Modelling the sensitivity of changes in sediment flux and grainsize distributions on flooding in the Kathmandu basin, Nepal

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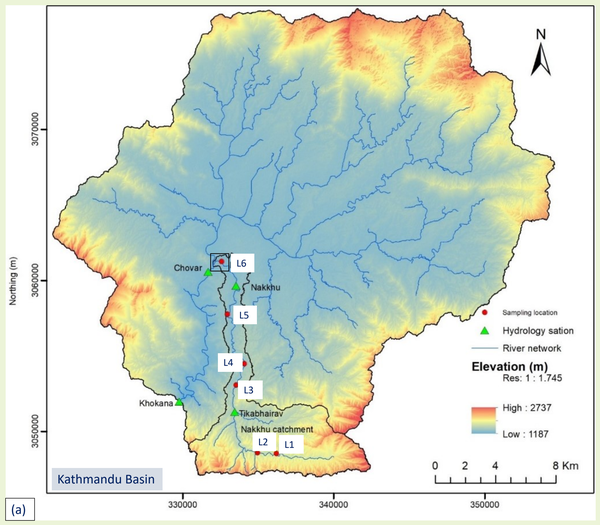
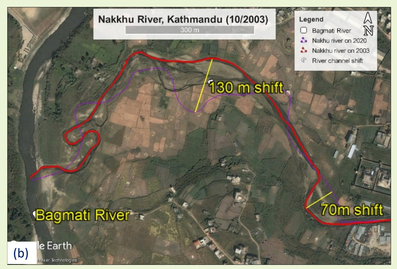
Introduction

- Flooding is one of the most common natural hazards in Nepal that carries huge amount of sediment and affects human lives and causes enormous damage to properties every year during the monsoon.
- Changes in climate, land use change, landslides, and upstream mining activities cause variations in sediment flux and grain size distribution.
- Variations in sediment flux and grain size distribution affect the river morphology and flood inundation in the Nakkhu river in the Kathmandu basin, Nepal.





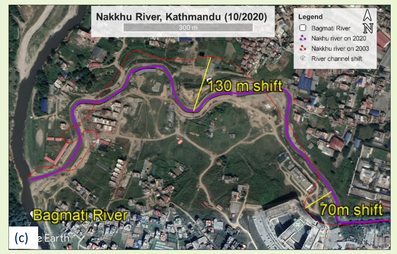


Figure 1. (a) Illustrating the Nakkhu river catchment in the Kathmandu Basin, with bed load sediment sampling locations (L1–L6) and hydrology stations. (b) and (c) showing the channel migration and urbanization from 2003 to 2020

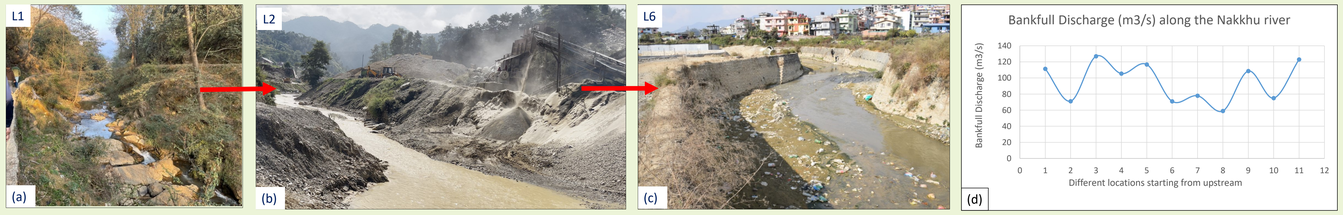
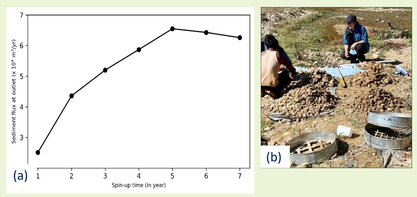


Figure 2. (a) Clean water flowing at the upstream of the Nakkhu river with no suspended sediment. (b) Mining activities contributing sediment to the river. (c) The river bed aggradation in the downstream. (d) High degree of variation in the calculated Bankfull discharge using manning's equation.

Methods and model inputs

- The movement of water and sediment over the landscape is simulated using the landscape evolution model (LEM) CAESAR-Lisflood (Coulthard et al., 2013).
- The model is run for a 14 km reach of the Nakkhu river using a high-resolution digital elevation model (10m), field-derived grain size data, and daily discharge data to simulate erosion and deposition along the river.



