Review of: The vulnerability of buildings to a large-scale debris flow and outburst flood hazard cascade that occurred on 30 August 2020 in Ganluo, Southwest China

Overview:

The manuscript describes a hazard cascade where a debris flow dammed a river, causing upstream flooding and a downstream outbreak flood. Separate hydraulic modelling analyses were completed for the debris flow and subsequent flooding and outbreak flood. Three zones were defined, with primary debris flow impacts, secondary flooding/outbreak flood impacts, and sequential debris flow, then flood impacts, and vulnerability curves were defined. The model results were used to assess the contribution of the different components of the hazard cascade to the expected levels of building damage.

General comments:

1. The number of significant figures used throughout the manuscript should be representative of the level of confidence in the numbers reported. For example, discharge estimates coming from empirical relationships are reported to four significant figures, which suggests a level of precision that is not appropriate for these relationships, and the volume of the landslide dammed lake is reported to six significant figures.

2. The introduction and conclusion focus on confluence zones between debris-flow prone catchments and larger rivers. Would the approach developed in this work apply more generally to any area downstream of a landslide dam? In the introduction "confluence zone" should be defined, how far upstream/downstream is considered in this zone?

3. I would recommend the authors more explicitly compare the results of their simulations with the field observations. There is description of the actual event, and of the model results, but it's not clear as written where the model performed well or did not. This is important for evaluating the overall approach for representing the hazard cascade described in this manuscript.

Specific comments:

Line 29: Would "occasionally" be more appropriate than "frequently"? In my experience landslide dams formed by debris flow deposits are not common.

Line 32: This could be a good point to introduce how you are defining "confluence zone" in this work (see general comment 2).

Line 42: If the six steps of the Argyroudis et al. (2019) methodology are relevant to this work, they should be listed, otherwise you can delete "is comprised of six steps and".

Line 50: 300% increase in damage relative to what?

Lines 103 – 105: Can this geological description be better integrated into the rest of the work? Are there specific geologic units which tend to have more landslide events, etc.?

Lines 107 – 109: Provide a reference for the earthquake record.

Lines 118 – 120: Provide a reference for the climatic data.

Lines 126 – 127: The final sentence of this paragraph can be deleted because the information is presented in the following paragraph.

Lines 148 – 159: Provide a reference for the photogrammetry software/analysis technique used?

Table 1: Debris flow density – have the authors assessed how similar the debris flow at this site is to the debris flows that were used to generate the density relationship from Hu et al. (2019)? The fact this relationship uses a seventh order polynomial suggests the relationship is likely very highly fitted to the data. It should also explicitly state what the clay fraction is calculated by (I presume by mass).

Debris flow peak discharge – were the results from the equation cross checked against other methods (for example, volume-discharge relationships, see Ikeda et al., 2019)? The H term in the n_c calculation is not defined in the description column.

Line 161: Provide references for using FLO-2D for debris flow simulations.

Table 2: How were the model parameters used selected? I would recommend changing the table title to "FLO-2D model parameters used in the debris flow simulation".

Line 167: The limitation of using the post-event DEM should be discussed at some point in the manuscript. It makes sense to use it, as it is information that there is higher confidence in, however it should be recognized that as the landslide dam breached the channel geometry would have been changing significantly during that time. Lines 176 to 177 state that "it was assumed that the peak discharge of the dam-burst flood formed the post-event terrain, which was adopted to simulate the dam-burst flood". The flood may have had its maximum erosive power at the time of the peak discharge, but the post-event terrain would have been formed over the entirety of the breach process.

Lines 167 – 168: On a related note, the choice of a one-dimensional steady state simulation should also be justified. A dam breach is a very transient phenomenon, could assuming a steady state at the peak discharge have any effect on the results for the end purpose of estimating damage levels? Would a 2D model be more appropriate for representing flows given the complexity of the topography?

Table 3: Similar to Table 2, the title should be "Parameters used in the flood simulation".

Figure 2: Add a description of what the red star indicates either on the plot or in the caption.

Lines 223 – 224: Can the authors provide some qualitative description of the deposit to go with the grain size distribution, i.e., clast supported, matrix supported, etc.? It states that material smaller than 100 mm was sampled, what was the maximum particle size observed in the field? Since the density was calculated based on the clay fraction, if there was a significant portion of the material larger than 100 mm that could influence the density estimation.

Lines 238 – 240: There should be some commentary on how well the simulated debris flow matches the observed event.

Lines 240 – 243: This information is not relevant to the simulation, and was stated previously, it should be deleted.

Line 250: It states that “empirical formulas” were used to verify the Manning’s result, but only one formula is discussed following.

Line 258 – 259: There are more recent empirical relationships for landslide dam peak discharge (e.g., Froelich, 2022), I would recommend evaluating multiple empirical relationships given the importance of the peak discharge on the simulated flow depths and velocities.

Line 260: Please clarify, the relative error is relative to the result from the Manning’s equation?

Lines 272 – 275: This information belongs in the methodology section.

Lines 275 – 276: Related to the comment on lines 223 – 224, how does the calculated maximum transported sediment size compare to the field observations of mobilized material?

Line 315: Please check that units are consistent throughout, km^2 is used here while m^2 is used elsewhere for area. See also lines 390 – 395 where pressure units switch from kPa to Pa.

Lines 346 – 348: This commentary seems out of place, it seems to be a more general statement on the effects of different hazards and local topography, not related to the event that is the focus of the manuscript.

Lines 361 – 362: A statement is made that buildings closer to the channel are always more vulnerable. This may not be true in all cases (for examples, buildings near a channel may be constructed to be extremely resistant to damage, and in that case the maximum vulnerability could be in areas with less inundation, lower impact pressures, but less robust construction. This statement should be changed to discuss this specific event, and not making unsupported generalizations.

Line 396: It is stated that there is no evidence the debris flow abraded the structure – can the authors connect this to their simulation results, are the simulations consistent with the field observations?

Line 431: Aside from being professionally constructed, are there any details on the construction of the buildings that lead to their greater resistance to damage? What makes them “tougher”?

Lines 469 – 472: It is unclear whether this is meant to be a general discussion on landslide dam outbreak floods, or if this is referring to this specific case. Please revise to make whichever you intended clearer.

Line 473: Should 110^5 be 10^5?

Line 483: Be specific as to how an “ordinary flood” is defined in this context. Similarly, an explicit comparison reference is needed for lines 535 – 537.

References:

Froelich, D.C. (2022). Peak discharge from a landslide dam outburst. Natural Hazards Review 23(2). https://doi.org/10.1061/(ASCE)NH.1527-6996.0000545

Ikeda, A., Mizuyama, T., Itoh, T. (2019). Study of prediction methods of debris-flow peak discharge. http://dx.doi.org/10.25676/11124/173152