Dear Editor,

We sincerely thank the Editor and the two reviewers for taking the time to review our manuscript (EGUSPHERE-2025-3206) and for providing valuable and constructive feedback. Their insightful comments have helped us to substantially improve the quality of the manuscript. We are pleased to submit the revised version, which incorporates the amendments suggested by Reviewer 2. In particular, as suggested, we have replaced the term “danger” with “GLOF hazard” and “risk” wherever appropriate throughout the manuscript. Accordingly, the title of our study now reads as: “Advancing Glacial Lake Hazard and Risk Assessment in Bhutan through Hydrodynamic Flood Mapping and Exposure Analysis”. Likewise, some topics and sub-topics were also changed slightly. Also, in this version of the MS, we have moved the sensitivity analysis to the Supplementary Information.

In addition, all suggested minor corrections have been addressed, and the entire manuscript has been thoroughly proofread and revised. All amendments are indicated using tracked changes in the revised manuscript and are also highlighted in blue in the point-by-point response below. With the revisions, we can confirm that the overall conclusions and findings of the study remain unchanged from the original submission.

Sincerely

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Major comments

"Danger" remains an inappropriate term used in this study. Danger is often used synonymously with threat and usually describes a natural phenomenon that could lead to damage. It is not a measure of the expected damage, and the terminology of risk assessment offers enough terms that can accurately describe the subject of this study.

I recommend that the authors reconsider the choice of terms used in their study. In their reply, the authors argue that their analysis does not account for the probability component (hazard) in the risk equation. True, but the terms assets at risk, vulnerability, damage, exposure do also not have a probabilistic connotation. Also, I have not found any previous studies that have used the term danger in this way.

Risk assessment requires precise, measurable terms and concepts. The term "Danger" varies by perception and context, and lacks a standardized definition, making it unsuitable for quantitative evaluation or comparison. Using well-defined terms improves clarity, consistency, and scientific rigor. Both previous reviewers have criticised the use of this term and I think that the response of the authors does not provide sufficient justification for why this term should be retained.

We appreciate the reviewer's concern regarding the use of appropriate terminology. As noted in our earlier response, we initially used the term "danger" because the study does not explicitly quantify the probability component typically required in formal hazard and risk definitions, and we wished to be conservative with our claims. However, upon further consideration, we agree that "risk" is the most appropriate technical term to describe our assessment, given that the analysis integrates hazard intensity with downstream exposure and vulnerability. Accordingly, we have replaced the term "danger" with "risk" throughout the manuscript, including all figures and tables. All revisions are clearly indicated using track changes in the revised manuscript.

In addition, the manuscript requires careful proofreading before resubmission.

I recommend major revisions before the manuscript is ready for publication.

The revised manuscript has been carefully proofread and checked for typographical and language errors. In addition to addressing the reviewer's comments, we have thoroughly corrected all grammar and spelling issues throughout the manuscript.

Minor comments

L16 - "which in turn has been assessed only based on upstream lake area/volume ...". This is not true. For example, see: https://nhess.copernicus.org/articles/24/2523/2024/

Corrected as suggested. Now the sentence reads as follows:

"Hazard and risk from glacial lake outburst floods (GLOFs) in Bhutan have traditionally been assessed with limited consideration of the downstream exposure and vulnerability associated with individual lakes."

L17 - "However, this approach is incomplete ..." - this is unclear at this point because PDGLs are not yet defined, yet. So at this point, the reader cannot know what PDGLs are. Why not start like this:

Previous region-wide assessments of glacial lakes have largely neglected the potential risks associated with individual lakes. Major components of these risks are exposure and vulnerability, that - when ascribed to each lake - could help prioritizing efforts to investigate the hazards associated with individual lakes. Here we introduce the concept of Potentially Dangerous Glacial Lakes (PDGLs) (please use a better term) which we define as ...

Thanks for the suggestions: Suggestion has been inserted into revised manuscript with minor rephrasing: Now it read as follows:

“Hazard and risk from glacial lake outburst floods (GLOFs) in Bhutan have traditionally been assessed with limited consideration of the downstream exposure and vulnerability associated with individual lakes. However, exposure and vulnerability are key components of risk and, when explicitly attributed to each lake, can provide a more robust basis for prioritising hazard investigations and mitigation efforts at the lake scale”

L21 - Consider reporting approximate numbers if you state they are approximate (>11,000 people, >2,500 buildings ...)

