Response to Reviewer Comments

Manuscript ID: egusphere-2025-4454
Title: Simulating avalanche-triggered lake overspill and downstream impacts at Birendra Lake using RAMMS and HEC-RAS
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Dear Editor and Reviewers,

We thank the reviewers and community members for their insightful and constructive feedback on our manuscript. We have addressed the comments, particularly regarding the manuscript structure, technical terminology, and overspill volume calculations.

Our point-by-point responses are provided in the table below:

Response to Referee #1 (RC1)

ID	Reviewer Comment	Author Response
RC1.1	*The manuscript requires significant restructuring to clearly convey the objective, methodology, results, limitations, and conclusions of the study. Currently, many technical terms, topics, and section headings are introduced abruptly without prior explanation or context, making it difficult for the reader to follow the narrative.*	Accepted. The manuscript has been organized to ensure a logical flow and alignment between the objectives, methodology, and results. We have clarified the technical terms and ensured that the headings are introduced with proper context.
RC1.2	*There is a noticeable lack of alignment between the study's stated objectives, the flowchart presented in Figure 3, the methodology described in Section 2, and the Results and Discussion section. These components should be revised to ensure coherence and logical flow throughout the manuscript.*	Accepted. The stated objectives and methodology have been revised to align with the study flow chart (Figure 3), ensuring consistency throughout the sections.
RC1.3	*It is suggested to restructure the methodology into two separate sections as follows:* • ***Section 2 – Study Area*** • ***Section 3 – Materials and Methods****, with the following subsections:*	Accepted. We have restructured the methodology as suggested.

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	○ ***1 Avalanche Susceptibility Mapping*** ○ ***2 Glacial Lake Volume Estimation*** ○ ***3 RAMMS Modeling*** ○ ***4 HEC-RAS Modeling*** ○ ***5 Exposure Analysis*** *Each subsection should clearly describe its role in the study, including the input parameters used and references where applicable. A similar structure should also be followed in the Results and Discussion section for consistency. Subsections can be further divided as needed to highlight important components.*	
RC1.4	***Results and Discussion Section*** *The Results and Discussion section should focus solely on the outputs and findings of the present study. Currently, this section often reads like an extended version of the methodology. The descriptive elements already covered in the methodology should not be repeated. Instead, this section should include clear interpretation and analysis of the model outputs, supported by relevant figures and tables.*	Accepted. This section has been revised to focus on the interpretation and analysis of the model outputs.
RC1.5	*There are two unnumbered subsections presented under Results and Discussion which were not introduced or discussed in the methodology:* • ***Temporal Characteristics and Warning Implications*** • ***Sensitivity Analysis and Hazard Assessment Implications***	Accepted. These subsections have been formally integrated into the manuscript structure and discussed in the methodology.

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RC1.6	*These need to be formally integrated into the manuscript structure. Additionally:* • *The source of the outflow timing estimate (8–10 minutes) should be clarified. Including a figure showing the progression of the flood from initiation to downstream points would greatly enhance clarity.* • *The parameters considered for sensitivity analysis should be clearly identified and their impact discussed.*	Accepted. The 8–10-minute estimate represents the duration of the primary overspill pulse at the lake outlet, as derived from our HEC-RAS inflow hydrographs. We have expanded the discussion of flood progression in Section 4.5. Rather than adding a new figure, we have referenced the arrival times provided in Table 5, which detail the temporal progression of the flood from initiation to the six downstream monitoring sites. A formal discussion on sensitivity based on Poudel et al. (2025) which conducted the Manning's n sensitivity analysis is provided.
RC1.7	*Section 3.7, titled Exposure Analysis of Avalanche-Induced Flood Scenarios at Different Sites, currently discusses flood arrival time, maximum flow depth, and velocity. However, it does not include any actual* ***exposure analysis****, which by definition involves identifying and quantifying the* ***elements at risk*** *(e.g., population, infrastructure, land use). This section should be revised to include or refer to such analysis, or the section title should be changed to accurately reflect its content.*	The discussion is revised with incorporation of the impacts based on secondary data (population, infrastructure, settlements).
RC1.8	***Figures*** *The following revisions are suggested for the figures:* • *The* ***Study Area Map*** *should be labeled as* ***Figure 1****.* • ***Figures 4 and 5*** *present similar information except for the three different release zones; these could be combined into a single comparative figure for better clarity and reduced redundancy.* • ***Figures 6, 7, and 8*** *(RAMMS simulation outputs) can be consolidated into one*	Figure labeling and organization have been updated: the Study Area Map is now Figure 1; Figures 4 and 5 are merged to show susceptibility and release zones together; and RAMMS simulation outputs (originally Figs 6,7, & 8) are consolidated into a single multi-panel figure with panel labels, parameter-specific color bars, and descriptive captions.

