Response to the Editor:

We sincerely thank the Editor for considering our manuscript for potential publication in the 'Natural Hazards and Earth System Science (NHESS)' journal and for sending it out for peer review. We appreciate the time and effort the editor and reviewers invested in providing constructive and insightful comments that helped improve the scientific clarity and robustness of our work.

We have carefully addressed all reviewer comments and prepared a detailed, point-by-point response to each. Necessary modifications have been made to the manuscript, and a revised manuscript incorporated all suggested changes to improve clarity, methodological transparency, and the interpretation of results, and to address the limitations of the current study. We believe that these revisions will significantly improve the overall quality of the manuscript, and we sincerely thank the reviewers for their constructive and thoughtful evaluation.

The responses to reviewer comments are provided in blue font, and the corresponding excerpts from the revised manuscript are shown in green italic font within the response document.

Reviewer Response

We would like to thank Harold Lovell and the anonymous reviewer for their careful evaluation and constructive comments on our manuscript. Here, we provide point-by-point responses to each reviewer's comments, clarifications where needed, and details of the revised plan for our present study. All the reviewer comments are in black, whereas the responses are in blue.

Reviewer 1 (Harold Lovell)
General comments:

This study presents evidence for previously unreported hazards/hazard cascades in a basin containing five glaciers (plus one more nearby) in the Western Himalaya. It is shown how several avalanches have occurred onto glaciers, in one case entering a glacial lake and triggering a small GLOF. These events appear to have been unreported at the time they occurred, indicating they had minimal impact on immediate downstream communities. However, the point is made that similar hazards in the future from the basin have the potential to be more problematic, and avalanche and GLOF modeling effectively demonstrates this. Thus, this is a useful contribution to the literature on a very important topic. I do however, think that improvements can be made to the paper as it stands, particularly to streamline the text and figures and improve consistency of terminology and how this appears across the text and figures, in addition to a number of other minor edits to improve the clarity of the writing throughout.

Response: We are thankful to Dr. Harold Lovell for his constructive comments on our manuscript. We have carefully implemented the reviewer's suggestions and revised the relevant text and figures accordingly.

Specific Comments

The introduction could be more focussed and streamlined. It is currently quite long and I'm not sure all the paragraphs are necessary – see some of the technical suggestions below. There is some repetition too. The paragraph stating the aim of the project could be streamlined and shortened – focus on one or two sentences stating the purpose of the study.

In the revised manuscript of the manuscript, we have shortened the introduction section to make it more streamlined

I'm missing a clear explanation in the results of the impact of the 2020 GLOF from Lake-A on Lake-B. Figure 12 suggests the GLOF could have entered Lake-B, but there is little apparent change to the lake. There is a sentence on this in the discussion, but a clearer explanation of this in the results would be useful – Figure 3 and 5 do not really provide good wider context of the lakes and their proximity to each other, so it is hard to appreciate this relationship in the results at present. Figure 12 does illustrate this relationship very nicely, but is a long way into the paper. I would actually suggest moving Fig. 12 to the results and providing a broader description of the interaction between the lakes during these events – this is of course important from a hazard cascade viewpoint.

We thank the reviewer for this comment. We would like to mention here that the magnitude of the 2020 GLOF from Lake-A was smaller, and the release volume was smaller. This has resulted in a minimum impact on Lake-B, which is immediately downstream of Lake-A. Here, we would also like to mention that meltwater from Lake-A flows directly into Lake-B, and both Lake systems are interconnected (see revised Fig. 5 and 6). In case of higher magnitude GLOF event in Lake-A, would have greater potential to impact Lake-B, given their geomorphic settings. We have made it clear in the revised manuscript. As suggested, we moved Fig. 12 to the Results section.

The schematic diagrams (Figures 11 and 13) are not really needed in my view. The sequence of events they describe is clear from the text and the other figures, so these diagrams add little value (and there already quite a lot of figures).

Following the reviewer's suggestion, we moved Figures 11 and 13 to the supplementary section as Fig. S3 and Fig. S4.

Periglacial is used throughout, but in most cases I think proglacial is more accurate - particularly where you are referring to the areas in front of the glaciers/lakes.

We thank the reviewer for this comment. As suggested, we have carefully cross-checked and revised the relevant text.

Check consistency of labelling in text and figure. For example, you sometimes use "Lake-A, Lake-B" and other times "Lake A, Lake B".

We thank the reviewer for pointing this out. We have carefully revised throughout the manuscript to maintain consistency as 'Lake-A' and 'Lake-B'.

Figures: in quite a few places I found that adding labels to the figures would really help the reader, such as labelling Lake-A and Lake-B on relevant figures, alluvial fan (which is mentioned in the text but not on figures) and a few more besides. See some of the technical suggestions below.

We thank the reviewer for this helpful suggestion. In the revised manuscript of the manuscript, we provided labels as suggested.

Technical suggestions

Abstract

Page 1, line 5: I don't think "glacial lake outburst floods" needs to be capitalised in this way.