Corrected as suggested

L23 - One or more sentences would be required in the abstract to inform readers about the methodological approach taken here. Instead, some of the details about specific lakes could be shortened or removed entirely in the abstract.

Added following lines (lines 20-24) as suggested:

“We modelled hypothetical GLOF scenarios for all glacial lakes with an area greater than 0.05 km² and located within 1 km of a glacier terminus. We then identified GLOF risk by explicitly accounting for downstream impacts; depth–velocity at each exposed element affected by the simulated GLOF from each lake as well as the vulnerability of the affected community.”

L30 - I'd avoid naming these LGUs in the abstract. This is too much detail.

Avoided the names here as suggested. Now the sentence read as follows (lines 30 to 31):

“Five downstream local government administrative units (LGUs) were associated with very high GLOF risk, while eight others are associated with high GLOF risk. Five of these LGUs had not been previously documented as being at risk from GLOF.”

L38 - Rewrite: "The area of glacial lakes has increased by ~22% between 1990 and 2020, primarily ..". As it reads now, it's only the 110,000 lakes that have grown in area, which is inconsistent with the fact, that new depressions have formed.

Corrected as suggested

L54 - "are high magnitude yet eposidic". The reference to Sattar et al., 2025b, is likely not appropriate. Please cite a paper that supports this statement.

References are edited.

“Now following references have been cited: (Zhang et al., 2025; Shrestha et al., 2023; Lützow et al., 2023)”

L177 - Don't report numbers with such high accuracy.

Thank you for the suggestion. However, we prefer to retain this value, as the total population data are adopted from the 2017 Bhutan Population and Housing Census, which provides sufficiently accurate and authoritative information for the purpose of this study.

L267 - Did you do any more DEM preprocessing? Previous research has shown that hydrologically conditioned DEMs are often needed before hydraulic simulations.

Yes, we conducted basic hydrologic correction of DSM data used here. We did not add this in the previous version as thought it was not necessary since DEM correction for flood modelling is very basic procedure. However, acknowledging the reviewer’s concern, we have not added following in lines (lines 266 to 268):

“The DSM was hydrologically corrected by removing spurious depressions and burning in artificial flow paths in locations where deep gorges were incorrectly represented as floodplains (Rinzin et al., 2023).”

L298: "at the Bhutan scale". Why not simply "in Bhutan".

Corrected as suggested

L388: damaged grid cells?

Corrected as “damage pixel”

L470 - Better write: "Hydraulic models rely on...". Hydraulic models are usually not complex models as they rely on well-defined physical models. They may be complicated, though.

Corrected as suggested.

L492 - total volume of

Corrected as suggested

Fig. 3 - There is enough space to write out danger level (instead of D. level) in the legend. And why not showing the inundation extents (spell out in legend) in the detailed panels?

The legend level “D. level” is now corrected as “hazard level”. Inundation extent is now described in the caption as suggested.

Fig. 4 - The panels b-e also need scale bars.

Scale bar is added

L571 - Five of the LGUs were ...

Corrected as suggested

Fig 5 - Number of buildings (s is missing). In addition, the y-axes labels are confusing. What is the GLOF risk index?

Corrected as suggested. GLOF risk index in the y-axis label now remain same as we now use technical terminology ‘risk’ instead of danger in all appearances as mentioned earlier.

L636 - "41% of them". What does them refer to?

It refers to the building. “It is now corrected as at least 41% of exposed building”

L831 - What is hydraulic intensity?

We meant to refer to the flood magnitude in terms of its hydraulic characteristics such as flow depth and velocity. However, to avoid confusion we now replaced ‘hydraulic intensity’ by the “GLOF magnitude”

L833 - any reference for the statement that downstream settlements are evolving (growing)?

Following references are added: (Nie et al., 2023; Uddin et al., 2021)

Table S1 - In contradiction to your response letter, there is no header on each page.

We apologize for this oversight: we now added table header in each page as suggested

**References**

Lützow, N., Veh, G., and Korup, O.: A global database of historic glacier lake outburst floods, Earth Syst. Sci. Data Discuss., 2023, 1-27, 10.5194/essd-2022-449, 2023.
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