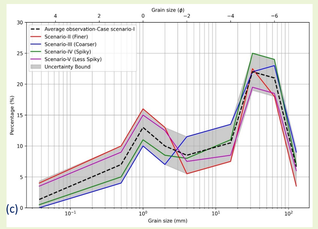
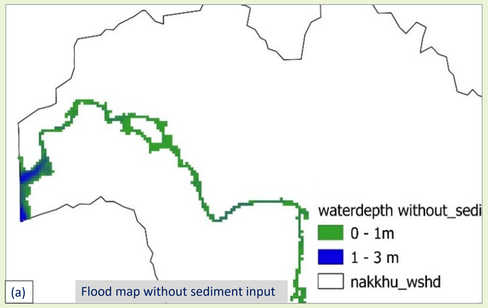
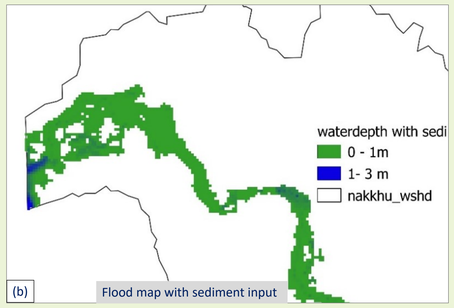


Figure 3. (a) Sediment flux outflow per year for the model spin-up using repeating daily flow of year 2001 (each year recurring flood). (b) Sediment sampling. (c) Bimodal grain size distributions with envelope showing the uncertainty bound of the field observation data.

Results

- Flood maps with and without sediment transport have a significant difference for the flood of 2002 which approximates the 25 year return periods shown in Fig. 4 (a), (b). However, when we experiment with grain size variations for a moderate flood year of 2006, we see minor changes in inundation, but major changes in internal channel morphology which is highest with the finest sediment (up to 2.0 m channel relief change) (Fig.5 (a)).
- The volume of sediment erosion and deposition is approximately double for the fine compared to the coarse sediment distribution for the flood of 2006 in Fig. 5 (b).





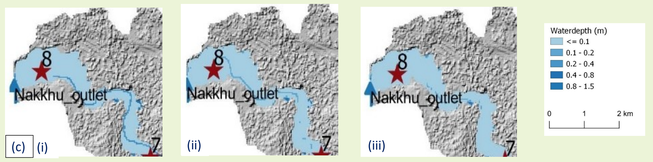


Figure 4. Flood maps: (a) and (b) are for with and without sediment transport (flood 2002) and (c) is for the flood of 2006 with different grain size distributions: (i) Fine (ii) Average and (iii) Coarse on the Nakkhu river.

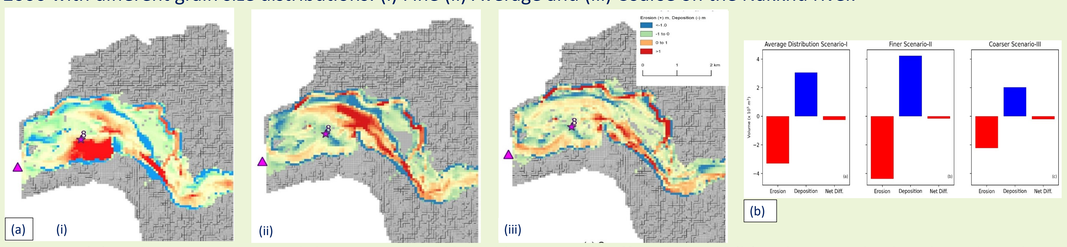


Figure 5. (a) Sediment erosion and deposition map from the DEM of Difference and (b) Volumetric budget based on the DEM of difference for different grain size distribution: (i) Fine (ii) Average and (iii) Coarse respectively for flood 2006.

Discussion and Conclusion

- This project is the first attempt to apply the landscape evolution model CAESAR-Lisflood with sediment transport to a mountainous river in Nepal.
- The flood inundation map with sediment input has a bigger impact than without sediment input.
- Experiments with grain size variation do not impact inundation but generate variation in channel morphology.
- Future work will investigate the impact of sediment with more extreme flood scenarios from climate change and variation in grain size and flux in response to mining.

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