We revised them accordingly.

Page 1, line 21: "a" is missing before "potentially hazardous". Also suggest "in its present condition" instead of "at the present condition"

We thank the reviewer for pointing this out. We considered this in the revised manuscript of the manuscript.

Introduction

Page 2, lines 2-5: It is not clear if this is referring to global glacier loss or regional loss in

High Mountain Asia, for example. Suggest clarifying this as most of the references appear to relate to HMA (or HKH as you use).

We thank the reviewer for this comment. That was for the High Mountain Asia (HMA). We have mentioned HMA in the same sentence.

Page 2, lines 10-12: Suggest “pose a challenge to” instead of “challenge”

We have revised the manuscript accordingly.

Page 2, lines 17-19: I’m missing the time period covered by these reported increases in lake numbers – is this still referring to the last three decades? Suggest adding this for clarification.

The time period was 2001-2013. We have mentioned it in the revised manuscript.

Page 2, line 20: suggest adding “formed in front of retreating glaciers” after “glacial lakes to clarify that you are not dealing with ice-dammed or supraglacial lakes.

Thanks, we have addressed this in the revised manuscript of the manuscript.

Page 2, lines 20-21: I don’t think “glacial lake outburst floods” needs to be capitalised in this way.

This has been implemented in the revised manuscript.

Page 2, line 25: suggest “that threatens” instead of “and threatens”

We have revised the manuscript accordingly. as “that threatens”.

Page 2, line 30: remove “and” before “affecting” as there is another “and…” later in the list.

We considered the suggestion and incorporated the necessary changes in the revised manuscript.

Page 2, line 31: “destroying” would fit better with the verb form in the rest of this sentence.

We have incorporated the suggested change in the revised manuscript.

Page 3, line 2: suggest “have been” instead of “were”

We have incorporated the suggested change in the revised manuscript.

Page 3, lines 4-6 “which was amplified by the huge debris eroded along the channel where the 2015 Gorkha earthquake deposited the majority of the debris” – this is slightly untidy phrasing and could be improved.

Following the reviewer’s suggestion, we have rephrased as “For instance, the 2016 Gongbatongsha GLOF event in the Poiqu Basin of China (Sattar et al., 2022), which was amplified by the huge debris eroded along the channel, previously deposited during and post-earthquake landsliding of the 2015 Gorkha earthquake.”

Page 3, lines 7-8: Why not simply: “The village of Til was impacted by bank erosion and collapse” ?

This part has now been removed from the manuscript to shorten the “introduction” section as suggested by both reviewers.

Page 3, lines 11: Suggest “a GLOF” and “a debris flow”

We have incorporated the suggested change in the revised manuscript.

Page 3, line 20: “mass movements”

We have revised the manuscript accordingly. in the revised manuscript.

Page 3, line 21: these two citations seem to relate only to GLOFs in the Himalaya, so don’t really support the “GLOFs and mass movements” and “globally and regionally” points. I suggest adding more refs here to cover these.

We thank the reviewer for pointing this out. We added more relevant citations, such as the Global GLOFs database (http://glofs.geoecology.uni-potsdam.de/); Emmer and Cochachin (2013) (), which compares similar moraine-failure events from the Himalaya, the Andes, and North America; Lützow et al. (2023) (); and Zhang et al. (2024)

.https://doi.org/10.14712/23361980.2014.23https://doi.org/10.5194/essd-15-2983-2023https://doi.org/10.1038/s43017-024-00554-w

Page 3, line 23: “after” should be “since”

We made the suggested changes in the revised manuscript.

Page 3, lines 24: are “new” and “unreported” both needed here?

We now just mention “unreported”.

Page 3, lines 24-26: what are “GLOF sources”? Does this mean lakes that produced GLOFs? Rewording this would improve clarity. “~95% moraine-dammed glacial lakes” needs to be integrated into the sentence better. “were located in the Himalaya” is needed.

We have rephrased it in the revised manuscript for clarity.

Page 3, lines 28-30: “Identifying these unreported past events is therefore crucial for reconstructing geomorphic process regimes and understanding the hazard frequency in mountain catchments”. I would swap the order of these in the sentence – the contribution to understanding hazard frequency seem the important point that follows immediately from the preceding sentence. What are “geomorphic process regimes”? I feel that this could be rephrased in simpler language. Perhaps just “geomorphic processes”?

Thanks for the comment and important suggestions. We rephrased the sentence for greater clarity in the revised manuscript as “Identifying these unreported past events is therefore crucial for reconstructing geomorphic processes and understanding the GLOF frequency in mountain catchments (Carrivick and Tweed, 2013; Richardson and Reynolds, 2000; Veh et al., 2025).”

Page 4, lines 3-13: This paragraph seems out of place. Either it should be incorporated in the study area section, or in the earlier paragraph in the introduction that describes some examples of GLOFs (although I would argue this is probably too many examples for there).

We have shifted the paragraph to the introduction section that describes the past GLOF examples.