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	composite figure with clearly labeled panels. Each panel should include color bars indicating the dynamic parameter being shown (e.g., height, velocity, momentum). Be sure to mention that these represent RAMMS outputs in the figure caption.	
RC1.9	***RAMMS:*** *What is the basis and background for identification, demarcation and consideration of the release zones and the release depth?*	Release zones were identified using the susceptibility map; the medium scenario source area specifically aligns with zones identified by Maharjan et al. (2024). A consistent 5.0 m release depth was applied based on ice failure depths used in Sattar et al. (2021) and Mandal et al., (2025) for similar Himalayan contexts.
RC1.10	*If the main implementation of the RAMMS model has been done to estimate the volume of material reaching at the lake, then it is not clear why the 2nd/3rd scenario was proposed/assumed. Different scenario might have also formulated using different release depth and initial volume at the scenario-I (Small) .*	Three distinct release zones were selected based on the susceptibility map to evaluate the influence of varying flow-path topography on lake impact. The results confirm that release location is as critical as volume; for instance, the 'Small' scenario followed a more direct, channelized path, achieving higher deposition efficiency than the 'Medium' scenario. Section 3.3 has been updated to clarify that these scenarios test topographical path variability rather than volume scaling at a single site.
RC1.11	***Input Data:*** *Make a table to show all the input data used in this work. (DEM resolution, time, frictional parameters, entrainment (if any), release condition (block/hydrograph) for RAMMS & HECRAC.*	Accepted. A comprehensive Input Data Summary Table has been added as Appendix E (Table E1). This table consolidates all parameters used in the coupled modeling chain, including DEM resolutions (ALOS PALSAR 12.5m and SRTM 30m), RAMMS frictional parameters (μ=0.12,ξ=1000m/s), Manning's *n*(0.06), and the specific release conditions for RAMMS and HEC RAS were added.
RC1.12	***HEC RAS:*** *Why was a Manning's n value of 0.06 considered appropriate for the modelled Himalayan stream reach?*	A spatially uniform Manning's n value of 0.06 was adopted for the entire 2D flow area. This value was selected as a conservative composite roughness to reflect the high energy dissipation across both the boulder-strewn channel and the rugged, debris-covered valley floor. While studies like Poudel et al. (2025) utilized variable roughness values, our use of a single,

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		higher value ensures a "safe-side" hazard assessment.
RC1.13	*Why was roughness calibration considered limited or not performed in detail for this model?*	This is assumed as limitation for the data scarce region like High Mountain Himalayas and could be future scope.
RC1.14	*How can sensitivity analysis be incorporated within HEC-RAS modeling to improve flood hazard assessment?*	Various parameters used in HECRAS, such as roughness coefficient, river geometry, glacial lakes and dam characteristics etc can be incorporated for sensitivity analysis, if all the data values are known.

CC1.1	*For figures 9, 10 and 11, merge them and describe giving sub-number*	Figures 9, 10, and 11: Merged into a single composite figure with sub-number.
CC1.2	*L715 cite the published paper not the preprint* *Banerjee A, Meadows EM, Yadav N, et al. Glacier and glacial lake dynamics from 1990 to 2024 and their impact on flood hazard in the central Nepal Himalaya[J]. Journal of Mountain Science: 2025, 22:1926-1943. 10.1007/s11629-024-9298-0* *Chaulagain M, Chand MB, Pradhananga D, et al. Recurring avalanche hazards at Birendra Lake, Manaslu region: Interdisciplinary insights from the April 21, 2024, avalanche event[J]. 2025, 7:59-77.* *Khadka N, Zheng G, Chen X, et al. An ice-snow avalanche triggered small glacial lake outburst flood in Birendra Lake, Nepal Himalaya[J]. Natural Hazards: 2024, 121:6357-6365. https://doi.org/10.1007/s11069-024-07014-0* *Poudel U, Gouli MR, Hu K, et al. Multi-breach GLOF hazard and exposure analysis of Birendra Lake in the Manaslu Region of Nepal[J]. Natural Hazards Research: 2025. 10.1016/j.nhres.2025.03.007* *Citation: https://doi.org/10.5194/egusphere-2025-4454-CC1*	Updated all citations from preprints to the final published versions for Banerjee et al. (2025), Chaulagain et al. (2025), Khadka et al. (2024), and Poudel et al. (2025).