Application Form – Andrew Whitham CASP Fieldwork Awards 2024

Applicant: Eliana Toro Paz
Project title: Sediment mobility in Himalayan rivers recorded by seismic monitoring with implications for flood risk under a changing climate
Award: £2,895

Scientific question and rationale: Hydropower plays a critical role in the green energy transition, particularly for high alpine environments such as Nepal. However, hydropower capacity is significantly limited by reservoir sedimentation, particularly coarse bedload, which cannot be readily flushed through dams (Kondolf et. al., 2014, *Earth's Future*). This affects dam stability and reduces energy production, and thus remains a key challenge in hydropower development. Sediment transport also exacerbates monsoon floods through changing discharge conveyance capacity. These hazards linked to sediment mobility are increasing with intensification of extreme monsoon rainfall and sediment release from retreating glaciers. Highly mobile gravel rivers exiting the Himalayan mountain front and entering the Gangetic Plains are prone to abrupt switching of their channel courses. The mobility of coarse bedload (e.g., cobbles) in these rivers currently remains unquantified and estimated only with outdated, 'rule-of thumb' calculations (e.g., Maddock and Borland, 1950, *Bureau of Reclamation*), yet has major implications for flood modelling, hydropower planning, and urban development. **Quantifying the threshold discharge for bedload mobility is a fundamental prerequisite** for understanding the conditions under which channels erode and resediment. This is essential for identifying channel switching mechanisms and determining future flood risk, in addition to informing hydropower development. **Newly developed techniques in seismic and acoustic monitoring** provide tools that quantify bedload motion, with applications in both sedimentology and engineering. Engineers in Tribhuvan University (Nepal) currently assume 35% of total sediment flux is bedload (personal comms., 2023). Here, for the first time, **we aim to quantify full sediment budgets** in Himalayan rivers to effectively inform hydropower development.

Specific objectives and deliverables: 1) Collect seismic and acoustic data as a record of bedload mobility, plus suspended load data, from two key study sites in Nepal over the course of a complete monsoon season. 2) Use stream gauge data and time series power spectra data of seismic frequencies, in addition to acoustic data for calibration, to characterise signals of bedload motion, water turbulence and anthropogenic noise and **determine the threshold discharge to initiate bedload motion**. 3) Use the above data to **quantify annual sediment budgets** for both bedload and suspended sediment load 4) Engage with stakeholders and collaborate with engineers at Tribhuvan University in Nepal to **inform practices on hydropower development**. The results will be published and presented at international conferences such as EGU and AGU.

Proposed work plan: A 10-day reconnaissance trip to Nepal has already been carried out in November 2023, where two study sites (Rapti and Karnali rivers) were identified, geophones and a trail camera installed at each site, and plans established for deploying hydrophones. Preliminary measurements were made using the hydrophones in a raft to investigate the spatial variation of bedload motion along a stretch of the Karnali river near Chisapani. Local community members are employed to measure suspended sediment load and maintain the field site, and we are collaborating with a Master's student at Tribhuvan University in Nepal who will download data. Stream gauges at each study site give daily measurements of water level which will be used to determine river discharge. A return trip to the study sites is planned for March 2024 to deploy hydrophones and evaluate equipment already installed. This trip is essential to ensure equipment is operating at maximum efficiency to produce high quality data, before the onset of the monsoon in May/June. Field observations from this trip, including characterising terraces and geomorphic features, will provide important context for the study and spark new research questions and ideas. A final trip is required after the monsoon season to investigate outstanding research questions, remove equipment to reduce environmental impact, and download all data. The methods used here build on expertise from a previous study based at Glen Feshie in Scotland (Matthews et. al., preprint*, eartharxiv.org*). Bedload movement can be distinctly heard in hydroacoustic data, providing an effective way to distinguish the seismic signals from bedload movement and other noise such as water turbulence, improving the accuracy of the method. The data collected will be used first **to identify the onset of bedload motion and quantify sediment budgets**, with further research avenues including examining the temporal lag between the onset of the monsoon rainfall and bedload mobility, and investigating the spatial distribution of bedload motion within a channel. This is a high-cost project with specialist equipment, and thus care will be taken to ensure the best possible results.

Proposed expenditure, including details of any other sources of funding: As part of the NERC E4 DTP, a standard RTSG of £3,450 is received, in addition to an ARCs grant of £3,500. Fieldwork costs for one 10-day trip include flights (~£1,400), insurance (£20), 15-day VISA (£25), driver and vehicle (£73 per day, £730 for whole trip), fuel (£220, based on previous trip), accommodation and food (1 person, £50 per day, £500 for whole trip). **Total requested for 10-day trip: £2,895.** All field equipment, including geophones and hydrophones, are already purchased.