Page 4, lines 14-31: These two paragraphs should be combined and shortened into a snappier “purpose of this study” paragraph. Twice in three sentences “Here, we…” is used, as an example. Save the details for the methods and elsewhere.

We have combined and shortened these paragraphs as suggested.

Study area and importance of the region

Page 5, lines 2-19: watershed and catchment are both used in this paragraph, suggest sticking with one.

We thank the reviewer for this comment. To ensure consistency, we used the term catchment in the revised manuscript.

Page 5, lines 4-5: how important is 0.8 km2 and .61 km2 in these values? Especially as the glacier data is reportedly >10 years (or more? 2000) old. Suggest rounding to whole integers.

We thank the reviewer for this comment. We revised and rounded them.

Page 5, lines 6-9: This data is presumably RGI outlines based on the citation, so it is important to state that here, and which version, e.g. RGI 7.0 (which you can cite directly, e.g. https://nsidc.org/data/nsidc-0770/versions/7). You should also then qualify the date stamp on these dimensions, which according to the RGI 7.0 information is “approximately the year 2000”.

We used the RGI 6.0 boundary and corrected it using the respective satellite timestamp. Therefore, we state that we used the RGI 6.0 boundary and corrected it for the 2024 time stamp using PlanetScope imagery.

Page 5, lines 9-10: “are associated with proglacial lakes” – can you be more specific, are these glaciers in direct contact with the lakes? And can you say when this was the case?

We thank the reviewer for highlighting this important point. Both glaciers are in direct contact with lakes. We refined the sentence to increase clarity in the revised manuscript.

“In the glacier complex, Lake-A and Lake-B are proglacial lakes associated with GL-A and GL-B, respectively”

Page 5, lines 10-11: “…and have experienced mass movement events in September 2020 and 2005” – isn’t this the results from this paper? If so, I suggest removing from here.

We thank the reviewer for highlighting this point. As suggested, we removed them from Study area section

Page 5, line 12 “Fariabad Nalla” – the spelling is different on Figure 1.

Thanks to the reviewer for pointing out the inconsistency in the spelling of Fariabad Nalla. To ensure consistency, we used the spelling “Fariabaad Nalla” throughout the revised manuscript.

Page 5, line 13: use “the Marusudar River” on both occurrences in this line. Where is this river located on Figure 1? Where is Yordu village?

In the revised Fig. 1, we marked Marusudar River and Yordu village. Yordu village is located at the junction of the Fariabaad Nalla and the Marusudar River, ~58 km downstream of the Lake-B, near Qaderna (see Fig. 1a).

Page 5, line 14: Chenab River and Bandarkoot – are these beyond the Figure 1 study area? These should be labelled really.

We thank the reviewer for pointing this out. Chenab River and Bandarkoot are far downstream of the study region. We have revised and removed these words in the revised manuscript.

Page 5, lines 16-19: this sentence “According to…” is out of place and would be better placed after you first introduced the glacier dimensions. You also don’t need the second citation to the same study.

We shifted the sentence after we first introduced the glacier dimensions and also reframed this sentence in the revised manuscript. We removed the second citation as suggested

Page 5, line 20: These placenames should all be on Figure 1 in the same format (e.g. “Metwan” or “Metwan village”)

Thanks to the reviewer for pointing out the inconsistency. To ensure consistency, we used the term “Metwan village” throughout the revised manuscript.

Page 5, line 26: what and where is the “Kishtwar Window”?

We have revised it to Kishtwar District in the revised manuscript.

Page 6, lines 3-7: Panel A - The shortened letters in the figure inset map need explaining: J and K, LDK, HP. Panels B and C - I’d suggest explaining what the different colour polygons are in the caption: red, grey and turquoise (presumably avalanche source, runout and lakes) – or add a legend.

We thank the reviewer for this helpful suggestion. We agreed and explained the shortened letters in the figure caption. We have added a legend for different coloured polygons in Fig 1.

Data and methods

Page 7, line 4: Suggest “images” instead of “imageries” and “imagery” - the next sentence calls them images.
We thank the reviewer for this helpful suggestion. We used the term “imagery” and “imagery” throughout the revised manuscript.

Page 7, lines 5-9: These sentences can be combined to make the writing more succinct.

We thank the reviewer for this helpful suggestion. We have combined and shortened the sentences in response to the reviewer's comments. The refined sentence is added below for the reviewer's reference.

“These imageries, captured during post-monsoon and peak ablation periods, were used to delineate glacier and glacial lake boundaries using Normalized Differential Water Index (NDWI) and standard FCC (False Colour Composite)”

Page 7, line 8: How are “past GLOFs” determined from satellite images?

We have used time series of imagery on a daily scale to identify the changes in the proglacial environment. Past GLOF events were identified based on the moraine changes and the debris fan deposited downstream. We have clarified this in the revised manuscript.

Page 7, line 8: spell-out “FCC”

FCC stands for "False colour composite." We incorporated the expanded form into the revised manuscript.

