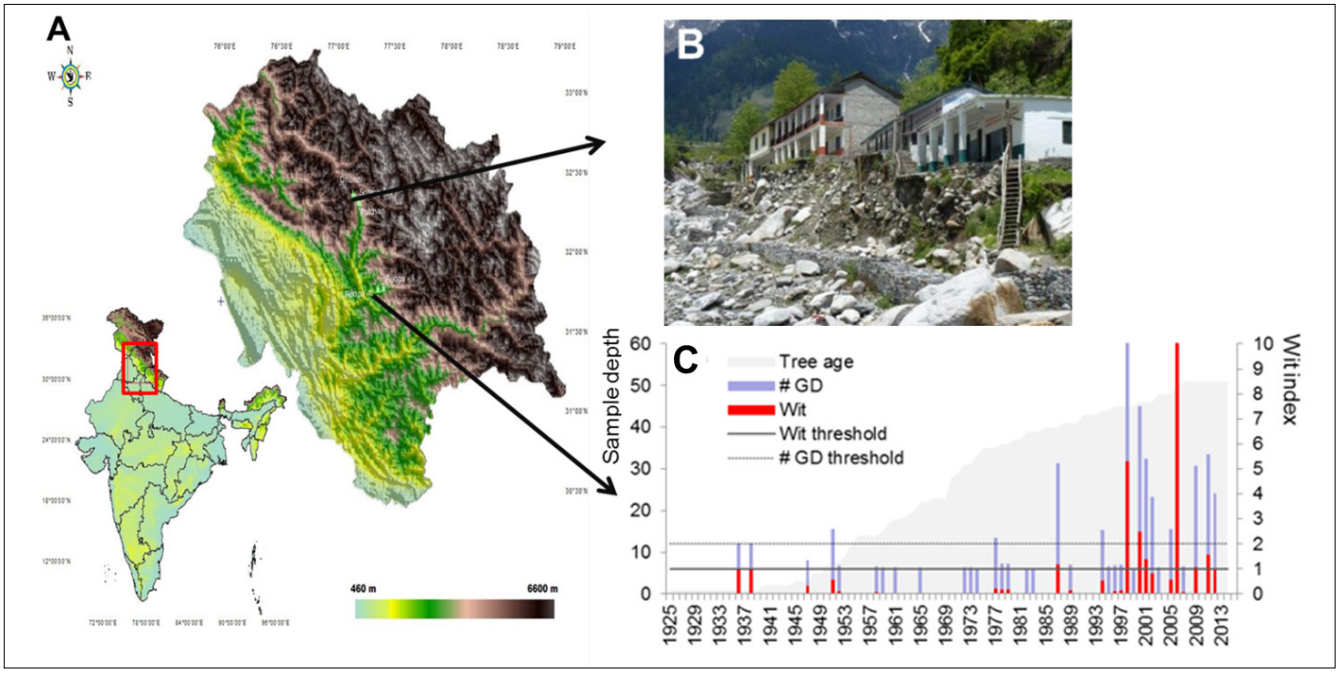

Figure 1. Study area and growth disturbance (GD) and weighted index (Wit) diagram

KEYWORDS

Paleohydrology; Flood monsoon; dendrogeomorphology; Indian Himalayan; mountain streams

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