

Post-disturbance evolution of tectonically active fluvial catchments impacted by hydro-electric power development

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Durham University, Geography Department

In partnership with Glasgow University, School of Geographical and Earth Sciences and the Indian Institute of Technology, Kanpur

Supervisory Team

- [Patrice Carbonneau](#), Durham University
- [Alex Densmore](#), Durham University
- [Nick Rosser](#), Durham University
- [Zhenhong Li](#), Glasgow University

Key Words

UTTARAKHAND FLOOD DISASTER; GEOHAZARDS; LANDSLIDES; HYDROPOWER IMPACTS; REMOTE SENSING

Overview

In June 2013, the Indian state of Uttarakhand experienced intense and prolonged rainfall triggering many landslides and widespread flooding in the upper Ganga (i.e. Ganges) River basin, resulting in a death toll of 5,748 and material damages estimated at £6.7 bn¹. As a tectonically-active landscape within a monsoon climate, the area is characterized by high rates of erosion and sediment transfer. At the same time, there is rapid (peri-)urban development in support of a growing religious tourism industry due to the revered status of the Ganga, along with proliferation of hydro-electric power (HEP)². These intense HEP development efforts have created considerable controversy: Critics argue that during the construction of dams and the excavation of associated reservoirs, huge volumes of unconsolidated sediment are abandoned and remain on the channel margins and so are available for transport. For example, one report alleges that the construction of the 330 MW Srinagar HEP scheme has made available 500,000 m of material which has been deposited and has damaged the town. However, central and state governments argue that completed projects manage sediment and provide needed energy-security thus fuelling India's development. These arguments generally



lack a solid evidence-base which demonstrates a lack of knowledge and understanding regarding the geomorphic evolution of alpine catchments subjected to intense hydro-power development. Indeed whilst there is significant work reporting the effects of HEP on the ecosystems³ of these catchments, there is no equivalent work considering the evolution of the hillslopes and rivers from a geomorphic perspective. However, such an understanding is increasingly urgent in the light of the Uttarakhand tragedy and the accelerated pace of hydropower development

across the entire Himalayas. Therefore, **the primary aim of this doctoral project is to examine the geomorphic response of this tectonically active region to the major perturbation caused by the Uttarakhand tragedy.** Understanding the processes and mechanisms of geomorphic response along with the initial conditions, both human and physical, that lead to the tragedy will provide a much needed evidence-base in the debates and policies of hydropower development.

Methodology

Fieldwork and remote sensing will aim to map the spatial distribution, extent and character of recently mobilised sediment deposits in the catchment, ranging from bank collapse to fluvial deposits and landsliding. Fieldwork will be carried out with established collaborators from the **Indian Institute of Technology, Kanpur** who will provide crucial in-kind logistic support and assistance in this region of the world where fieldwork logistics are not trivial. We propose to use a novel, low-cost, car-based 3D videogrammetry approach using Structure from Motion technology in order to survey the presence or absence of fluvial deposits along the main roads and extract approximate particle size distribution for these deposits. This device will be used to rapidly and safely survey the roadside exposures and valley bottoms (by boat) of the Bagirathi, Mandakini and Alaknanda rivers which are the 3 main rivers affected by this tragedy. Satellite remote sensing will be used to derive catchment-scale data for multiple epochs. First, the lead supervisor is part of a team who has recently been tasked by the Indian Ministry of Earth Sciences to acquire and process declassified images from the 1960s and 70s for the upper and middle Ganga in order to estimate the reference condition of the river prior to major human impacts. The student will have access to declassified spy-satellite photography to provide 2 meter resolution imagery of the catchment in 1962 and 8 meter resolution imagery of the catchment in 1979. For the recent epoch, we will use very high resolution SAR imagery in targeted areas. Following a novel processing technique developed at Glasgow University, we will use Terrasar-X 1 meter imagery acquired at the start of the project and after 2 years. This 2-epoch dataset will allow us to detect small changes in

the landscape which will not be detectable in the optical satellite imagery.

Ultimately this project will deliver much needed data on the evolution of these catchments. The knowledge thus generated will be transferable to other regions of the Himalayas which face similar challenges of development and conservation.

Timeline

Year 1: Acquisition, processing and Organisation of Remote Sensing data. Fieldwork in April 2015.

Year 2: Second acquisition of Terrasar-X data and updating of remote sensing database. Fieldwork data analysis and initiation of the modelling work.

Year 3: End of the modelling work and final write-up.

Training & Skills

The candidate will gain experience of fieldwork in the Himalayan foothills. Through the project, the candidate will develop in-depth knowledge of surface geomorphology and mass movements through the use of advance satellite and terrestrial remote sensing.

References & Further Reading

- 1 Parkash, S. 2013, Brief Report on visit to Alaknanda Valley, Uttarakh and Himalaya during 22-24 June 2013, Report of the National Disaster Management Institute, Delhi.
- 2 Qiu, J. 2012, Flood of Protest Hits Indian Dams, *Nature*, v492, 7427.
- 3 Pandit and Grumbine, R. 2012, Potential Effects of Ongoing and Proposed Hydropower Development on Terrestrial Biological Diversity in the Indian Himalaya. *Conservation Biology*. Vol. 26. pp.1061-1071
- 4 Sinha, R. Das, J. and Dikshit, O. 2002, GIS-assisted mapping of catchment-scale erosion and sediment sources: Garhwal Himalaya, India. *Z. Geomorphologie*, 46-2, 145-165

Further Information

Please contact Dr Patrice Carboneau
patrice.carboneau@durham.ac.uk