Page 7, line 10: “images” not “imageries”

We thank the reviewer for this comment. We used the term imagery throughout the revised manuscript for consistency.

Page 7, line 11: see comments on study area section about RGI – this should be clearly stated there too.

We state here that we have used the RGI 6 boundary, which has been rectified for each respective satellite image timestamp.

Page 7, line 12: again, how are past GLOFs identified from satellite images? More details are needed. How is ice calving detected, and is this dry calving or in the lakes? Did you examine temporal images to identify new calving events? More details also needed on this.

We thank the reviewer for this comment. We have used temporal PlanetScope imagery to map the calving process. We looked for changes in the glacier terminus and floating ice on the lake to identify the calving episodes. This is now clarified in the method section of the revised manuscript.

Page 7, lines 14-16: Mapping uncertainty – you use Landsat and Planet images, so which pixel size is used for the uncertainty analysis? State this here. It sounds like the mapping was mostly done from the Landsat data.

We mapped the 1999-2015 period using Landsat imagery, and after that (2016-2024), we used only PlanetScope imagery. For the Glacier mapping, we used a half-pixel buffer at the respective satellite image resolution, and for the lake mapping, we used a one-pixel buffer following Gransaw and Fountain (2006), and Racoviteanu et al. (2015). The same has also been mentioned in the text (also see Tables S3 and S4).

Page 7, line 28: “pre- and post-event PlanetScope imagery” – unless I’m mistaken,

aren't some of your avalanches from before Planet images were available? Best to clarify this here.

We thank the reviewer for this comment. Yes, the 2005 avalanche occurred on GL-B, which is associated with a proglacial lake (Lake-B), which we identified using Landsat 5 (TM) and Landsat 7 (ETM+) imagery. For the 2020 avalanche on GL-A and GL-F, we have used pre- and post-PlanetScope images.

Page 8, line 16: "To estimate the future volume…", "we first matched its potential maximum extent…" – future volume and potential maximum extent of what?

Here, we refer to the future lake volume of Lake-B. To avoid ambiguity and improve clarity, the sentence is revised accordingly.

"To estimate the future volume of Lake-B, we first mapped its potential maximum extent by reconstructing the glacier bed using a spatially distributed glacier ice thickness product combined with a DEM."

Page 8, lines 27-30: check "D. D. More" citation – this appears to include initials.

We have checked and corrected the citations throughout the revised manuscript.

Page 9, lines 2-6: "SC-1" etc. on the figure needs to be explained in the caption.

We thank the reviewer for this suggestion. In the caption, we have mentioned that SC stands for scenario.

Page 10, lines 2-3: I think the Shugar et al. citation should probably come immediately after "the Chamoli event".

We thank the reviewer for this suggestion. We have revised it accordingly.

Page 10, lines 3-5: Sentence beginning "Similarly,…" is missing some words.

We revised the sentence for improved clarity in the revised manuscript.

Page 10, lines 23: Sections 1-3 should be identified on a map somewhere.

We thank the reviewer for highlighting this point. Accordingly, we have demarcated the avalanche source in Figure 11 in the revised manuscript.

Results

Page 11, lines 4-5: Figure 4 should be cited before figure 5, or perhaps the order of these figures should be swapped.

We have revised the manuscript to maintain consistency between figure ordering and their corresponding citations, ensuring that each figure is cited in the text before it is placed in the manuscript. Additionally, Figures 4 and 5 were interchanged to improve the overall clarity and flow of the narrative.

Page 11, lines 8-9: “shifts in the thermal regime” – what is meant by this and how does it link to the “water-ice interactions”? More details needed here if you are to keep this interpretation.

We have removed the terms “thermal regime”

Page 11, lines 12-14: sentence beginning “While Lake A…” doesn’t work currently. I suggest removing “while”, “has” and “only”. Should this also be “Lake-A” for consistency?

We thank the reviewer for this comment. We have revised the sentence in the revised manuscript as follows to ensure grammatical correctness and overall readability.

“Lake-A (associated with GL-A) expanded by ~25.61% (1999-2020) before the 2020 GLOF event (Fig. 3, Fig. S1 & Table S2).”

Also, to ensure consistency, we mentioned the lake as Lake-A throughout the revised manuscript.

Page 12, lines 3-7: It would make sense to use “Lake-A” here so the reader is clear how this name links to the figures.

We thank the reviewer for this helpful suggestion. We included Lake-A in the figure caption as suggested.

“Fig. 3. Evolution of the proglacial lake (Lake-A) and surrounding periglacial environment at GL-A from 1999 to 2024. Continuous sediment infill since 1999 led to bifurcation of the lake (Lake-A) by 2008, with a connecting channel visible in 2009; the main glacier shows consistent retreat throughout the period; the 2020 imagery captures the avalanche event and the fully drained lake following the GLOF. (Background images: Landsat for 1999 to 2015 and ©PlanetScope from 2016 -24)”

Page 12, lines 9-11: add labels to the fore-basin and main basin to Figure 4.

