Review 1:
We would like to thank the reviewer for their insightful and constructive comments on our manuscript. The reviewer has highlighted several areas of the manuscript that required clarification, particularly regarding the explanation of the levee effect and the implementation of methodological parameters. In response to these suggestions, we have significantly expanded the methods section and added two new paragraphs to provide a clearer explanation of these analyses. Additionally, we have added a dedicated paragraph to explain the levee effect and adjusted the introduction and conclusion to ensure better alignment with our research objectives and improve overall clarity. Below, we provide specific responses to each of the reviewer's comments:

1. **Lines 143-226: The methodology section should include the rationale for the selection of model parameters and provide a sensitivity analysis to enhance the credibility of the model results.**
   We have revised the methodology section (lines 145-271) to include a detailed rationale for the selection of model parameters. This now explains the factors we considered when selecting each parameter including their relevance to the study area and impact on model accuracy. Furthermore, we have incorporated a sensitivity analysis of the DEM on the model's output. This addition enhances the robustness of the results and justify the model's applicability in the context of our research.

2. **Could authors further explain how the 'levee effect' influence exposure of large-scale debris flow events?**
   We have expanded the explanation of the 'levee effect' in the revised manuscript (lines 550-572). This section now describes how levees can alter the natural flow patterns of debris, potentially redirecting flows or causing accumulations in areas that may not otherwise be exposed. We highlight Cutou specifically to demonstrate how the 'levee effect' influences debris flow risk in the context of our study area. This helps to better integrate the theory into our analysis of debris flow exposure and risks.

3. **Expand the analysis of the Xiaojia area to explore the specific reasons for its low exposure changes, such as natural terrain barriers, land-use planning, or building quality.**
   We have included an expanded analysis of the Xiaojia area (lines 353 to 377), focusing on the factors contributing to its relatively low exposure to debris flow events. Specifically, we noted factors of natural terrain barriers as well as land-use planning measures, including zoning and construction regulations that mitigate risk. Additionally, we have considered the quality of buildings in Xiaojia, which may influence the ability of structures to withstand debris flow events. These factors are now discussed in greater detail in the revised manuscript.

4. **The introduction and conclusion sections should better align with the research objectives.**
   Response shown in lines 91 to 100 (introduction); Lines 612 to 648 (conclusion).

   We have made edits to both the introduction and conclusion sections to better align with the research objectives. In the introduction, we now clearly outline the key research questions and objectives that guide the study. In the conclusion, we explicitly relate the findings back to the original research objectives, ensuring that the main contributions of the study are clearly communicated. This revision strengthens the coherence between the introduction, body, and conclusion of the manuscript, to ensure our study's main contributions are clearly communicated.

Review 2:
We want to thank the Reviewer for their helpful comments. The reviewer has raised important points regarding the explanation of the LAHARZ model, the parameterisation of exposure analysis, and the

presentation of vulnerability data. In response, we have expanded several sections of the manuscript and edited Figure 7 to include additional details on building numbers and vulnerability levels. We have also worked to align our research objectives more clearly with our scientific arguments. Specific responses to each of the reviewer's comments are provided below:

1. **Line 217 The facility value and related parameters selection were overlooked, and that increase the vagueness of application process in case the reader was interesting in similar application design.**

   We have clarified and expanded our methodology section for assigning fragility values to buildings (lines 233 to 239) . To address the vagueness, we have explicitly stated that the fragility values were assigned based on a combination of literature sources and satellite images. Specifically, buildings that were inundated or damaged in previous events, or those located along the channel or gully mouth, were given a fragility value of 1, while all other buildings were assigned a value of 0. We validated these values using historical damage reports from the 2008 earthquake recovery period to ensure their applicability. Additionally, we emphasised this approach allows for replicable application designs in similar hazard-prone areas, thus addressing the concern regarding the transferability of the methodology to other contexts. We believe these revisions provide the necessary clarity for readers interested in applying this approach to similar designs.

2. **The justification of using -1 to +2 as units of measure to be inserted and its quantification relationship to vulnerability value is missing.**

   We have added a justification for using the -1 to +2 scale as units of measure in our analysis (lines 243 to 264). The scale was selected based on its ability to represent a range of vulnerability values that are meaningful for our study area. We have also included a quantification relationship between this scale and vulnerability values, explaining how each unit on the scale corresponds to specific levels of vulnerability, both physical and economic.

3. **LAHARZ simulation, data processing, assumption, and technical details were missing.**

   We have now provided additional details regarding the LAHARZ simulation (lines 200 to 218), including the specific data processing steps, key assumptions, and technical details. This includes a description of the model setup, the sources of input data, and the assumptions underlying the simulation parameters. We have also discussed the limitations of the model, and any uncertainties associated with the assumptions made.

4. **Fig. 7 and the amount of buildings, types, and degree of vulnerability in terms of economic or physical were missing.**

   We have revised Figure 7 to include the total number of buildings, along with the total number of catchment buildings added to the figure caption. Additionally, the figure caption now provides this information for clarity. In lines 566 to 570, we explain why we did not include economic data in the analysis.

5. **Maps and figures are very simple, and the conclusion was almost predictable, as I am still looking for scientific arguments and proofs that may increase the credibility of research contribution.**

   We appreciate the reviewer's feedback. In response, we have revised the introduction and research objectives to better highlight the key scientific arguments and methods used to substantiate the credibility of our findings (lines 94 to 101). These revisions aim to strengthen the scientific rigor and contribution of our research. Regarding the maps and figures, we chose to keep them simple to ensure ease of interpretation and clear visualisation of exposure changes over time (Figures 5 and 6). We believe this approach enhances the accessibility of the findings without compromising the scientific integrity of the results.