We thank the reviewer for this comment. We revised Figure 4 by clearly labelling the fore-basin and main-basin regions to improve clarity and interpretation. In the revised manuscript it can be seen as Fig. 5.

Page 12, line 9: alluvial fan should be used on Figures 3 and 4 too so it is clear what feature you are describing here.

We thank the reviewer for pointing this out. We now use the same terminology as mentioned in the figures. Instead of 'alluvial fan' we use the term 'debris deposit'. We corrected it throughout the manuscript.

Page 13, line 4: "proglacial" isn't needed here.

We removed the term "proglacial" from the sentence in the revised manuscript.

Page 13, line 7: can remove "(or floating ice)"

The word "(or floating ice)" has been removed from the revised manuscript.

Page 13, line 9: Why is the alluvial fan included in the lake basin area? Doesn't this incorrectly inflate the lake area as there is no water where the fan is? This would then have knock-on effects on any further calculations from lake area, such as volume. I would just use the two basins where water is clearly visible for your lake area calculations, or provide a clearer explanation for including it.

We used this calculation to approximate lake basin volume. For future volume we consider only Lake-B, where we do not have these deposits within the lake basin. We have clarified this in the revised manuscript.

Page 14, line 16: suggest "infilled sediment". Is this the alluvial fan? If so, it would be helpful to use the same terms.

The terminology was revised and unified throughout the text.

Page 14, lines 17-18: "Following the event, satellite imagery revealed breaching of the Lake-A moraine, extensive GLOF outwash, and subsequent deposition in the downstream channel." – here is one of the places where it would be good to understand how this GLOF then went on to impact Lake-B, immediately downstream.

The GLOF from Lake-A did not lead to a cascading GLOF of Lake-B located immediately downstream. This is shown in the revised manuscript of Fig. 6. We have mentioned it in the text of the revised manuscript.

Page 14, line 18 to page 15, line 2: You seem to be suggesting that the lake formed entirely from melting of ice in the drained basin, what about meltwater inputs from the various glaciers that feed the basin? These surely also had an input. Also, debris can't strictly melt so suggest rephrasing.

Many thanks to the reviewer for the suggestion. We have revised as suggested.

Page 15, line 3: Remove "Again" because this is a different glacier.

We removed this in the revised manuscript.

Page 15, lines 8-10: "water seepage" – what do you mean by this? Meltwater emerging from this side of the glacier for the first time? This is also not immediately obvious from the figure, so you should label exactly where you infer this is happening and explain what the evidence is for water seepage.

We thank the reviewer for pointing this out. We have rephrased it as "Between 2013 and 2015, imagery revealed lake water intrusion along the right margin of GL-B's terminus"

Page 15, lines 10-11: "This seepage contributed to the development of extensive crevassing" – why is this the case? Further explanation is needed as the link between water emerging from the glacier and increased crevassing is not immediately clear to me.

We thank the reviewer for pointing this out. As we do not have clear evidence of seepage contributing to the development of extensive crevassing, we therefore rephrased the sentence in the revised manuscript for clarity.

Page 15, line 15: "However" is not needed here.

We removed it in the revised manuscript.

Page 15, line 16: “after” should be “since”. The comma after “Owing to this” should be moved to line 17 after “size”.

We rectified as suggested in the revised manuscript.

Page 15, lines 18-21: Sentence beginning “It is also noted…” needs to be edited and rephrased and is doesn’t work currently.

We thank the reviewer for pointing this out. We have rephrased the sentence as suggested.

Page 16, lines 2-6: It would make sense to use “Lake-B” here so the reader is clear how this name links to the figures.

We included 'Lake-B' after the word 'proglacial lake' in the revised manuscript.

Page 21, line 12: “the” is not needed before “Lake-B”.

Revised as suggested.

Page 22, line 15: Delete “at”. Check spelling of “MaruSudar”

We removed the ‘at’ and replaced the word as ‘Marusudar’ in the revised manuscript.

Page 22, line: “reach” instead of “are reaching”

We revised accordingly.

Discussion

Page 25, line 4: See also recent paper for this point, which could be cited here: Pepin et al. (2025) - https://www.nature.com/articles/s43017-025-00740-4

We thank the reviewer for this suggestion. We cited the relevant literature in the revised manuscript.

Page 25, lines 9-10: “Zheng et al. (2021) reported that at least 21 GLOF events occurred per year in the region from 1900 to 2016, with the majority being unreported

(Zheng et al., 2021a).” – how can GLOFs be both reported and unreported? Suggest rephrasing this so it is clear what is meant.

We thank the reviewer for pointing this out. We have rephrased it for clarity.

Page 25, lines 11-13: Suggest defining “unreported GLOFs” here – these are GLOFs that were not reported at the time they occurred? Or have not previously been reported, but have been identified retrospectively? Note “GLOFs” not “GLOF”.

Unreported GLOFs mean GLOF events that have occurred in the past but have not been documented or reported due to their remote location or minimal impact on the downstream. Also, due to minimal to no impact on downstream areas, such GLOF events are often not reported at the time they occur; they are identified retrospectively based on geomorphic processes and signatures. We now have defined it here as suggested.

Page 25, lines 14-16: This sentence would be better placed in the paragraph before, after the sentence ending with the citation “Harrison et al. 2018”.

We have moved the sentence as suggested.

Page 28, line 2: “proglacial” would be a better term here than “periglacial”.

We changed “periglacial” to “proglacial”.

Page 29, lines 10-12: Unless I missed it, this is the first time I see reference to the 2020 GLOF not impacting Lake-B. I think this should be explained clearly earlier in the results.

We thank the reviewer for pointing this out. We mentioned earlier in results for greater clarity in results section: 4.2.1 Observations.

Page 30, line 9: “The Lake-B present…” should be “Lake-B presents…”

We have revised the manuscript accordingly.

Page 30, lines 13-14: “High-resolution imagery shows that several settlements have emerged near the river in the past two decades” – the imagery shows that the settlements are there, but not that they have emerged as it is a single timestep. Suggest rephrasing

We thank the reviewer for this helpful suggestion. We have on rephrased as “High-resolution imagery shows that several settlements developed along the river in the span of two decades”.

Page 30, line 15: “could” not “can”

We thank the reviewer for this comment. Changed it to “could”.

Page 31, lines19-22: sentence starting “Recent observations…” – this is repetitive from the paragraph above, remove and merge the final sentence in this paragraph with the previous paragraph.

We have deleted the sentence and merged it with the previous paragraph as suggested.

Page 31, lines 27-28: “We reconstructed…” – the way this is phrased, it could be mistaken for a description of different avalanches, but you are still talking about the same ones from the previous paragraphs. Editing the phrasing here would improve this link and the fluency of the writing.

We thank the reviewer for pointing this out. We have rephrased it for clarity.

Page 32, line 16: “Mass-wasting”… until now this term hasn’t been used I don’t believe, but mass movements has. I suggest you use consistent terms unless you intend there to be a different meaning here.

We thank the reviewer for pointing this out. We replaced it with “mass movement” for consistency.

Page 32, line 28: “GLOFs”

We have corrected this in the revised manuscript.

Page 34, line 4: “MaruSudar River” – check spelling as it is different elsewhere.

We have changed it as “Marusudar”

Page 34, line 5: Make sure these locations are labelled on a map somewhere.

We have labelled the locations in Fig. 1

Page 34, paragraph 1, final sentence: Could also add 2022 Shisper Glacier GLOF in the Karakoram, which caused a lot of damage to infrastructure: Muhammad et al. (2021: https://www.tandfonline.com/doi/full/10.1080/19475705.2021.1975833)

We thank the reviewer for this helpful suggestion. We will cite Muhammad et al. (2021) in the revised manuscript.

Page 34, paragraph 2, final sentence: “In this region” – suggest you are more explicit that you mean the basin you have studied.

We intended to state, “in the Himalayan region.” We have corrected it in the revised manuscript

Page 34, paragraph 3, first sentence: do you mean the “modelled high-magnitude scenario flow channel” – suggest adding this if so.

Yes. We have added this in the revised manuscript.

Page 35, paragraph 1, first sentence: remind the reader that SC-1 is the worst-case scenario.

We have revised it accordingly as “.....respectively in SC-1 (worst-case scenario)”.

Page 35, paragraph 1, sentences 2 and 3: these are currently grammatically incorrect sentences and should be merged or edited.

We have corrected and merged sentences 2 and 3 for greater clarity.

Page 35, paragraph 1, sentence 4: what form could an early warning system take? A stream gauge of some sort to detect increased discharge? Some detail here would be helpful.

Following the reviewer’s suggestion, we have given details in the revised manuscript. It is now rephrased as “However, an early warning detection system that can include discharge sensors, and /or water level sensors, and/or seismic stations, closer to the source (Lake-B) will potentially be able to provide a good lead time in case of GLOF warnings.”

Page 35, paragraph 1: “Also, for a conservative approach effective adaptation requires integrated approaches that combine glacial lake hazard assessments with community-based vulnerability evaluations and social protection policies.” – I can’t follow this sentence at present, it should be rephrased.

It is now rephrased for greater clarity as “However, effective GLOF adaptation requires integrated approaches that combine glacial lake hazard assessments with community-based vulnerability evaluations and social protection policies.”

Page 35, paragraph 1, final sentence: the last bit of this sentence is unnecessary as this has just been stated in the previous sentence.

We have deleted this as suggested.

Conclusions (note - no line numbers here)

Page 35, paragraph 2, first sentence: “past two and a half decades” – why not “25 years”?

We have corrected this as suggested in the revised manuscript.

Page 35, paragraph 2: “mass-wasting” – see previous comments on whether “mass movements” would be better, given the article title.

We have corrected this as suggested in the revised manuscript.

Figures

Figure 1: Adding an arrow to the GLOF path in panel (B) would be helpful. Make sure all placenames mentioned in the text are labelled on the maps wherever possible, and spellings match between text and figure. Label Lakes A and B.

We updated Figure 1 to reflect the suggested changes. Few places, such as Bandarkoot and Chenba River, are very downstream, and this particular Fig 1 captures the extent of Lake-B catchment, so therefore, that will not be covered. However, we added other village such as Yordu locations accordingly to avoid confusion.We continued to refer to Lake-A and Lake-B throughout the manuscript.

Figure 4: Adding arrows to the drainage paths would be helpful. Label fore-basin and main basin

We have revised Fig. 4 to include the fore- and main basins, with corresponding text.

Figure 6: The avalanche runout label is not very clear – it took me a while to realise this related to the red dashed outline because the label overlaps with the glacier outline. Suggest making this clearer.

The red dashed line shows the avalanche runout. The extent of glacier and runout overlap may be causing confusion. For clarity, we have added text which marks the avalanche runout.

Figure 7: Label avalanche runout.

We have labelled avalanche runout in the revised manuscript

Figure 9: panel labels are lowercase letters here, elsewhere they are capitals.

We thank the reviewer for pointing this out. We have revised the labels accordingly.

Figure 10: the bridge symbol should be in the legend. Yordu is in the caption but not labelled on the figure.

We have revised Fig. 10 accordingly.

Figure 11: I'm not convinced this schematic figure is required – the events depicted here are already described well in the text and Figure 3.

We moved them to the supplementary section as Figure S3.

Figure 12: Suggest moving this to the results. Panel labels are lowercase letters here; elsewhere, they are capitals

Following the reviewer's suggestion, we have moved this figure into the result section and panel labels are made uniform throughout

Figure 13: Similar point to Figure 11 – this isn't really needed in my view, and there are already quite a lot of figures.

We moved it to the supplementary section as Fig. S4.

Figure 14: This seems like it would fit better in the results too.

Following the reviewer's suggestion, we have moved the figure in the result section and also discussed it in the discussion section.

Reviewer 2

General Comment

This paper details mass movements in the remote Warwan sub-basin which has experienced development and population increases. Multiple mass movements, including GLOF events, have largely gone unreported due to the inaccessibility of the region. This paper focuses on three major events; one triggering a GLOF. They carry out geomorphological mapping, avalanche reconstruction (using scenario-based modelling), GLOF process-chain modelling and Mapping GLOF-exposed infrastructures

The paper aims to model past events and quantify future downstream GLOF exposure in order to provide a foundation for the future of GLOF research. They also hope to provide information for future planning and infrastructure to help build resilient communities. They highlight the need to integrate cascading hazards in future assessments, as the interactions of different triggering hazards can exacerbate the rick to communities. The results presented highlight the need for integrated monitoring of cryospheric processes, improved early warning systems, community-based preparedness, and robust mitigation strategies to safeguard life, livelihoods, and infrastructure in the region.

We sincerely thank the reviewer for their careful evaluation of our manuscript and for their encouraging comments on the relevance of our work. We addressed all the comments from the reviewer and have prepared point-wise responses, which will be incorporated into the revised manuscript of the manuscript. All the reviewer comments are in black colour, while the responses are in blue in this response document.

Suggestions for improvement:

I would consider revising the title to include GLOFs, as this is a focus of the paper.

We revised the title as “Unreported mass movement cascades and future Glacial Lake Outburst Flood (GLOF) hazard in Jammu and Kashmir, Western Himalaya”

I would consider shortening the introduction - there is a lot of information contained, not all of which is particularly relevant to the study or narrative of the paper. Specifically paragraph 2 could introduce the ideas presented around hazard potential and integrate this with paragraphs 3 and 4. I don’t feel like you need so many specific examples, but if you feel that these add weight, then please do consider condensing the information. Paragraph 5 highlights how these are underreported but could be shortened.

We thank the reviewer for this helpful suggestion. We have substantially streamlined the Introduction and incorporated the reviewer’s suggestions throughout the revised manuscript.

Specific comments:

P1 L3 You mention that the population of the area has expanded, it would be interesting to put this into context if you have any regional statistics.

The increase was identified from the available time-series satellite imagery. Because reliable regional population statistics are not available for the study area, we have avoided reporting numerical estimates.

P5 L7-9 - could the area of the glaciers be in a figure/table and removed from the text? It’s hard to read.

We have retained the individual glacier areas for GL-A to GL-F in the text, while removing repetitive units and reporting the units only at the first occurrence to improve readability.

Figure 1. You include the modelled GLOF path, but this is coloured differently in 1A and 1B. It is also not clear if this is for the 2020 GLOF or for a modelled (e.g. Fig 9) scenario; you just need to clarify.

We thank the reviewer for pointing this out. We have made the suggested changes to the revised manuscript of the figure by labeling the GLOF path as ‘modeled GLOF’ and making the colour uniform in both panels.

P8 L16-18 It’s not clear what you’re talking about, the future volume of what? The glacier? How? What is the “ice thickness product”?

Many thanks to the reviewer for pointing this out. We talk about the volume of Lake-B in the sentence. We have revised the sentence and added Lake-B into the sentence for clarity.

The spatially distributed glacier ice thickness product is based on Farinotti et al. (2019).

The method of calculating the volume of Lake-B is now explained for greater clarity and has cited relevant citations.

The new text in the revised manuscript is given as:

"In the absence of direct ice thickness measurements and subglacial topography data, we utilized ensemble ice thickness data (Farinotti et al., 2019). Raster-based calculations were performed to derive a spatially distributed glacier-bed surface by subtracting the ice thickness from the glacier surface (DEM). The overdeepening on the glacier bed was mapped following Sattar et al. (2019) and Sattar et al. (2020).We followed contour-based bathymetry generation approaches used previously in western Himalayan lake-bathymetry reconstructions (Sattar et al., 2021, 2023)."

Section 3.3 could do with revision - it's obscure and not clear what you were trying to achieve or how. It feels like you have cut out elements which are fundamental to being able to reproduce the methodology. For example, P9 L10-11 are unclear: "The density of the modeled avalanche was assumed to be 2300 kg m-3 assuming it to be potential rock-ice avalanches." Doesn't make sense.

We thank the reviewer for this constructive comment. We have revised the section thoroughly giving details of the model parameters and maintaining clarity of the modeling approach. We rephrased multiple sentences to bring clarity to this section. We now combined section 3.3 and 3.4 as 'GLOF process-chain modeling and downstream exposure'.

P10 L23 What do Sections 1-3 refer to?

Sections 1 to 3 refer to different cross sections downstream of Lake-B where modeled GLOF discharge was extracted. We have revised this for greater clarity. We now combined section 3.3 and 3.4 as 'GLOF process-chain modeling and downstream exposure'.

P11 L11-14. You mention that lakes have expanded by different percentages, but it would be better to be consistent about the dates that you choose - it might be that there was rapid expansion between 2020 and 2024 which is not captured in your reporting of lake-A. Can you please address this for context or make sure you state why this is not necessary.

We thank the reviewer for pointing this out. We have revised this portion of the text; we now give absolute lake area instead of percentage growth of the lakes. We have also included a new

table in the supplementary section ‘Table S3’ that gives the lake area for individual years from 1999 to 2024.

P13 L10/11 Consider revising, this is unclear. You also refer to “empirical equations” in section 3.3, but there are no equations in this section. Can you please explain.

The equations are now listed in new table S2 in the supplementary material.

P15 L15 You talk about lake expansion. Previously, you used percentages. Can you please keep this consistent?

We have revised this and keep only lake area change and not percentage to maintain consistency.

P17 When talking about the R1-4 scenarios, you quote different release volumes for R1 (L4 it is 8.53 x 105 m3, L12 you quote 8.69 x 105 m3) - can you please provide more detail on this? It might be useful to have this in a table so that you don’t need to quote scenario specifics in the text.

Thank you for the constructive comment we have added a new table- S5 in the supplement section giving the details of the different avalanche scenarios and the release volumes.

P20 L10 What V–A scaling approach was used?

We applied several V–A scaling relationships, including those proposed by Evans (1986), Fujita (2013), Wang 2012 (D), Huggel (2002), Loruax and Casassa (2013), Emmer and Velmik (2014), Cook and Quencey (2015), Kapisita (2017), Munoz et al (2020) to estimate lake volume. We average all V-A scaling outputs to determine ensemble volume. A Supplementary Table-S2 giving details of the V-A scaling approaches is now provided in the revised manuscript.

Other:

Please make sure you consistently use either Lake A and Lake B or Lake-A and Lake-B.

We have used “Lake-A” and “Lake-B” consistently throughout the manuscript and revised the figures accordingly.

Consider revising your use of “respectively”. It would be easier to say P10 L 3/4: Similarly, in scenarios 2 (SC-2) and 3 (SC-3)… You have used “respectively” a total of 9 times in the paper.

We thank the reviewer for pointing this out. We have reduced and avoided unnecessary use of the term “respectively” throughout the manuscript.

You don’t refer to your figures in order. You should reorder these.

We have reordered the figures so that they are cited sequentially in the manuscript.

“Basin” is used throughout and sometimes seems as if it is a substitute for the word “lake”. Can you please check the use of this? This first happens on P12 L9 - I think this needs reconsideration/clarity.

We thank the reviewer for pointing this out. We have carefully revised the entire manuscript and corrected such instances.

There are a number of times you reference twice in the same sentence. Please remove the second references in the following locations:

P5 L 18/19; P25 L26; P29 L7/8; P29 L9; P31 L10

We have corrected them in the revised manuscript.

Please check grammar, punctuation and for typos (e.g. P5 L19; P15 L16/17; P20 L14).

We thank the reviewer for pointing this out. We have carefully checked for grammar and typos and corrected them in the revised manuscript.

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